Metrics for Enterprise Transformation

by

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Bachelor of Science in Mechanical Engineering,
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Submitted to the Engineering Systems Division
and the Department of Aeronautics and Astronautics
in Partial Fulfillment of the Requirements for the Degrees of

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ABSTRACT

The objective of this thesis is to depict the role of metrics in the evolving journey of enterprise transformation. To this end, three propositions are explored: (i) metrics and measurement systems drive transformation, (ii) employee engagement is a proxy to gauge transformation progress; and (iii) metric considerations enable enterprise transformation when systematically executed as part of a transformation roadmap.

To explore this problem, the aerospace measurement community was consulted to help grasp a better understanding of the context in which transformation is currently defined and measured. Once the problem space was defined, the environment of doing research with the enterprise as the unit of analysis was described with the intent of exploring the role of metrics and transformation. In particular, the performance measurement literature helped identify tools and methods used to select metrics to enable decision making at the enterprise level.

After this review, two case studies were performed, considering: (1) the implementation of a bottom-up measurement system to drive transformation and (2) the effect of a top-down corporate measurement system on the enterprise. The first case study revealed insights regarding the benefits and challenges of implementing measurement systems and highlighted the use of employee engagement as a proxy to measure enterprise transformation. In the second case study, contemporary measurement issues were discussed and mapped to an Eight Views of the Enterprise analysis to identify critical enterprise interactions. Ultimately, the Lean Advancement Initiative's Enterprise Transformation Roadmap was used as a method for depicting how performance measurement can help enable enterprise transformation.

The implications of research in metrics for enterprise transformation span across thee areas: (1) the extensive literature reviews provide an academic contribution for performing enterprise and measurement research; (2) a common language and framework for exploring measurement problems is depicted for practitioners through the case study analysis; and (3) a connection between enterprise *measurement* and enterprise *transformation* is established to drive future transformation success.

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Before getting to the content of this thesis, I need to take a brief moment to acknowledge all those who made this aggregation of work possible, as I assuredly could never have done this alone.

Most importantly, I am forever grateful to Dr. Ricardo Valerdi and Professor Deborah Nightingale for all of their support over the years. Dr. Valerdi, thank you for being not only a professional and inspiring teacher and adviser, but a great mentor and friend as well. Professor Nightingale, I would also like to thank you for being a great professor, mentor and friend. Moreover, I am forever indebted to yourself and Professor Widnall for all your hard work and efforts to bring me into the Lean Advancement Initiative Community, not to mention the professional advice and assistance. For the Lean Advancement Initiative community, I extend my gratitude to all students and staff, for always making the office a great place to come in and work with some inspiring intellectual conversation. I would also like to extend a special thank you to some of the consortium members in particular who have been tremendously helpful to me during this long journey – John Day and Jim Stubbe of Raytheon and John Gill of BAE Systems – for providing, data sources, case study support, and practical advice and encouragement from industry that was paramount for success.

Last, I would like to thank my family and friends for being there for me over the years and supporting me in my professional and personal endeavors – I cannot thank you all enough. For my loving parents, James and Margaret Blackburn, I extend one last special thanks for all your enthusiastic involvement in my life, having helped guide me to where I am today and assuredly to a bright future to come. Thank you.

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Chapter 1

Introduction

In 1990, *The Machine that Changed the World* was published, providing insight to the automobile manufacturing world regarding the implementation of more effective and efficient practices that could significantly improve corporate performance – a concept later embodied by the term *lean* (Womack et al, 2000). As knowledge about lean thinking began to grow exponentially over time, researchers and practitioners quickly understood that lean was applicable to not only the automobile industry, but to other manufacturing industries as well. With this understanding, the United States Air Force began to inquire as to if lean principles could be applied to assist in military aircraft production – spawning the birth of a research group at the Massachusetts Institute of Technology that was known at the time as the Lean Aircraft Initiative (LAI). Expanding their scope to encompass all space-focused entities, the mission of LAI was to help facilitate the implementation of lean processes across the entire aerospace industry. As lean has matured as a science over time, research has correspondingly expanded in scope from exploring the traditional factory floor operations-level to investigating more global enterprise-level principles and practices across various industries. With this expansion, LAI's (now Lean Advancement Initiative) research focus has broadened and the new mission has been to develop and promulgates practices, tools, and knowledge that enable and accelerate enterprise transformation.

In addressing this new mission and the holistic topic of enterprise transformation, LAI's research focus can be segregated into four areas, which can be seen along with the questions they are geared at answering in Figure 1.1 below.

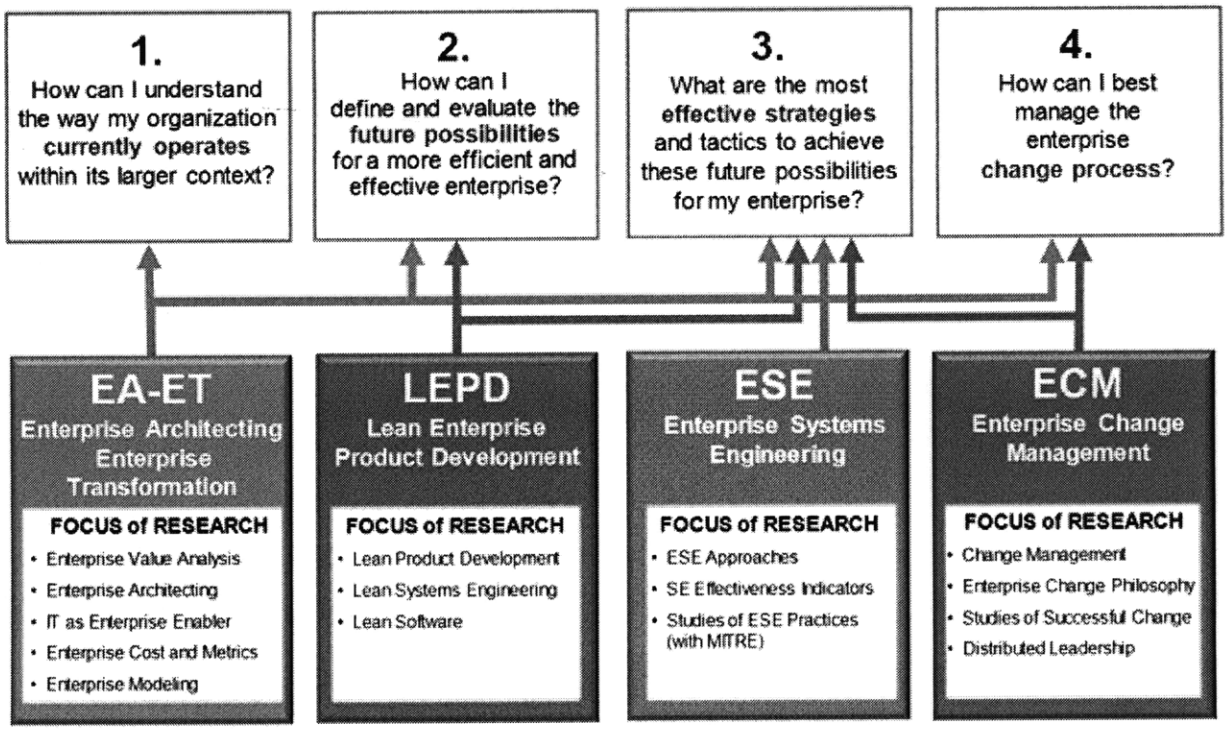

Figure 1.1 – LAI's Research Teams and the Four Research Questions

As this research structure has evolved, LAI consortium members have frequently posed the question – *"how can we measure the progress of our enterprise transformation"* – which correlates strongly to questions 1 and 2 in Figure 1.1. Thus, to help mature and expand the knowledge base around this topic this thesis explores metrics for enterprise transformation in the context of LAI's research structure and their membership base (primarily aerospace industry centric).

1.1 Exploring the Problem Space

Addressing this topic of interest – a great wealth of research has been performed regarding enterprises as systems (or using the enterprise as the unit of analysis), measurement, and the science of transformation. However, these three mature bodies of literature have yet to converge to provide researchers and practitioners with insights or a conceptual framework for metric considerations in their own enterprises' transformation journey. Considering this knowledge gap and the interest in metrics for enterprise transformation, it is first necessary to

explore the problem space that embodies the intersection of these respective knowledge bases. Henceforth, before delving into the research feedback from stakeholders was obtained regarding metrics for enterprise transformation. In particular, an exploratory survey was given to twenty-four representatives from an aerospace measurement community, including: various organizations within the United States Air Force, primary commercial aerospace companies, and many first tier suppliers as well. One goal of the survey was to discover contextual insight as to: (1) how transformation is currently defined and its typical duration, (2) how their enterprises currently measure transformation progress, and (3) what can be considered leading and lagging indicators for enterprise transformation success and failure.

For the first question of interest, half of the representatives stated that transformation is either a more than seven-year or a never-ending journey. This result indicates that transformation is not necessarily radical or disruptive, but rather more often than not it encompasses an organization's progress towards either their long-term goals or their corporate vision. Since measuring transformation calls for some understanding of how transformation is defined by consortium stakeholders, each participant was asked to define transformation – the most representative of these 24 definitions are listed.

Enterprise Transformation Representative Definitions:

- *To change the process, culture, organizational mindset, and values to improve the work output and value to the customer*
- *A radical shift in individual and organizational behavior that is driven by an urgent need to change (or reposition) an organization for breakthrough performance or competitive advantage*
- *Adapting behaviors and practices to a changing market*
- *From: Collection of individual business units, To: Networked enterprise, leveraging best practices to become the premiere multi-industry company*

With this rough understanding as to the context of transformation, the second question is now considered, how enterprises are currently measuring transformation progress. Based on the interest in the research topic, it was predicted that directly asking this question would yield some

key fundamental insights regarding current measurement frustrations – the most representative comments are listed.

How Transformation Progress is Currently being Measured:

- *Too vaguely, sporadically, inconsistently. That said, we tend to break our measurements into small pieces (like good Systems Engineers) and never re-integrate back into a big picture.*
- *There are strategic level (enterprise) metrics at the top, then lower level metrics. However, these metrics have no target goals and they don't align well at all.*
- *Incrementally – many different measures can drive the same transformation, the initiatives that are launched drive more.*

Third, with reflections as to how transformation is currently being measured, the next logical coupled question seemed to be to ask practitioners their opinions as to what leading and lagging indicators for enterprise transformation success or failure in fact are. These results, seen in Table 1.1, provide preliminary insight as to some novel metric considerations that need to be addressed in the corresponding research and analysis.

Table 1.1 – Lagging & Leading Indicators for Enterprise Transformation Success/Failure

Lagging Indicators	Leading Indicators
"Estimating factors for bidding new work. Earnings. Returning Customers. Positive weightings by customers on past performance as related to new business proposals."	*"Leadership involvement, employee understanding and buy-in, linking compensation to organizational goals and objectives."*
"Sabotage. Lack of commitment from managers using the breakfast analogy (bacon & eggs – chicken is involved, but the pig is committed)."	*Leadership promoting and leading transformation. Basically, the transformation is 'something we are working toward' rather than 'something being done to you.'"*
"Customer satisfaction, profitability. These tell you the value streams are operating well."	*"When the new techniques become part of the language and culture of the enterprise."*

From the comments in this section as well as the complete response set, it is observed that although most enterprises have higher-level metrics or use measurement systems, most do

not have a formal system for evaluating their corporate transformation trajectory towards their goals or visions. Additionally, one can foreshadow that a critical leading indicator for transformation success might be the extent to which employees have bought in or are engaged in the transformation. With this contextual understanding about measurement issues in enterprise transformation, an informed research direction can be defined.

1.2 Research Derivation, Questions, Hypothesis & Desired Results

This brief and articulate insight from the aerospace metrics community of practice provides an array of insight into the measurement problems faced. Previous LAI metrics research topics have provided additional insight, including: Cory Hallam's doctoral thesis that depicts how by measuring an organization's leadership in driving lean change one can predict success or failure in the change initiative and ultimately the revenue generation (Hallam, 2003); Vikram Mahidar's masters thesis that establishes a methodology for organizations to develop a lean enterprise performance measurement system (Mahidar, 2005); and a wealth of joint industry and academic work that suggests return on investment capital change over time can be a proficient indicator of an organization's lean transformation progress (Kessler et al., 2003). However, despite the many valuable insights produced from these works already – there is still a significant degree of understudied material in the topic of metrics for enterprise transformation. The gaps identified between the knowledge base of academia and the needs of practitioners thus far are threefold, namely: (1) better understanding the roles of top-down corporate metrics and bottom-up factory floor level metrics in facilitating transformation, (2) determining how employee involvement can be considered in measuring transformation progress, and (3) formally understanding a holistic view of the various metrics considerations in the transformation journey.

First, although a significant body of literature has been produced articulating the needs to link higher-level corporate metrics to operations-level factory floor metrics, as shown in Mahidar's work, a more in depth understanding of the dynamics at both these levels needs to be developed. Although there needs to be a strong linkage, the problems at the top and bottom of the organizational ladder will vary significantly and thus should be investigated first independently to get a big picture view of metrics issues in practice. In particular, two aspects need to be investigated: (i) the ability to leverage top-down corporate metrics and measurement

systems to drive enterprise transformation; and (ii) the ability to leverage bottom-up factory floor level metrics and measurement systems to drive enterprise transformation. Second, now that a linkage between leadership involvement and lean transformation has been developed in Cory Hallam's work, the complementary concept of using employee engagement as a proxy for enterprise transformation progress, although uncertain, should be further developed. Third, a broad and direct connection between metric considerations and the transformation roadmap needs to be developed – giving practitioners a holistic understanding of the role of metrics in facilitating transformation.

Considering these three knowledge gaps, the fundamental and issue encompassing hypothesis proposed is that *top-down and bottom-up metrics and measurement systems can be leveraged to drive enterprise transformation.* Although this hypothesis question relates mainly to the first identified knowledge gap, it can be predicted that employee engagement can be a proxy for enterprise transformation similar to how leadership involvement is – an idea that will be explored. Furthermore, it is thought that even though different enterprises can be at various levels of lean maturity or at separate points in their own respective transformation plan, a framework for metrics to enable the transformation journey can be developed to guide all enterprises.

1.3 Supporting Evidence & Research Methodology

Next, in order to develop a research methodology it needs to be understood how to answer this implicit question posed – *how can top-down and bottom-up metrics and measurement systems be leveraged to drive enterprise transformation?* In order to gather practical insight to answer this question, two in depth case studies of both bottom-up and top-down metrics and measurement systems are performed. With regards to case study structure and methodology, the formal structure proposed by Yin (2003) is used. According to Yin, the five critical attributes to consider for case studies are as follows:

(1) a study's questions;

(2) its propositions;

(3) its unit of analysis;

(4) the logic linking the results to the propositions; and

(5) the criteria for interpreting the findings.

Having identified the question, the propositions are: (i) metrics and measurement systems drive transformation, (ii) employee engagement is a proxy to gauge transformation progress; and (iii) metric considerations enable enterprise transformation when systematically executed as part of a transformation roadmap.

Next, the unit of analysis will be different for each case study due to the nature of the problem being explored. For a bottom-up measurement system, an individual business unit within a major aerospace enterprise is investigated. In particular, many different areas are looked at, to include: the system origin (the burning platform), the development and adoption of the system, the advantages, disadvantages, future challenges, and the implications of expanding the use of the system beyond the traditional manufacturing boundaries. To gather this input, fifteen stakeholders from different positions are interviewed, ranging from the developers, end users, and even the managers that use the system to make decisions. Additionally, five site visits are executed to understand the context of the organization and to be able to empathize with the day to day needs of the practitioners and stakeholders. For the top-down measurement system, the unit of analysis will be the corporate enterprise – including all the major business units, functional areas or external stakeholders that interact with the corporate metrics in any capacity. To gather input for this case study, one in-depth interview with the enterprise measurement lead is performed, and feedback from a two day intra-organizational measurement community of practice event is gathered.

The logic linking the results to the propositions is strictly empirical. For the bottom-up measurement system, it is predicted that interview results will converge on a few common theses regarding advantages, disadvantages, and future challenges of the system. Considering the top-down system, the results will be extrapolated from self identified measurement issues from a two-day workshop of enterprise stakeholders and through an intensive follow-up interview of the Enterprise Measurement Lead. Similarly, for interpreting the findings, consistency of the results amongst stakeholder views and the extent to which these views converge will be examined. A concise depiction of this case study methodology can be seen in Figure 1.2.

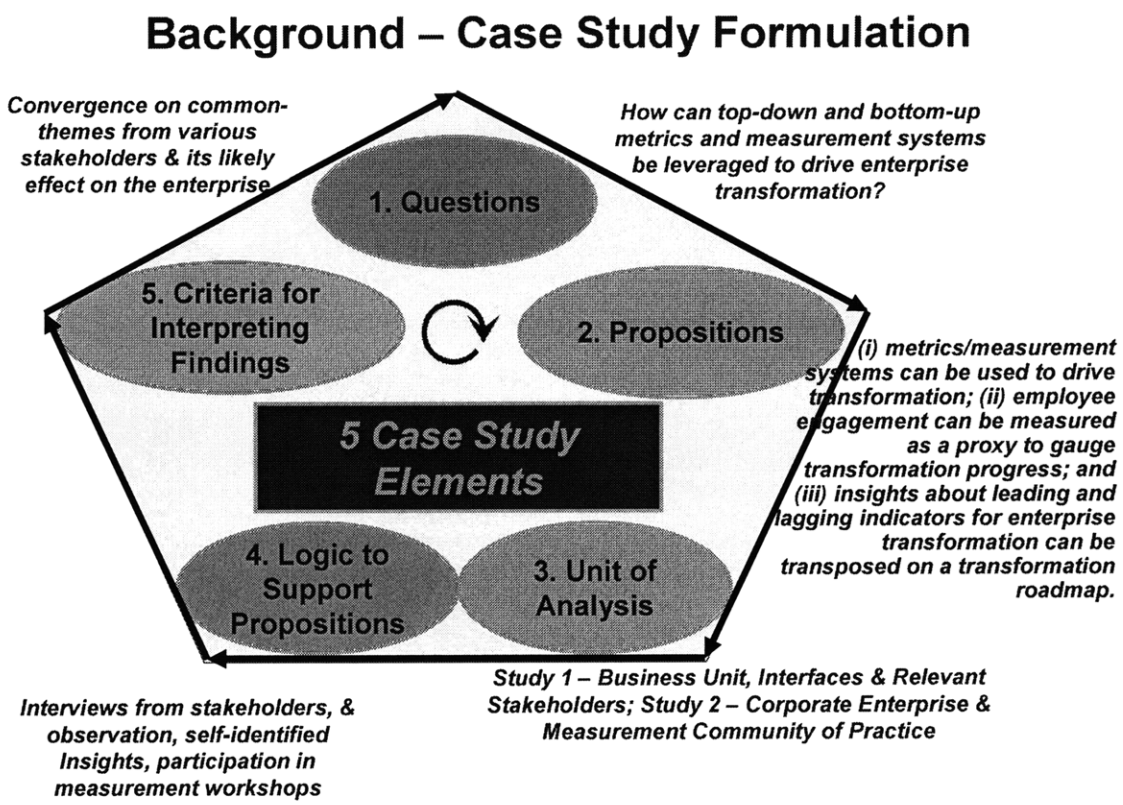

Figure 1.2 – Case Study Formulation from Yin Methodology

1.4 Thesis Overview

Understanding the design of this research, an overview of the thesis contents is now presented. In general, the earlier chapters are focused at doing thorough literature reviews. Once the fundamental background knowledge is developed, the two case studies are executed and ultimately an insightful analysis regarding the aforementioned hypothesis and propositions is performed. A more in depth view of each chapter is now given.

Chapter 2 – Enterprise Research

The focus of this chapter is to describe the domain of enterprise analysis. This is accomplished through an exploration of relevant definitions, a discussion on boundaries, and a summary of practical implications for researchers and practitioners. Specifically, the perspectives of stakeholders involved in small- and large-scale enterprise transformation are considered, be they executives in corner offices or line workers on the factory floor. Anecdotes

derived from research experiences with enterprise transformation provide insight into current enterprise research opportunities. To illustrate the domain of enterprise analysis, three critical enterprise attributes are identified – structure, function and value delivery – and it is investigated how these attributes can be used to influence boundary analysis, a discussion which provides researchers and practitioners the ability to use enterprise thinking as an invaluable tool to transform enterprises. These attributes will be used in later case study analysis and will also provide pivotal insight regarding the role of measurement in the transformation journey as well.

Chapter 3 – Metrics Research

The purpose of this chapter is to depict the vast landscape of literature related to enterprise performance measurement in a concise and comprehensible manner for researchers and practitioners. The focus is particularly on the enterprise as the unit of analysis and considers measurement systems from stakeholders at all levels. A broad range of considerations will be explored, ranging from bottom-up considerations such as employee performance measurement to top-down considerations such as enterprise measurement systems. Moreover, common measurement-related problems identified in practice and solutions proposed in academic literature are discussed. To illustrate this landscape of measurement knowledge, three distinct areas are examined: (1) selecting the right metrics, (2) creating and implementing measurement frameworks; and (3) metrics for decision making. Insights from these three areas provide a valuable background for understanding measurement systems, metrics issues identified in the case studies, and where metrics considerations will fit in the transformation roadmap.

Chapter 4 – Transformation: the Notion, Context & Tools

This chapter provides a brief literature review and background regarding transformation as a science, and then begins to transition into a discussion of contextual transformation problems and the use of transformation roadmaps. LAI's Enterprise Strategic Analysis for Transformation and the Enterprise Transformation Roadmap will be introduced as it will help serve as the backbone for understanding the role of metrics in the transformation journey expanded on in Chapter 7.

Chapter 5 – Case Study 1: Implementation of a Bottom-Up Measurement System

This chapter describes the effective implementation of a bottom-up measurement system in a large company for the purpose of organizational transformation. How this measurement system affects not only managers, but factory floor workers as well are both considered. The major aerospace defense contractor studied in this chapter has recently undergone a significant transformation – enabled by this measurement system – hence employee insight regarding the influence of the measurement system on that transformation should be invaluable. This chapter is organized in four main sections: (1) the organizational background and burning platform that incites transformation, (2) the development and adoption of a measurement system, (3) the practical implications of the measurement system on enterprise transformation, and (4) the direction, challenges, and future considerations in sustaining a measurement system throughout the ongoing journey of continuous improvement. Through the consideration of these four main factors – a unique foundation of insight on how measurement systems can be developed and used to guide future enterprise change is provided. This chapter will yield conclusive insight regarding propositions (i) and (ii) – the ability to leverage a bottom-up measurement system for transformation and the use of employee engagement as a proxy for enterprise transformation progress.

Chapter 6 – Case Study 2: The Corporate Enterprise Metrics Dashboard

This case study explores the effects of a top-down corporate measurement system on an enterprise. First, a background is provided regarding the formulation and the overall structure of the corporate measurement group. Second, insight regarding the modern corporate enterprise measurement challenges facing the organization is given. Third, understanding the background of the measurement community of practice and their challenges, LAI's enterprise architecture analysis framework is used – the Eight Views of the Enterprise – to better understand the influence of the organizational enterprise architecture on the measurement system.

Chapter 7 – Integrating Metrics & the Transformation Roadmap

The goal of this chapter is to develop a foundation to consider proposition (iii) – the need to provide a framework depicting concise metrics for enterprise transformation considerations to compliment the Enterprise Transformation Roadmap. This metrics layer of the roadmap will tie together key insights from all prior chapters, from the general insights regarding enterprise-level

analysis introduced in Chapter 2 to the practical findings unveiled in the case studies of the bottom-up and top-down measurement systems.

Chapter 8 – Implications, Conclusions & Future Research

This chapter will provide a concise summary of the critical findings identified in this thesis as well as the results obtained that confirm the three propositions. Additionally, the implications of these results will be briefly explored. Ultimately, the next logical steps and research direction for the continuation of building a mature knowledge base in the area of metrics for enterprise transformation are articulated.

Chapter 2

Enterprise Research – A Literature Review

The focus of most systems analysis tools and methods has traditionally been on systems in well-defined boundaries of manufacturing, software, communication, transportation, etc. Industrial and systems engineering have enhanced the development and operation of such systems, but there is an emerging movement to apply the same systems-oriented view to a different class of systems: enterprises. Rouse (2005) provides a window into this unit of analysis by distinguishing between "enterprise systems" and "enterprises" as systems. An example of an enterprise system is an Enterprise Resource Planning (ERP) software tool that enables organizations to run their operations more efficiently. At the same time, the organization that uses an ERP tool can be considered an enterprise itself and hence can be analyzed from a systems perspective.

By considering enterprises as systems in their own right, new challenges emerge for this newly defined unit of analysis. With the experiences in enterprise research performed at LAI, one of the most common questions LAI comes across is – "how do you define the term *enterprise?*" Ensuing conversation has tended to yield descriptions that have aimed at describing two issues: (1) the context under which enterprises are being studied and (2) the boundaries used to define the unit of analysis. Insight from these inquiries suggests that it is important for researchers and practitioners to develop a common understanding of enterprise analyses – wherein articulating the context and boundaries provides a standard method to begin analyses and prevent miscommunication. These issues are further discussed in subsequent sections, as well as (3) corresponding implications for decision makers and researchers. In addressing these points this chapter will provide a foundation for future studies of enterprises.

First, *context* is focussed on by providing a synthesis of more than 58 definitions commonly used for the term "enterprise" and associated concepts that depict both the evolution of the construct and the current state of understanding. This range of definitions was obtained from INCOSE, IEEE, and various academic institutions that perform enterprise research. From

these definitions, three main enterprise attribute lenses are identified that aid in enterprise analysis.

Second, the use of *boundaries* in defining enterprises is described. Three different enterprise levels are considered, ranging from those defined only by the specific program or product they influence to those that encompass the operations of multiple international programs. Clearly defining enterprise boundaries helps practitioners identify the scope of their analysis and helps researchers identify the appropriate scope of their respective research. Moreover, how the enterprise attribute lenses identified in the first section can contribute to and significantly improve the quality of findings from an enterprise analysis is looked at. To demonstrate this point, two examples are given that show how boundary analysis can lead to either an expansion or contraction of the scope of analysis, which if done correctly can yield meaningful findings. Within this discussion, the difference between research at the enterprise level versus the enterprise context is distinguished. Differentiating between these two perspectives enables researchers to more accurately convey to stakeholders a clearer depiction of both the scope and the magnitude of the enterprise being studied. Additionally, the contrast between how metrics differ at these two levels is discussed.

Third, the *practical implications* of performing enterprise analysis for both researchers and practitioners are discussed. It is described how enterprise research is unique by comparing how it draws from but is different from research done in other academic areas, such as management, psychology, sociology, and industrial/systems engineering. Although there are many similarities between best practices across these fields, it is proposed that enterprise level analysis maintains unique properties. Specific examples are provided for how enterprise thinking is not applicable to all levels of the organization, from the executive office to the factory floor. Finally, survey results are presented that aim to converge on the most common themes that both future enterprise leaders and middle managers believe are critical for improving enterprises in both the short-term and the long-term.

An understanding of enterprise research will assist future practitioners by (1) exposing them to the context of enterprise research and (2) providing them with a methodology for bounding an enterprise as a unit of analysis from structural, functional, and value delivery perspectives. This methodology, emerging from a rich historical background across many

diverse areas, will be used in Chapter 5, 6, and 7 for depicting the relationship between metrics and the enterprise in consideration.

2.1 Context

Before venturing into the world of enterprise research, it is important to understand what exactly is meant by "enterprise." The term "enterprise" is often synonymous with "corporation" (Nightingale, 2000), but depends on the context as indicated by papers published by technical communities such as the Institute of Electrical and Electronics Engineers (IEEE) and the International Council on Systems Engineering (INCOSE). The following analysis summarizes key elements of the enterprise concept extracted from these communities and provides the most representative definitions from each.

When searching for variations on the term "enterprise," it became immediately apparent that the term not only differs in magnitude, but that there is also a wide variance in the attributes that are used to describe it. With regards to size and scope, the term enterprise has been used to describe entities as small as business departments or single technology development programs to as large as an industry or government with a broad portfolio of programs. The context of the term enterprise appears to be the most significant driver, with many authors commonly considering the term in tandem with information technology, strategy, or human interactions – while others relate the term to more specific elements such as supply chain integration or organizational structure. In order to understand how the term enterprise is commonly defined, usages from INCOSE and IEEE publications are separately summarized, and then these definitions are compared to how the term is understood and used within the various academic communities. Selection of critical enterprise concepts and characteristics chosen from the wide range of definitions were based on two criteria: they needed to provide a clear scope of the enterprise and they needed to inform understand enterprise transformation.

INCOSE Definitions

To converge on the definition of "enterprise," 30 definitions from INCOSE papers published over the period of 1994-2007 were collected. The following twelve themes emerged:

- industry collaboration

- common visions or goals
- value
- complex systems or system of systems
- integration of multiple business segments or processes
- companies or organizations as single entities
- supply chain integration
- services, products, projects, & processes
- information technology (IT)
- environmental and external factors to one's sphere of influence
- societal & human interactions
- regulations, doctrine, or standardization

The summary of definitions is shown in Table 2.1.

Table 2.1 – INCOSE Definitions Breakdown of the Term "Enterprise"

		Service/Product/ Project/Process	Societal & Human Interactions	Industry Collaboration	Vision/Goal	Complex Systems or Systems of Systems	Information Technology (IT)	Integration of Business Segments & Processes	From the Environment	Regulations, Doctrine or Standardization	Supply Chain Integration	Value	Companies or Organizations as Single Entities
1	DeRosa		1	1		1	1		1				
2	White	1	1							1			1
3	Lintern		1	1			1						
4	Martin				1	1			1				
5	Faisandier		1	1				1					
6	King				1	1	1						
7	Kuras		1			1							
8	Walker	1											
9	Ibrahim		1	1	1		1		1				
10	McMahon				1		1	1		1			
11	Siegers							1		1			
12	Madni						1	1	1	1			
13	Clegg		1	1		1		1			1	1	
14	Shulz			1							1		
15	Osvalds					1	1						1
16	Walden							1				1	
17	Fairbain	1		1					1				
18	Meakin	1	1	1			1			1	1		
19	Grossman	1			1		1	1					
20	Gates							1					
21	Mason-Jones	1									1		
22	Norovita	1											1
23	Grady	1				1							
24	Roberts	1				1							
25	Palmer		1		1								
26	Carl				1	1						1	
27	Kennedy	1	1			1							
28	O'Grady	1	1	1	1								
29	Yeoh				1		1	1					
30	Jones			1	1								
	TOTALS	11	11	10	10	10	10	9	5	5	4	3	3

With these common themes shown, one can easily appreciate the variety of contexts in which enterprise research has been occurring. By dissecting how the term "enterprise" has been defined, one can infer how enterprises have commonly been used as a unit of analysis in past INCOSE journals and international symposia. Hence, these themes are of special interest to businesses and practitioners since the attributes implicitly convey the critical factors in leading successful enterprise transformation efforts. By identifying the context in which these critical success factors are studied, one can begin to construct an understanding of the term enterprise that can be universally applied for the benefit of both researchers and practitioners.

Given INCOSE's membership composition, it was not surprising that the most common attributes were product and human oriented. Interestingly, most of the papers that referred to enterprises appeared in 2007, probably as a result of the INCOSE international symposium theme: *Systems Engineering: Key to Intelligent Enterprises*. To broaden the context analysis beyond what can be extracted from the INCOSE community, the larger and more diverse IEEE community is investigated.

IEEE Definitions

IEEE conferences and journals were searched with the intention of exploring not only the term enterprise, but also its variations. Compared to the INCOSE sources, the IEEE database provided a wider breadth of disciplines because of its broader membership base. Since the database had more than 4,000 publications that included enterprise as a key word, it made sense to determine a method for narrowing the search. From inspection of the INCOSE definitions, it was apparent that the term enterprise was often coupled with another term. Thus, since the definition of enterprise had already been dissected independently of this coupling, it was determined that clarity would be achieved by breaking down the definitions of the most commonly used couplings – which were all extensively referenced throughout IEEE literature. The top four results of the search were all investigated, since other combinations of terms in the literature did not yield enough results for a relevant analysis. The four most commonly used collective terms and the respective amount of times each appeared in the IEEE literature title search are:

- Enterprise Integration (79 times)
- Enterprise Architecture (74 times)

- Extended Enterprise (32 times)
- Enterprise Transformation (8 times)

After compiling definitions from a sample from each category, the most common characteristics were extracted. Twelve themes emerged as shown in Table 2.2.

Table 2.2 – IEEE Definitions Breakdown of the Term "Enterprise"

			Information Technology (IT)	Incorporated Business/Org. Systems/Segments	Collaboration & Partnerships	Common Goal Focus	Environmental Interactions or Considerations	Social Elements & People/Human Interaction Dynamics	Improve Performance & Efficiency	Value Chain	Relationships	Systems or SoS	Scope of Mission/Operations	Organizational Structure Change
Enterprise Architecture	1	Kamogawa	1											
	2	Aier	1											
	3	Johnson		1			1							
	4	Harmon	1									1		
	5	Hjort-Madsen	1	1										
	6	Lam-Son Le	1	1										
	7	Shah					1	1			1		1	
	8	Janssen	1									1		
	9	WenAn Tan		1							1			
	10	Lam-Son Lė	1	1										
Extended Enterprise	1	Hsairi	1											
	2	Zhao	1	1				1						
	3	Wang			1			1						
	4	Furst			1									
	5	Clegg			1	1								
	6	Winans			1	1								
	7	Walters	1	1										
Enterprise Integration	1	Morgan		1		1			1					
	2	Lam		1	1				1	1				
	3	Salaka	1							1				
	4	Smith	1	1		1			1					
	5	Jeusfeld	1	1										
	6	Brosey	1						1					
	7	Bendz		1	1	1	1							
	8	Goh	1		1					1				
Ent. Trans.	1	Rouse								1				1
	2	Anderson	1				1	1						
	3	Adensaner											1	
Category Total			16	12	7	5	4	4	4	4	2	2	2	1

The four collective terms demonstrate how the term "enterprise" has vastly ranged in meaning, and in some instances diverged, hence the need to develop collective terms to articulate the appropriate context of the enterprise under consideration. Similar to the key attributes from the INCOSE definitions, understanding the context of these collective terms and their attributes can help businesses and practitioners identify analysis interests that have been masked by a broadly used term – enterprise.

As it can be seen from inspection of the two tables, many of the same attributes arise – but in varying frequencies. This analysis unveiled many common themes in how the term

enterprise is used, not only with respect to similarities with Table 2.1 but also with respect to similarities amongst coupled enterprise terms. For example, (i) improving performance and efficiency are emphasized more in the consideration of enterprise integration, (ii) both information technology and incorporating business segments were used frequently amongst all coupled terms, and (iii) enterprise transformation did not have any one particular key element that was emphasized.

Considering the results provided in Tables 2.1 and 2.2, one can appreciate the diversity from which the terms have been used and the biases towards certain contexts. For the INCOSE definitions, since the analysis was performed independent of any term groupings, Table 2.1 served the purpose of identifying key definition characteristics. However, since the IEEE definitions were considered in conjunction with their respective term groupings, it was decided that identifying the most representative definitions from each respective grouping would be a useful exercise. Most representative definitions of the IEEE coupled terms – those which identified most closely with the main characteristics of each respective category – are summarized in Table 2.3. Moving forward, understanding these coupled definitions will compliment the definition breakdown exercises as a backbone for analysis is built by fully considering the vast pre-existing body of enterprise context knowledge.

Table 2.3 – Representative Enterprise Definitions from Primary Categories

Coupled Enterprise Term	Most Representative Definition
Enterprise Integration	"Enterprise Integration has the goal of providing timely and accurate exchange of consistent information between business functions to support strategic and tactical business goals in a manner that appears to be seamless." (Smith, et al., 2002)
Enterprise Architecture (EA)	"An EA identifies the main components of the enterprise, its information systems, the ways in which these components work together in order to achieve defined objectives and the way in which systems support business processes (Kaisler, Armour and Valivullah, 2005). EA has been characterized as a system of systems (Kaisler, Armour and Valivullah, 2005) as the "master plan" or "city plan" (Rohloff, 2005) that detail policies and standards for the design of infrastructure technologies, databases, and applications (Bernard, 2004), (Ross, 2003)." (Janssen and Hjort-Madsen, 2007)
Extended Enterprise (EE)	"An extended enterprise is a community of discrete businesses who partner for the purpose of jointly conducting commerce. Extended enterprise goals center around the joint evolution of existing market-spaces, as well as the creation of new ones. This is often accomplished through the creation of on-line and off-line, branded consumer experiences that are sufficiently rich and diversified to develop and nurture a growing base of loyal customers." (Winans, 1998)
Enterprise Transformation	"Enterprise transformation concerns change, not just routine change but fundamental change that substantially alters an organization's relationships with one or more key constituencies, e.g., customers, employees, suppliers, and investors. Transformation can involve new value propositions in terms of products and services, how these offerings are delivered and supported, and/or how the enterprise is organized to provide these offerings. Transformation can also involve old value propositions provided in fundamentally new ways." "Enterprise transformation occurs in – and is at least partially driven by -- the external context of the economy and markets." (Rouse, 2005)

Interpretation of Enterprises across Academic Entities

Now that an understanding of enterprise research from INCOSE and IEEE has been developed, an array of academic entities was consulted to supplement this knowledge base. First, in this section the in depth enterprise research being performed at LAI is discussed. Then, in order to get a more broad academic perspective, enterprise research at both management and engineering schools across the country are investigated, namely: the Georgia Institute of Technology's Enterprise Innovation Institute, the Georgia Institute of Technology's Tennenbaum Institute, the Stevens Institute of Technology's School of Systems and Enterprises, and the University of Texas at Dallas's Enterprise Transformation 20/20 Center of Excellence. After establishing this academic background of enterprise research, a holistic analysis from all the information gathered thus far will be performed.

LAI's mission is to enable the focused and accelerated transformation of complex enterprises through collaborative stakeholder engagement in developing and institutionalizing principles, processes, behaviors, and tools for enterprise excellence. Since its conception in

1992, LAI has been involved in enterprise research primarily in the aerospace domain, as mentioned in Chapter 1. Naturally, as the membership base has expanded over time, LAI's own definition of "enterprise" has evolved to articulate the constantly changing scope of research being done. This working definition of an enterprise is needed for two reasons: to serve as a foundation for the research being performed, and to communicate to the stakeholders of the research and relate to their mental models.

Although the terms "organization" and "corporation" are often interchanged with "enterprise," one clear distinction is that the former terms often carry the connotation of single-function groups or legal entities. In contrast, the scope of enterprise research can span from single organizations to entire industries. Adding to the complication is the blurred understanding of boundaries of such enterprises, which will be discussed in the next section. This explanation being noted, LAI's working definitions for the terms enterprise and lean enterprise are as follows:

> *"Enterprises are complex, highly integrated systems comprised of processes, organizations, information and supporting technologies, with multifaceted interdependencies and interrelationships across their boundaries."* (Nightingale, 2000)

> *"A lean enterprise is an integrated entity that efficiently creates value for its multiple stakeholders by applying lean enterprise principles and practices."* (Murman, et al., 2002)

The definitions obtained from LAI have similar elements to those identified from the literature review above. For instance, consistent with the most popular IEEE theme of information technology, LAI explicitly stresses the role of "information and supporting technologies." Moreover, consistent with the INCOSE definitions, the importance of processes and social interactions are emphasized. Whereas processes are specifically included, one can infer the value of social interactions from the socio-technical overtones of the definitions. Lastly, LAI emphasizes the highly complex and interdependent nature of enterprises – inherently general and common themes with both INCOSE and IEEE.

One distinction between LAI's definitions and many of those from INCOSE and IEEE pertains to the importance of maximizing value delivery to stakeholders, which LAI highlights as a goal of the lean enterprise. However, even though value delivery did not emerge as one of the most common themes from other sources, it is important to note that it did emerge a non-trivial amount of times and can also be considered interdependent with other themes, to include: improving efficiency, supply chain management, and others.

Understanding the breakdown of LAI's definition, the manner in which other academic entities have defined the enterprise within the contexts of their respective research is considered. Since LAI is associated with both MIT's College of Engineering as well as the Sloan School of Management, it is appropriate to consider other academic entities from both engineering and management. Moreover, since engineering and management are both relevant fields to the INCOSE and IEEE communities from which the definitions are derived, it was first thought that both academic areas needed to be explicitly explored. However, exploration into the aforementioned academic communities quickly leads to the conclusion that most academic communities studying enterprises are inherently interdisciplinary. By describing these communities as interdisciplinary, it is inferred that although some may slant their research towards a management or technical audience, all these communities appear to address the fundamental interaction within a system between engineering and management. The summary of how these five different academic communities define the term enterprise can be seen in Table 2.4.

Table 2.4 – Enterprise Definitions from Academic Entities

Academic Entity	Context or Definition of Enterprise
Georgia Institute of Technology, Tennenbaum Institute (Primary Definition)	"A goal-directed organization of resources – human, information, financial, and physical – and activities, usually of significant operational scope, complication, risk, and duration. (W. B. Rouse, personal communication, October 16, 2008)."
Georgia Institute of Technology, Enterprise Innovation Institute	"We define enterprise as an entity that produces products, goods or services… Since our Institute is organized around a number of customer or service sets we define enterprise broadly around those areas. For example, we work with new ventures (Commercialization Services - Venture Lab), start-ups (Entrepreneurial Services - ATDC), small to mid-size companies (Industry Services - which has centers that focus on Lean, Quality, Energy and Environmental Mgt as well as new product development. We also have a Community Policy and Research group that does economic development research and outreach to chambers of commerce, city and county governments, economic development authorities etc - they define those service, governmental and non-profit organizations as an enterprise. So for each of these areas the object of those service areas is considered an enterprise (G. King, personal communication, October 29, 2008)."
Stevens Institute of Technology, School of Systems and Enterprises	"An enterprise is a continuously evolving arrangement of people, processes and systems (hardware and software) whose togetherness serves a collective purpose in response to a business, governmental or social need. A deeper understanding of an enterprise, its structure, dynamics and attributes of agility, resilience and governance, is best achieved by regarding the enterprise as a system (in the abstract sense) and articulating its architecture systemically, that is in relation to other enterprises, to the wider systems e.g. extended enterprises, and to the contextual setting of these various systems (J. Boardman, personal communication, October 24, 2008)."
University of Texas at Dallas, Enterprise Transformation 20/20 Center of Excellence	"Most frequently the 'enterprise' has represented the company at large - or, less often, a stand alone division or business unit within the company (M. D. Oliff, personal communication, October 21, 2008)."
Massachusetts Institute of Technology, Lean Advancement Initiative (Primary Definition)	"Enterprises are complex, highly integrated systems comprised of processes, organizations, information and supporting technologies, with multifaceted interdependencies and interrelationships across their boundaries (Nightingale, 2000)."
Georgia Institute of Technology, Tennenbaum Institute (Other Definitions)	"A venture, particularly one of some scope, complication, and risk (W. B. Rouse, personal communication, October 16, 2008)."
	"A purposeful or industrious undertaking, especially one that requires effort or boldness (W. B. Rouse, personal communication, October 16, 2008)."
	"Industrious, systematic activity, especially when directed toward profit (W. B. Rouse, personal communication, October 16, 2008)."
Massachusetts Institute of Technology, Lean Advancement Initiative (Other Definition)	"A lean enterprise is an integrated entity that efficiently creates value for its multiple stakeholders by applying lean enterprise principles and practices (Murman, et al., 2002)."

Similar to the LAI definitions already dissected, each of the other respective definitions are consistent with the many themes highlighted by the INCOSE and IEEE definition breakdowns. One can hypothesize that since these interdisciplinary academic communities often

do the vast majority of their research with practitioners, it is not a coincidence that similar themes continue to emerge. Now that a broad range of enterprise definitions and themes to assist researchers and practitioners in establishing enterprise context have been considered, in this next section a simple analytical method is proposed to provide researchers a foundation for the future study of enterprises – and for ultimately helping understand the roles of metrics in an enterprise.

Enterprise Attribute Characterization

By identifying critical definition themes from INCOSE, IEEE and various academic institutions – one can begin to consider what attributes are most useful in determining enterprise boundaries for the purpose of defining a static unit of analysis. The importance of understanding the key elements of these definitions is to present to researchers and practitioners the elements used in prior studies for establishing the enterprise context. One can infer that these elements used in the past were attributes that researchers believed were central to an effective analysis. To concisely classify the broad range of themes without neglecting any – distinct enterprise attributes are identified that are collectively exhaustive, but perhaps not mutually exclusive. There are two steps taken in determining the critical attributes: (i) consolidating the twelve themes from INCOSE and the twelve themes from IEEE, then grouping the remaining themes based on interdependencies; and (ii) establishing support for these attribute-based groupings from prior management and engineering literature.

First, cross-referencing the INCOSE and IEEE themes quickly eliminates many of the twenty-four total themes since a non-trivial amount of themes were constant throughout both literature reviews, such as: information technology, collaboration and partnership, and common visions or goals. Next, some highly interdependent themes are merged for simplicity, for example: the value, value stream, and supply chain themes were merged into one – value stream & supply chain management. After this simple exercise, twelve total themes are left. Within these remaining themes, groups are created based on general similarity into three categories identified through inspection – pertaining to either the (1) structure, (2) function, or (3) value delivery attributes of the enterprise. For the purposes of creating these three categories, the attributes are defined as follows: (1) structure – pertaining to the organizational hierarchies and how different departments interact, (2) function – pertaining to how people within the enterprise

establish relationships and interact to get work done and (3) value delivery – pertaining to how value is created and maximized for a specifically-defined group of stakeholders.

After completing this categorization, the total number of theme occurrences derived from the definition breakdown exercises from Table 2.1 & Table 2.2 is calculated to understand the frequency of each major attribute category. Structure and function each appear a similar amount of times, fifty-seven and sixty respectively, but value delivery only results in thirty-seven occurrences. Although thirty-seven occurrences are certainly a non-trivial amount, also note that two of the academic definitions have themes consistent with the value delivery category: LAI's lean enterprise definition emphasizes creating value for stakeholders, and the Tennenbaum Institute's enterprise definition describes a "goal-directed organization." Results of the exercise are seen in Table 2.5.

Table 2.5 – Groupings of Enterprise Themes from INCOSE & IEEE

(n=total number of theme occurrences as derived from the definition breakdown exercises from Table 2.1 & Table 2.2)

Structure (n =57)	Function (n=60)	Value Delivery (n=37)
Service, Product or Process Based	Information Technology (IT)	Common Visions or Goals
Complex, Integrated Systems or Systems of Systems	Inter-Organizational Collaboration & Partnerships	Regulations, Doctrine and Standardization
Incorporated Businesses, Organizations, Systems or Segments	Intra-Organizational Relationships & Social Dynamics	Value Stream & Supply Chain Management
Environmental & External Factors to One's Sphere of Influence	-	Improve Performance & Efficiency
Organizational Structure/Change	-	-

In order to support these categorical groupings, engineering and management literature is examined to gather an understanding about the novelty of using structure, function, and value delivery attributes to analyze an enterprise. After looking into the literature, it is found that

many researchers either directly or indirectly focus their unit of analysis around any one of these three attributes. However, rarely is it considered to consciously articulate the option to view a problem through one or all of these three distinct attribute "lenses" – structure, function and value delivery.

Although these attributes are commonly used individually, other literature bodies do not necessarily use the same terminology presented here. For example, Edson (2002) declares that "the boundary can be in space and time, as well as other dimensions, such as organizational." Conversely, Brown and Schwab (1984) specifically use the terms "structure" and "function" in their analysis of boundary-spanning activities. However, these authors use them somewhat synonymously, whereas in this analysis they are considered independently. With respect to the attribute definitions presented above, the following similarities are observed: (1) structure is similarly defined as "organization" in organizational sciences; (2) function is similarly analyzed as "processes" in studies of process enterprises and engineering; and (3) value delivery is used in a similar context as in studies of value-based software and systems engineering. This literature comparison can be seen in Table 2.6.

Table 2.6 – Enterprise Attributes as Characterized by a Literature Analyses

Attribute	Literature Equivalent	Field	Context of Literature Usage
Structure	Organization	Management	Organizational evolution over long periods of time (punctured equilibrium). Organizations maintain stability over long periods and short bursts of fundamental change disrupt the stability. Disruption can perhaps cause: centralization or decentralization, or even a structure to change from regional divisions to functional divisions, or vice versa. (Romanelli and Tushman, 1994)
		Management	Organizations arise from one of the four theories of social change over time: life cycle, evolution, dialectic, and teleology. The unit of change can be seen as nested hierarchies – individuals, groups, organizations, populations, or larger communities – changing, adapting or replicating. (Van De Ven and Poole, 1995)
Function	Processes	Management	Organizational redesign often occurs around the core function, with a focus on the culture, teamwork, and the customer. Organizational units should change to accommodate for process despite any intra-organizational resistance. Horizontal and vertical management structures can co-exist in partnership. (Hammer and Stanton, 1999)
		Software Engineering	Processes are seen as methods through which work gets done. Technology, organization, and external factors can all influence whether or not new processes are adopted. (Rifkin, 2003)
Value Delivery	Value-Based	Software Engineering	Value neutral decisions were used when every use case, defect, etc… was considered equally important. As software costs have increased over time, value neutrality can degrade project outcomes. Value-based software engineering needs to track not only cost and schedule, but stakeholder and business value of project elements as well. (Boehm, 2003)
	Systems Engineering Return on Investment	Systems Engineering	System development cost avoided due to the correct amount of planning and systems engineering upfront is a proxy for value. (Boehm, Valerdi and Honour 2008)

Even though there are many distinct similarities between what is found in this chart and how the attributes are defined, there are subtle differences as well. For instance, the analysis in this thesis grouped external factors as affecting structure whereas Rifkin included this theme in the context of process, the proxy for function. This subtle difference is pointed out to note the limitations of using the three attributes – that although for the most part they are collectively exhaustive, they are not mutually independent of each other. Acknowledging this limitation, each of these attributes can still be thought of independently as separate lenses through which one can view an analysis.

To supplement use of these lenses for analysis, it is also emphasized that the importance of considering profit and loss accountability and program completion accountability (Nightingale and Stanke, 2005) for defining structure, function, or value delivery boundaries. In practice, considering profit and loss accountability might affect whether an analysis should be viewed through a structural or functional lens (depending on the enterprise), whereas considering program completion accountability might imply an analysis should be viewed through a value delivery lens. Regardless as to how these factors are viewed, it is imperative that accountability be considered in any analysis to ensure that stakeholders are engaged and recommendations are aligned with strategic actions for improvement. With this comparison of definitions and convergence on common attributes important to both researchers and practitioners, these three critical lenses are elaborated on as the issue of enterprise boundaries is explored.

2.2 Boundaries

The term enterprise is not confined by traditional organizational or inter-departmental boundaries, but rather it encompasses all of the factors that influence an entity and the factors which it can influence. When considering the enterprise as the unit of analysis, three levels are commonly considered: program enterprises, multi-program enterprises, and international enterprises (Nightingale, 2000). After identifying these units of analysis, it is shown how the structural, functional, and value delivery attributes of an enterprise can be used to assist practitioners in bounding problems and identifying critical issues.

A program enterprise is one of the simplest elements of an organization that functions to create a single product, system or service. Programs normally are accountable for cost, schedule, and performance of the end product, system, or service. Such an enterprise could be a multi-billion dollar aerospace industry program like the F-22, or even an automotive program enterprise that would include a brand name like Lincoln or Mercury. An essential distinguishing feature of the program enterprise is that it has one core distinct value stream.

A multi-program enterprise is one that serves to execute multiple programs. Due to the increased complexity, both leadership and enabling infrastructure become increasingly more important at this level. The multiple programs will collectively influence several value streams, which might converge to produce an entire product or multiple parts of a product. Furthermore,

these related value streams might even produce unrelated products in a company's portfolio. Defined as such, Ford Motor Company could be considered a multi-program enterprise due to its vast amount of brands (Lincoln, Mercury, Ford, Volvo, and Mazda) and product lines (within Ford: Mustang, Focus, Escape, Edge, F-150, etc…). This being noted, an individual sub-division of Ford, such as the "light truck" division, could be considered an enterprise itself amongst the bigger multi-program enterprise that would consist of Ford's broader automotive portfolio. A critical characteristic of the multi-program enterprise is that it has profit and loss accountability of the collective programs, which of course each have their own profit and loss accountability.

The largest of boundaries that can be drawn pertain to either a national or international enterprise. An example of an international enterprise is the aerospace industry. This enterprise consists of U.S. aerospace prime contractors and suppliers, and in some cases it consists of international customers and suppliers as well. The concept of the international enterprise is best exemplified in the development of the Joint Strike Fighter (JSF). The JSF is a military strike fighter, also known as the F-35, which is funded by the United States and a coalition of eleven other countries, including: the United Kingdom, Italy, the Netherlands, Canada, Turkey, Australia, Norway, Denmark, Israel, Singapore, and India. An illustration of how these levels of enterprises may be bounded is shown in Figure 2.1.

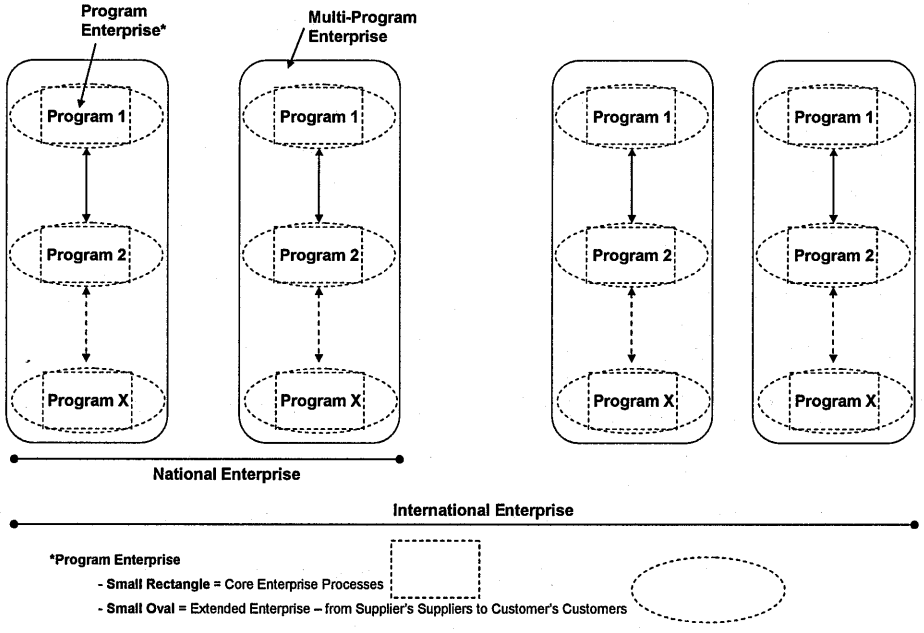

Figure 2.1 – Boundary Levels of Enterprise Research

Within any of these three levels, there is often the distinction between the "core" enterprise and the "extended" enterprise. The core enterprise often refers to seamlessly integrated entities with well articulated terms of collaboration and partnership, whereas more loosely coupled customers, suppliers, government, and entities that might have indirect influence are considered part of the extended enterprise.

Although it is helpful to consider these three distinct units of analysis, bounding an enterprise by viewing it through the lens of one of its critical attributes – structure, function and value delivery – may serve more useful for practitioners. For example, a multi-program enterprise could experience issues that can be best analyzed by looking through one of the three lenses. Structurally, one might consider issues pertaining to bureaucratically constructed hierarchies that cause sub-optimization and could be architected in a better way to facilitate knowledge sharing and improve day to day operations. Functionally, a multi-program might focus on process integration and harmonization to minimize internal waste. Finally, a value delivery analysis might focus on the multi-program strategy, its ability to deliver value to the customer, or even its interactions with internal and external stakeholders. It is important to note that not all views may be necessary for a given problem; the lens chosen may also influence the unit of analysis.

Considering these attributes at different levels of analysis will not always yield similar issues. For instance, within an international enterprise, a functionally-bound enterprise analysis might focus more on how to minimize the effect of cultural differences on communication and process integration. As these examples portray, an optimal way to bound enterprises would be to first identify the unit of analysis, then to consider how the three main enterprise attributes apply within the context. By isolating these attributes, one can begin to understand how manipulating some of the characteristics of an enterprise can lead to better performance. With a method for bounding an enterprise now established, two examples are provided wherein an expansion and reduction in scope of an enterprise has helped clarify the boundary and focus of the analysis.

Example #1: Healthcare Enterprise

In the process of working with a large hospital to investigate causes of bottlenecks in the emergency room (ER), it was determined that there were no beds available (in-patient problem), test results were delayed (laboratory problem), and primary care physicians were slow (primary

care problem). Therefore, the enterprise being studied was expanded from the ER to include in-patient processing, laboratories and primary care organizations since they were critical parts of the analysis (Oliveira and Nightingale, 2007). Moreover, from the initial analysis of the ER, it became clear that there existed a broader array of possible causes than previously considered and it was necessary to include these external stakeholders since they ultimately contributed to the bottleneck problem in the ER.

Initially, there were many reasons for justifying the ER alone to be the enterprise studied – a seemingly independent operational area of the hospital that could benefit from improvement. Suggested simple fixes included the rearranging of workflow to minimize patient wait time and maximize resource utilization, and even the introduction of an electronic medical records system to improve efficiency. Moreover, the improvement of communication between emergency service dispatchers and the hospital would shorten the transition time between medical personnel and improve the accuracy of the data and information shared. Although these solutions seemed necessary for improving conditions in the ER – it became clear that more significant sustainable improvements could be made by expanding the boundary of the enterprise under consideration to account for more departments and stakeholders.

With the broader unit of analysis determined, many stakeholders concerned with ER operations were identified including: patients, physicians, nurses, administrative staff, regulators, etc. Moreover, there were multiple departments considered, to include imaging (e.g. X-rays), pharmacies, cleaning services, etc. In addition to the various groups of stakeholders and departments, there was also a significant flow of materials around the ER that needed to be accounted for – ranging from paperwork and medicine to heavy medical equipment.

From this brief problem description, one can easily see how analyzing the problem from the three critical enterprise attribute lenses could yield meaningful findings. First, from looking through the structural lens, it became immediately clear that each department was unnecessarily isolated from the others – which in turn led to the resource misallocation and communication waste described above. Next, from a functional perspective, it is seen that integrating processes between primary care, labs, primary physicians, and other stakeholders is necessary to avoid sub-optimization. Considering value delivery, it was important to consider the customer's path through the healthcare process and suggest means to minimize waste, to include: improving communication, perhaps by implementing a self-diagnosis process; or rearranging workflow,

perhaps by having more centralized services to patients are not continuously bounced around to differing specialists. Ultimately, by first determining the proper unit of analysis and then examining isolated issues identified through the three critical enterprise attribute lenses the researchers were able to provide valuable recommendations.

Example #2: Military Enterprise

The goal for the analysis of a United States Air Force's Air Logistics Center (ALC) was to assess top-level transformation efforts and provide recommendations for improvement (Roth, 2004). It is common in large organizations for multiple transformation efforts to occur simultaneously, such that clear alignment and a prioritization of initiatives are necessary for success. The ALC was responsible for managing a vast range of inventory for thousands of aircraft, in addition to tens of thousands of jet engines at Tinker Air Force Base in Oklahoma.

To formally analyze the enterprise, the research team used an Enterprise Value Stream Mapping and Analysis (EVSMA) – as an exercise that serves to provide "an integrated framework for diagnosing and improving overall enterprise performance by identifying enterprise-level waste and enhancing the value delivery to each enterprise stakeholder" (Murman, et al., 2002). During the exercise, it was determined that the suppliers were critical to the Air Logistics Center value streams, but the scope of analysis should only involve the ALC as defined by the government. The reasoning for this unit of analysis was based on the assumption that, for the scope of the project it would be best to only include entities within the ALC's direct control in order to effectively begin transformation. Some of these external stakeholders consisted of: prime contractors, other Air Force acquisition organizations (i.e., Air Force Materiel Command), Defense Finance and Accounting Services (DFAS), and other ALCs within Air Mobility Command (AMC). In essence, a broader multi-program enterprise in many respects had to be bound on the program level to achieve the most realistic results.

There were some negative effects to this smaller unit of analysis, the most important of which included reduced potential impact on the supply chain as a whole. It would have been preferable for the team to have influence over the entire value stream – those processes which span from the suppliers' suppliers to the customers' customers (i.e., the extended enterprise). With the project goal being to prioritize current improvement initiatives, it was critical to down-scope enterprise boundaries and focus the analysis at a level where the direct points of contact

within the enterprise could make an impact with their decisions. After the unit of analysis had been determined, examining the problem through the attribute lenses served to reveal some critical suggestions for improvements. First, from a structural perspective it was imperative that the initiatives were being championed at the right level of the organization such that managers had program completion accountability and the resources to follow-up on their decisions. Second, analysis from the functional lens showed that stakeholders needed to engage in better communication and knowledge sharing practices to avoid overlap. Similarly, the value delivery lens analysis showed that by diversifying resources into many uncoordinated initiatives, sub-optimization was occurring and the desired process improvement initiatives were counteracting each other.

To facilitate enterprise change it is always necessary that the engaged stakeholders not only understand their enterprise boundaries and through what lenses to view problems, but also understand what elements of the enterprise they have the proper authority to influence. One does not necessarily have to be at the highest rank in an organization to make decisions that influence the enterprise, rather one can make intelligent decisions at any level in an organization that resonate vertically in an organization or horizontally throughout the value stream. Thus, it is critical to distinguish between "enterprise level" and "enterprise context" decisions.

Enterprise Level vs. Enterprise Context

Enterprise Level perspective is commonly considered to have the potential to directly influence the entire core and extended enterprise. The ability to drive such significant change in an enterprise is often directed by senior leadership, such as a CEO or military Commander; those who have the highest authority of decision making and influence over enterprise operations. However, most enterprise tools and methods have implications that are not only valuable to the CEO – but for other internal stakeholders as well. In fact, most people that engage in enterprise improvement often wonder what exactly they will be able to do to improve their working environment and their organization – understanding the limits of their authority or influence in the organization. Here, it becomes critical for employees to have a sense of "bounded rationality," (Simon, 1991) wherein they understand what influence they have within their organization and are not disillusioned or discouraged from lean progress by cultural monuments that constrain the organization. Although most workers can not directly steer an enterprise by

themselves, they can be empowered to address problems and issues within their environment – in the context of the enterprise. Moreover, managers can instil a culture of enterprise context understanding by clearly communicating with employees about how their day-to-day efforts impact organizational goals and missions.

Enterprise context involves examining an issue in the context of the enterprise and the effects it can have on related areas outside an individual's sphere of influence; this is at the core of having n approach to enterprise transformation. Enterprise context decisions have the potential to affect everyone in the organization, especially when it comes to transforming the way business is done.

Once the bounds of an analysis have been determined and one has begun to dissect their unit of analysis from each of the three lenses, quantitative data is desired to support ensuing decisions, whether the conclusions are intuitive or not. Regardless of the level of an enterprise at which the aforementioned decisions are made and actions are executed, decision makers desire simple yet meaningful metrics to support their quantitative analysis – that is metrics that accurately describe the state of the enterprise and provide the proper amount of information to support the decision making process. With regards to enterprise level metrics, the decision makers are often higher level executives who can make an impact because of their authority to influence actions, initiatives and behaviors. One of the most common examples of enterprise level metrics used by these higher level executives can be seen in the balanced scorecard (Kaplan and Norton, 1996). The balanced scorecard metrics have four critical categories:

- financial, how the company is satisfying their stakeholders and creating profit;
- internal processes, understanding the operations of the enterprise and improving work that is done;
- learning and growth, pursuing continuous improvement and the creation of value; and
- customer perspective, how customers perceive the enterprise and the value that is delivered to them.

These high-level categories depict the current health of the enterprise by considering some traditional descriptive metrics – financial and processes related metrics. Also, the balanced scorecard portrays the future potential of the enterprise by considering some leading indicators – learning and growth, and customer perspective metrics. Leading an enterprise from the

descriptive state towards the future state, executives need to consider decisions impacting all four balanced scorecard categories. By being cognizant of all four categories executives can prevent sub-optimization and avoid focusing on metrics in one area of the scorecard at the expense of another. It is also argued that these high-level metrics support the lenses of analysis as well, wherein: (1) structural effectiveness can be seen through process efficiency, (2) functional effectiveness can be analyzed by considering the level of learning and growth occurring amongst employees and between business segments and (3) value delivery can be measured through both financial success and customer satisfaction metrics.

Unlike enterprise level metrics that are common knowledge to most executives and stakeholders within an enterprise, metrics that demonstrate the impact of enterprise context decisions are less understood. Enterprise context metrics are important since decisions can be made at lower levels of an organization that also serve to attain results that positively affect the enterprise and its bottom line. Just as high-level executives have metrics that describe the health of the enterprise as a whole, mid-level managers need metrics that depict the health of their department or function that consider its interactions with the rest of the enterprise. For example, encouraging and measuring product commonality within a department could have significant benefits to the entire enterprise – such as optimizing flexibility of operations and resource utilization amongst other factors. This metric is within an enterprise context because it not only influences operations within a department, but it also synergistically impacts the operations of other horizontal levels and can resonate vertically throughout the enterprise to maximize results. Furthermore, this metric would support a functional lens analysis since it portrays how a characteristic of one business segment could help improve the functionality of other segments as well. To the contrary, capacity utilization might be considered a metric that is not relevant within an enterprise context because it only pertains to the efficiency of a single isolated department and does not have a direct relationship to corresponding vertical or horizontal departments or processes within the enterprise. When all levels of an organization appreciate practical enterprise decisions, the positive implications can be significant for the entire enterprise.

2.3 Practical Implications

Enterprise analysis of an organization has a number of implications for researchers and practitioners, which can now be discussed since three main background topics have been discussed: (1) the context of enterprise research; (2) how to bound an enterprise and perform an analysis through attribute lenses, and (3) how one can use metrics to support decision making from an enterprise level or enterprise context perspective. The implications for researchers provided here are drawn from LAI's experiences studying enterprises in the aerospace and healthcare domains, whereas the implications for decision makers are drawn from a survey of graduate students participating in MIT's "Integrating the Lean Enterprise" class in the Fall Semester of 2007. Before understanding these implications, it is important to discuss the research landscape with enterprises as the unit of analysis.

Doing Research with Enterprises as the Unit of Analysis

As discussed earlier, the process of defining the boundaries of an enterprise is a critical step in defining the unit of analysis and the three lenses – functional, structural and value delivery – can aid in identifying the boundaries of an enterprise. Using the enterprise as the unit of analysis is similar to the field of sociology which involves the study of societies, including patterns of social relationships, social interaction, and culture. However, it differs in that the study of enterprises as systems takes on a socio-technical perspective, which is centered on the joint optimization of the social and technical parts of an organization (Cherns, 1987).

Having the enterprise as the unit of analysis also defines the "laboratory" setting in which hypotheses are tested and experiments are performed. Unlike controlled environments common in biology and chemistry, it is impossible to perform double-blind placebo-controlled experiments on a large sample of enterprises. Their size, complexity, and inherent links to their surrounding environment (i.e., global economy, government policy) make this a difficult task. However, there are several research approaches from fields such as management and psychology that help make sense of enterprises. One approach is to combine quantitative and qualitative methods – commonly referred to as mixed methods – to study enterprises. Another approach is to focus on an individual enterprise – or single case study – to understand successful or unsuccessful strategies.

These approaches differ from the traditional industrial engineering or systems engineering paradigms, which tend to be reductionist in nature by analyzing systems purely from a technical perspective. The study of enterprises requires multidisciplinary approaches that span across engineering, social science, and management. LAI's experience working with different types of enterprises has shown that certain research questions warrant specific skills. For instance, the study of how individuals within an enterprise think about change requires top-down analysis when determining how managers should best inject process improvement. It also requires bottom-up thinking when studying how employees accept and adapt to change. Another example involves the study of process commonality across different business units within an enterprise. This requires horizontal thinking to examine how different groups adapt their processes to integrate to proposed enterprise-wide process standards. Finally, systems thinking becomes critical when the dynamic nature of organizations is of interest. The interaction between contractors and the multiple levels of suppliers should be treated as a network of complex enterprises, much like the world of system dynamics.

Implications for Decision Makers

In order to gauge the impact of enterprise-level analysis, a focused survey was administered to 53 graduate students participating in the "Integrating the Lean Enterprise" course at MIT. In general, the objective of the course was to teach lean enterprise integration concepts that could be used to assist an organization to undergo the transformation of an enterprise with the help of established methods and analysis tools. Since these students will be better versed in understanding lean principles than practitioners, it was determined that this sample was representative of future middle-level managers and senior-level managers. Moreover, most all of the students have multiple years of experience in a wide variety of industries (i.e., health care, military, information technology, etc…) – which helps ensure the responses are not biased towards a particular industry or subset of stakeholders. These students were all exposed and versed in both: (1) the practice of bounding an enterprise for a thorough analysis; and (2) considering appropriate enterprise level or enterprise context metrics that help align an enterprises processes, strategic goals and stakeholder values. The two questions posed to the students were:

Based on the enterprise theories, frameworks, and tools learned in the class;

(a) Describe <u>two</u> ways in which you would do your job differently in the short term?

(b) *Describe <u>one</u> short term and <u>one</u> long term decision that you would make differently if you were CEO or commander of a large enterprise. Cite the reason(s) why these decisions changed as a result of the material learned in class.*

<u>Doing your Job Differently in the Short Term</u>

With regards to the first question, four underlying themes were prominent in the response: (1) more effective use of metrics, (2) increased focus on stakeholders, (3) value stream mapping, (4) identification and elimination of waste in conjunction with the proactive pursuit of continuous improvement.

Additionally, the comments highlighted the importance of communicating with peers and senior leadership, as well as the significance of embedding lean principles and aligning strategic objectives throughout the enterprise. The most representative comments from the four themes listed above are shown in Table 2.7.

Table 2.7 – Representative Comments: Doing your Job Differently in the Short Term

Themes of Short Term Change	Most Representative Comment from Survey
Effective use of Metrics	*"Think constantly about the metrics I am using to measure success, to confirm they are measuring the delivery of value to the customers."*
Focus on Stakeholders	*"Focus on understanding what each stakeholder values and make that a priority. Create feedback loops to understand if I am meeting these needs."*
Value Stream Mapping	*"Define and map the value that is delivered as a result of the enterprise in which I am engaged, chop activities that did not directly contribute to the delivery of value."*
Elimination of Waste	*"The EVSMA will enable me to have clear visibility of all steps in a process and therefore to easily identify waste or muda[1] steps and eliminate them – saving time and cost which is the main objective of the lean enterprise."*

The consistency of results from this focused survey confirms the importance of these four high-level themes. The use of metrics – emphasized by relating them to key processes, stakeholder values, and strategic objectives – will be on the forefront of these students' minds for aligning efforts within organizations and gauging their successes. Instead of being near-sighted and focusing on one's own department, considering and satisfying the needs of all stakeholders

[1] Muda is the Japanese term for "waste," as used in lean manufacturing and agile software development.

in a cooperative manner will bring about greater long term success and promote enterprise growth. Value stream mapping is not only an exercise that helps people to understand their role and how they contribute to their enterprise, but also promotes innovation for improving processes in revolutionary ways. Lastly, by constantly identifying waste, one can become more efficient and focus on what really matters to the enterprise: providing value to stakeholders.

Leading your Enterprise Differently in the Short & Long Term

Many of the responses pertaining to the second question of the survey embodied the same themes from the first question. The short term focus given by most students, as a new leader of an organization, included: (1) understanding and streamlining the value stream, (2) ensuring metrics were value oriented and aligned organizational performance and (3) the instillation of lean awareness in the enterprise culture.

In addition to distinguishing between enterprise level and enterprise context decisions, one of the principal aims of the second question was to identify critical decisions or actions that could yield long-term benefits through continued leadership support. The common themes that arose pertained mostly to improving the culture of the organization, relationships between all stakeholders, and long term continuous value stream improvement. The most representative comments from these three main themes are shown in Table 2.8.

Table 2.8 – Representative Comments: Leading Differently

Themes for Leading Long Term Change	Most Representative Comment from Survey
Culture	*"Establish more cross-functional teams that will increase the learning and communication across departments. This will help break down functional silos and help the organization in the long term."*
Stakeholder Relationships	*"Restructure offices and boundaries to better facilitate flow, and connect better relationships with customers and suppliers."*
Continuous Improvement	*"Think about value exchange, identification, proposition and delivery for every interaction with a stakeholder. This will help in reducing waste and unnecessary cost and process involvement. This is a model of continuous and adaptive lean implementation."*

For leading long term change, the survey responses made it clear that there are significant challenges to face with regards to the culture in an enterprise and the relationships between stakeholders. It is a well known assumption that enterprises have momentum and resist change, hence transforming a culture and a way of doing business was prioritized as a long term

investment rather than a short term goal. Also emphasized in the comments about culture was the need to increase learning and communication, such that cultural change is not forced but rather occurs naturally by enlightening the work force. In terms of long term stakeholder relationships, the focus of this improvement involves integrating operations and transparency within the value chain – from the customers' customers to the suppliers' suppliers. Although one can treat stakeholders right and identify their needs in the short term, as previously discussed, integrating their needs for long term enterprise improvement requires a greater level of devotion, communication, and behavior on everybody's behalf. Lastly, value stream focus was reiterated as a long term goal with the recognition of continuous improvement – that there is always a way to make one's enterprise perform better. Not becoming complacent is critical to maintaining success against competitors and maximizing value delivery.

The results from both questions highlighted the importance and implications of enterprise level research. Even though many of students who took the survey might not become the CEO or Commander of their respective organizations, the impact that these individuals will have on their enterprises will be of a significant magnitude in light of their ability to understand decisions within an enterprise context.

Although this survey reveals critical short-term and long-term implications for practitioners, it is suggested that without an appropriate framework for conducting an enterprise analysis such insight would be difficult to benefit from. Hence, this enterprise research analysis can assist future practitioners by (1) teaching them how to consider the context of enterprise research and (2) providing them a methodology for bounding and analyzing an enterprise as a unit of study based on its three critical attributes.

2.4 Enterprise Research Conclusions

The discussions on enterprise definitions, boundaries of enterprises, and the practical implications of treating enterprises as systems are aimed at providing a foundation for future study of enterprises and understanding the phenomenon of enterprise transformation. Ultimately, there are three important steps that guide decision making in the enterprise analysis: (1) decision makers need to define their enterprise and the context in which their decisions will be based; (2) decision makers need to establish an appropriate boundary for their problem, and

then analyze the enterprise level and enterprise context interactions within this boundary, which can be accomplished by using the three attribute lenses – structure, function and valued delivery; and (3) decision makers need to predict the practical implications of their actions as either leaders or middle managers, in both the short- and long-term. These three decision making steps emphasize that enterprise thinking is not limited to executives in corner offices, but it can also be an invaluable tool for any individual to spearhead change within their own sphere of influence. With this extensive background understanding moving forward, these three decision making steps and especially the critical attributes for enterprise analysis will be used in both measurement case study analysis and in recommendations for metric considerations in the transformation roadmap.

Chapter 3

Metrics Research – A Literature Review

The focus of this section is to depict the vast landscape of literature related to metrics and enterprise performance measurement in a concise and comprehensible manner for researchers and practitioners. Primarily, the enterprise is used as the unit of analysis and measurement systems are considered from the perspectives of stakeholders at all levels. To illustrate this evolution of measurement knowledge over time, the effects of metrics from three distinct viewpoints are discussed: (1) selecting the right metrics, (2) creating and implementing measurement frameworks; and (3) metrics for decision making.

First, the idea of selecting the right metrics is explored. In order to develop a common grounding, the concept of measurement and fundamental problems individuals and organizations face regarding measurement are expanded on. This discussion focuses around common mistakes and metric selection methodologies, considering respective implications on individual behavior. An example from professional baseball to demonstrate how thinking creatively can ensure metrics correspond to value added activities and increase human productivity is provided.

Second, the creation and implementation of measurement frameworks is discussed. Attributes of macro-level frameworks such as Kaplan and Norton's Balanced Scorecard presented in Chapter 1 will be compared with other complementary approaches (Kaplan and Norton, 1992). The many classifications of these frameworks are also discussed, from "traditional" to "contemporary" systems, considering "structural" and "procedural" models, understanding temporal aspects, and identifying unique challenges and benefits from a case study of a micro (bottom-up) measurement system implementation.

Third, the role of metrics in decision making is evaluated. In particular, how to use metrics with imperfect information is considered. To supplement various academic viewpoints provided, a practical discussion is provided regarding guidance for decision makers for focusing on the right problem and dealing with imperfect information – contextually relevant for managers.

This section is not intended to be collectively exhaustive, but indeed makes a point to articulate readings relevant to each section that one can consult for further information. In considering metrics selection, implementation and decision making there will never be a silver bullet – "a single development, in either technology or management technique, which by itself promises even one order of magnitude improvement in productivity, in reliability, in simplicity" (Brooks, 1995). The practical implications of all three metric subjects are highly dependent on a variety of factors, to include but not limited to: the maturity of an organization and their processes; top-down or bottom-up measurement system implementation; the industry being considered; the unit of analysis, such as people or business units; and the perspective taken during measurement. The principles and conclusions discussed in this chapter will be depicted universally such that they can be applied in any context. For a brief overview of the literature discussed, Figure 3.1 provides a rough correlation regarding how select representative readings fit into each subtopic. This figure is relevant to how the work is discussed in the text of this chapter, and should not be considered a complete classification of the work in question. Moreover, to supplement the literature breakdown, metaphors and practical implication examples are given where appropriate.

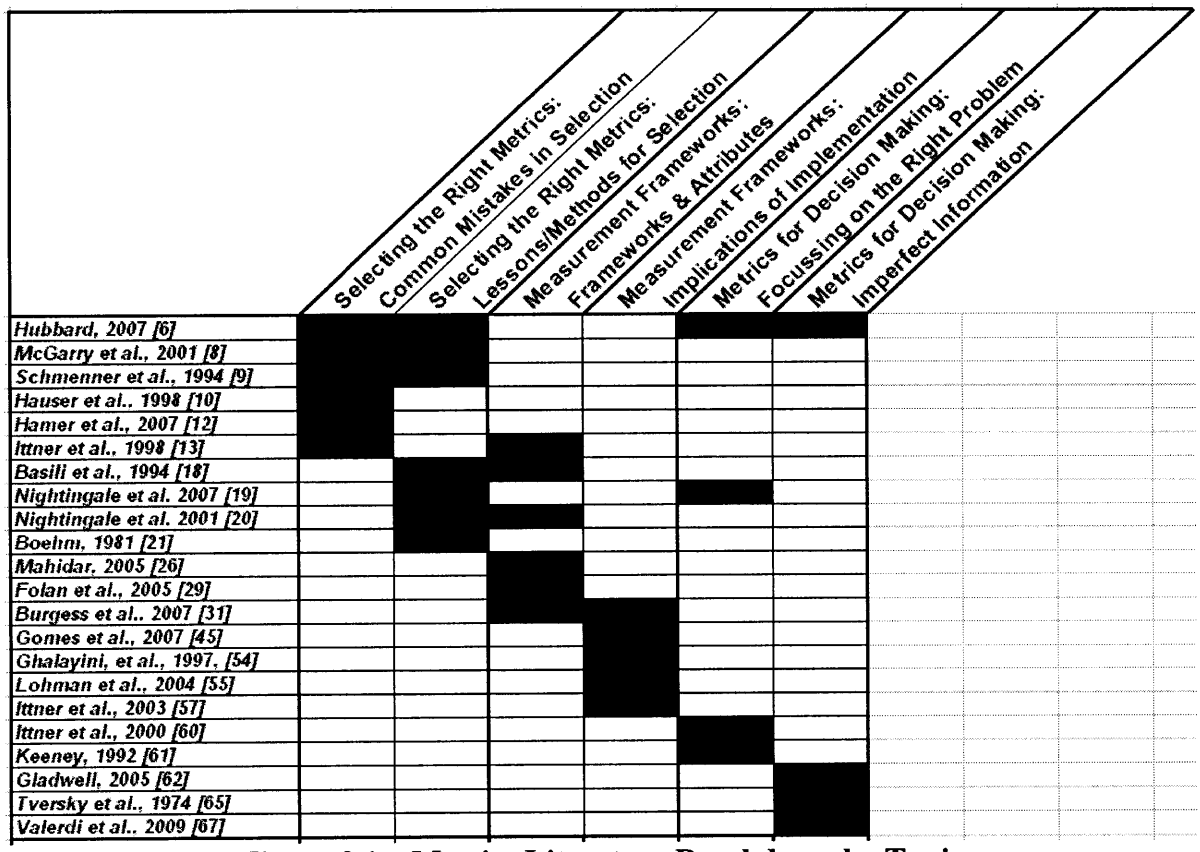

Figure 3.1 – Metrics Literature Breakdown by Topic

In the selection of these literary sources, works were chosen that emphasized macro-level measurement and works were excluded that focused on individual people or tasks. Different disciplines were drawn from, including: operations management, software engineering, aerospace engineering, product development, economics, accounting, etc. Within these disciplines influential papers and books were identified that provide fundamental ideas about performance measurement that could be generalized to other contexts.

3.1 Metric Selection

A great wealth of research has been performed on selecting the right metrics and behaviors that metrics will encourage. The importance of metrics is a topic that has been studied for over half of a century, dating at least as far back as 1956, when *Administrative Science Quarterly* published two articles about concerns with dysfunctional responses to performance measurement (Kelman et al., 2007; from Berliner, 1956; and Ridgeway, 1956). Currently,

research on this topic has spread throughout many industries and a mature body of knowledge has been developed. This section consolidates much of this research and identifies some critical lessons that can be generalized for any industry of interest. First, one needs to define what exactly a metric is. According to Hubbard (2007), a metric can be defined as an *observation that reduces uncertainty wherein the result is expressed as a quantity.* Thus, traditional manufacturing metrics such as cycle time and defect density are considered as well as more abstract concepts, such as culture and employee involvement. Similarly yet more formally, Kitterman (2005) defines a metric as a *quantified value of an attribute, obtained by the process of assigning numerical values to attributes, which is compared to what is expected.* Furthermore, McGarry et al., (2001) considers a measure *the objective data collected to fulfill the information needs of the manager.* The similarity between these definitions is that one is quantifying attributes in support of decisions.

There are many popular heuristics that authors employ to concisely articulate fundamental key principles of metric selection. For example: Schmenner and Vollmann (1993) identify the old adage "What gets measured, gets managed;" the well known Kaplan and Norton (1992) Balanced Scorecard claim's that "What you measure is what you get;" and Hauser and Katz (1998) state that "You are what you Measure." The general point is that these heuristics have repeatedly shown that metrics drive behavior in people. Ultimately, these simple heuristics are combined with lessons from previous literature to provide: (i) common metric selection mistakes; (ii) methods for metric selection; and (iii) how metrics relate to value identification.

Common Metric Selection Mistakes

Picking the wrong metric is easy. In the most rudimentary manner of expressing this measurement problem, many reward certain actions while hoping an unrelated and often contradictors results (Kerr, 1995). For instance, in professional sports if a player has incentives built into his contract where he gets bonuses based on the amounts of points he scores alone, that player is thus encouraged to be selfish and hence will diminish the potential of the overall team as a system. The same is true for performance metrics in education – wherein awarded grades influence employment, higher learning, tuition reimbursement and parental respect – yet those who award grades are trying to fulfill the goal of knowledge transfer from teacher to student (Kerr, 1995). Similarly, professors are expected to pursue excellence in teaching yet are

rewarded on publications (Kerr, 1995). In addition to not considering the consequences of a metric on human or system behavior, a collection of prominent performance metric mistakes has been articulated in an array of literature, in a non-exhaustive list identified below.

1. *Not using the right measure (ignoring something important) or choosing metrics that are wrong (i.e. for a phone help service, customers don't just want quick answers, they want accurate ones as well) (McGarry et al., 2003; Schmenner et al., 1994; and Hauser et al., 1998).*
2. *Having metrics reflect functions as opposed to cross-functional processes (Hammer et al., 2007; and Ittner at al., 1998).*
3. *Assuming one knows what is important to measure without giving enough thought or using measures that intentionally make you look good (Hammer et al., 2007).*
4. *Measuring only a part of what matters, measuring from your view rather than the customers, or forgetting your goal (Hauser et al., 1998; and Hammer et al., 2007).*
5. *Implementing metrics that focus on short-term results, or that do not give thought to consequences on human behavior and enterprise performance (McGarry et al., 2001; Schmenner et al., 1994; Hauser et al., 1998; Kerr, 1995; Hammer et al., 2007; and Ittner et al., 1998).*
6. *Having metrics that are not actionable or hard for a team/group to impact or collecting too much data (McGarry et al, 2001; Hauser et al, 1998.; and Ittner et al., 1998).*

Making any of these critical mistakes could counteract any good intention of standing-up a metric. From inspection of these common mistakes, three simple themes emerge: (1) measuring correct and complete value added activities, not just easy to measure attributes; (2) considering the effects of standing-up a metric on individual and team behavior – how they will respond to the metric in the absence of management intervention; and (3) fostering a culture of commitment to measurement and cross-company collaboration. This breakdown is deconstructed as follows (numbers corresponding to the measurement mistakes list above).

- Value Added
    - {1} – Ignoring Something Important
    - {4} – Measuring only part of what matters
- Behavioral Effects

- {5} – Not considering effect on humans
- {6} – Hard for a team/group to impact

- Commitment
  - {2} – Company boundaries dictate metrics
  - {3} – Not being serious about measurement

The implications of falling victim to these common metric selection mistakes can be quite profound. First, not measuring correct and complete value added measures effectively can lead to sub-optimization. It is important not to measure because you can, measure because it helps inform decision making about activities that add value to your company, your suppliers, and your customers. As an example, one can easily think too narrow and only measure part of what matters. In baseball, if a team measures only power maximization because it helps offense and fans enjoy homeruns, production may suffer as players become less agile and cannot steal bases or run as well. Even though teams may not openly emphasize it as much, they also need players that can run the bases fast and play great defense. Thus, when considering signing a player all these attributes need to be taken into account, not just power or easily measurable factors. Similarly, there are many interdependencies that cannot be ignored in all professions, thus one needs to ensure metrics are aimed measuring correct and complete value added activities.

Second, with respect to implementing metrics that actually cause the individual and behavioral effect desired, consider the example from professional sports. Understand that if rewards are risky (pay for individual as opposed to team performance), counter-productive behavior will become the norm. Conversely, if you attempt to reward a team on a factor that is hard to control – like if a team rewards a player only based on cumulative team performance – the player will not be motivated to succeed since they will understand their individual efforts have a negligible causal relationship to their potential for reward. Thus, the problem lies in determining optimal metrics that that link an individuals' contribution to team success. Baseball's statistician guru, Bill James, sought to quell this dilemma with the creation of "win shares" – a complex metric derived from both traditional and non-traditional metrics that together contribute to portraying a players' contribution to team performance (James, 2002).

Third, not being committed or serious about measurement can lead to disaster. If one uses metrics designed to make people look good, real problems will not be exposed until it is too late to address them. It would be naïve for managers to assume they know with absolute certainty what is right to measure, as they should constantly seek feedback from their regarding how metrics are affecting both behavior and enterprise performance. Furthermore, if traditional organizational boundaries dictate performance metrics and these factors are never audited, the true value of the selected metrics will be compromised. For example, baseball scouts traditionally measured talent by raw speed, power, and gut feeling (Lewis, 2004). A significant cultural movement was needed for industry analysts to think outside the box to reconsider metrics and value, an example that will be revisited later in this section.

Metric Selection Methodologies

Aside from avoiding these common pitfalls and mistakes, other broad criteria for metric selection has been proposed as well. Nightingale (2007) offers that metrics need to be: strategic, to align behavior with company objectives; quantitative, to provide understanding of progress towards these objectives; and qualitative, to provide organizational understanding as to how the metric is valuable. Implicit in these criteria is also the need for metrics to be actionable, thus a performance measurement system needs to help depict what needs to be done and by whom. Further, performance measurement systems should show that one is doing the right job (meeting stakeholder requirements) and doing the job right (being economically resourceful) (Nightingale, 2007).

Implementing these broad criteria and recommendations is often easier said than done, as often portraying a metric's value to employees or measuring intangible factors presents hurdles. In addition to the identification of the common measurement mistakes and criteria for effective metrics, research has been performed to identify some of the most over-measured and under-measured phenomenon in organizations. Schmenner & Vollmann (1994) performed a study across senior manufacturing executives to analyze which of the twelve items of greatest interest to them were over-measured or under-measured. Ninety-two executives rated how important they thought each measure was for long-term success and then articulated the degree to which current performance measures were either inhibiting or supporting them as summarized in Table 3.1.

Table 3.1 – Commonly Over-Measured & Under-Measured Metrics Relative to Importance on Long-Term Performance (Schmenner et al., 2004)

Under-Measured	Equal	Over-Measured
Employee Involvement	*Integration with Customers*	*Machine Efficiency*
Customer Satisfaction	*Overhead Cost Reduction*	*Labor Efficiency*
New Product Introduction	*Volume Flexibility*	*Direct Cost Reduction*
-	*Throughput Times*	-
-	*Quality*	-
-	*Computer Systems*	-

As one may have guessed, the most under-measured factors for long-term success are "softer" or more intangible metrics. Conversely, the most over-measured factors are those that are, albeit arguably, easier to measure. This important assumption leads to one main question – why are we not measuring these factors? Hubbard (2007) provides some insight to this question. First, he recalls from his experiences that often "costs are measured more than the more uncertain benefits" and "small 'hard' benefits are measured more than large 'soft' benefits." Moreover, the author identifies some common rationales given for under-measurement (or not measuring), including: measurement being too expensive, or perhaps that the resulting statistics would not be useful enough to support decision making. To these objections, four basic assumptions influence the measurement of "softer" factors: (1) your problem is not as unique as you think;" (2) you have more data than you think; (3) you need less data than you think; and (4) there is a useful measurement that is much simpler than you think. Considering the factors themselves, he adds "if it matters at all it is detectable and observable," "if it is detectable, it can be detected as an amount," and "if it can be detected as a range of possible amounts, it can be measured" (Hubbard, 2007). Taking this advice, some common methodologies are explored to assist with the problem of metric selection.

Given the common mistakes and intangible nature of some critical under-measured long-term success factors, the next question is: how does one choose the most appropriate metric? Some of the general guidelines proposed for metrics selection relate to the common mistakes discussed above. Although many researchers and practitioners converge on the appropriate steps for metric selection, different delivery styles exist. A sample of previously identified metric

selection methodologies can be seen in Appendix A. As a generalization extracted from inspection of Appendix A, there are four critical steps for metric selection, seen in Figure 3.2, and expanded upon below.

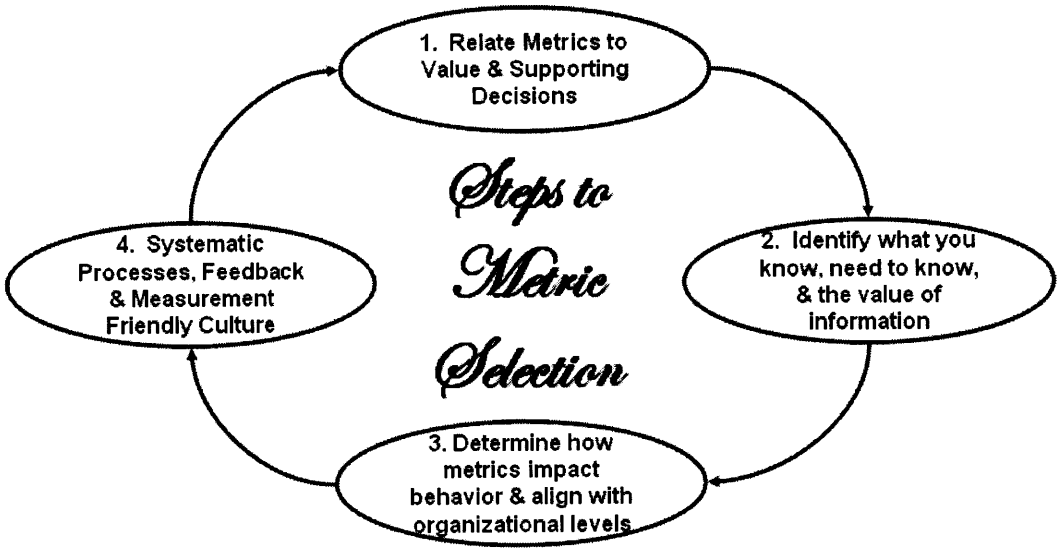

Figure 3.2 – The Steps to Metric Selection

Step 1: Identify what you are trying to measure, the decision it is trying to support, and how it is part of a greater purpose. This is the first step in identifying the right metric is one which helps avoid the aforementioned mistake of not relating metrics to value added activities. In this step, one needs to identify the stakeholder, their needs and consider how the metric will support the decision making process. Moreover, one needs to identify what decision the metric will support and how strongly it relates to a fundamental core goal, such as customer satisfaction. Some systems and software engineering measurement communities have endorsed Vic Basili's Goal-Question-Metric (GQM) approach to identify metrics, wherein you: (1) *identify the information goal* stakeholders want to know and why, working top-down, including organizational and project goals; (2) *ask the question* that will aid in evaluating if the goal is being met; (3) *determine the measures* that need to be gathered to collect information to answer the question; and (4) *apply* the selected metrics and *evaluate* their usefulness (McGarry et al., 2001; and Systems, 1998; from Basili, 1994). Similarly, LAI's Enterprise Strategic Analysis for Transformation (ESAT) X-Matrix tool compliments and could add more structure to using this

method, as it requires stakeholders to formally document links between metrics, strategic objectives, stakeholder values, and key processes (Nightingale et al., 2008).

Step 2: Determine what you know, and what you need to know - the value of unknown information. Now that you have defined the selected metric, one needs to determine how much information they actually know that can reduce uncertainty. Then, consider how much information needs to be acquired to optimize the decision making process relative to the cost of gathering it. Hubbard (2007) provides a step in his methodology that accounts for this need: determine the value of information – the consequences of being wrong and the chance of being wrong, evaluate what degree of measurement effort is justifiable. Another perspective regarding value of information decision guidelines comes from Boehm (1981), wherein five conditions are identified under which it would make sense to investigating alternatives prior to committing to a course of action (Boehm, 1981).

1. There are alternatives whose payoff varies greatly, depending on some critical states of nature.
2. The critical states of nature have an appreciable probability of occurring.
3. The investigations have a high probability of accurately identifying the occurrence of the critical states of nature.
4. The required cost and schedule of the investigation do not overly curtail their net value.
5. There exists significant side benefits derived from performing the investigations.

Boehm (2002) adds that one method of comparing risk exposure (RE) mitigation alternatives is by using risk reduction leverage (RRL) techniques. Using this method of comparison, alternatives are evaluated quantitatively by taking the difference between risk exposures before and after pursuing an alternative, and dividing this term by the implementation cost of the alternative, seen in Figure 3.3. Thus, the higher the risk reduction leverage value of an alternative, the more attractive it is since risk is reduced most efficiently relative to cost.

$$RRL = \frac{RE_{BEFORE} - RE_{AFTER}}{RISK\ REDUCTION\ COST}$$

Figure 3.3 – Risk Reduction Leverage Equation (Boehm, 2002)

Step 3: Understand who is impacted by the metric, and how it aligns vertically with different levels of the organization. This step is associated to the mistake of not considering how metric selection will affect individual or group behavior, but is more encompassing on an enterprise level. For example, not only does one consider the impact of the metric on individuals and groups, but it is also necessary to ensure the company's values are aligned to its customers' and suppliers' values. Moreover, metrics that are selected should be aligned vertically in the organization as well, relating incentives for factory floor level workers to core company goals.

Step 4: Have a systematic process and a measurement friendly culture; evaluate timeliness of information, quality, and whether or not the system has working feedback. This final step relates to the issue of not being serious about measurement and provides insight into implementation. In addition to collecting and disseminating metric information in a timely fashion, there needs to be an active feedback loop to ensure that when change occurs it is depicted in the metric. One method for method for considering this step would be with a thermostat approach, wherein periodic feedback informs management which metrics to emphasize based on the enterprise's current performance and where historical data dictates they need to be to ensure short-term and long-term success (Hauser, 2001). When this approach is applied correctly, managers and employees can constantly be focusing on only a few metrics, those which are easiest to manipulate to improve profitability. With a culture that is cognizant about the value of a metric and proactively seeking improvement, one can optimize their chances of success at metric selection.

Identifying Value with Metrics

Metric selection is important in many aspects, from one's personal life to their work life. Despite the varying contextual nature of metric selection, proper execution of the first step – identifying what you are trying to measure and ensuring it related to value added – is most paramount for success. Blackburn and Valerdi (2008) provide an example from professional baseball that articulates the need to define value appropriately, understanding that traditional industry-accepted metrics are not always the most appropriate.

The example provided stems from Michael Lewis' book *Moneyball* (2004) – a story depicting one of the most over achieving baseball teams of all time, the Oakland Athletics, and their methods for success (Lewis, 2004). These methods stem from the value system

implemented by their General Manager, Billy Beane. In professional baseball, measures of performance historically were based on what was easiest to measure, essentially the individual's sole contribution to run production in the form of runs, hits, homeruns, and batting average. Beane viewed baseball's performance metrics much differently, as he saw the offensive potential of the team as dependent on an integrated system wherein everyone had to do their part to manufacture runs – in an assembly line fashion. Starting from scratch, Beane's first step to metric selection was to understand what fundamental metric could embody the maximization of team scoring potential. Given that an offense in baseball can be limited only by outs (events), rather than time – Beane emphasized the need for his offense to *not get out,* and thus he was one of the first managers to use more holistic performance metrics that were in-line with the eventual goal of team victories (predicted by walks, on base percentage, slugging percentage, not getting caught out on the base paths, etc..).

Even though this example may seem somewhat unusual, it reinforces the need for one to first explore the problem space before moving to the solution and understanding value before determining the metric. Concluding, one critical lesson learned from this example is that if traditional organizational boundaries and mechanisms do not facilitate value identification, you can't be afraid to go against the grain and be the Billy Beane of your organization.

3.2 Measurement Frameworks

Although value identification and the steps to effective metric selection provide valuable insight, many have taken these established principles one step further and created measurement frameworks – more detailed models for guiding metric collection through implementation in the decision making process. Fundamentally, a measurement framework can serve two purposes within an organization, to measure and to motivate (Mintzberg, 1979). Considering these factors, most frameworks are as concerned with aligning efforts and influencing behaviors (motivating) as they are about determining the as-is state and the trajectory of the organization (measuring or monitoring). In addition to these roles, Mahidar (2005) adds that a performance measurement system serves three additional needs, all five listed below.

- Monitor: measure & record actual performance.
- Control: to identify & close the gap between target & actual performance.

- Improvement: to identify improvement opportunities.
- Coordination: determining information decision makers need (leading indicators) & facilitating both internal communication (across processes) as well as external communication (amongst stakeholders).
- Motivate: Align behavior & encourage transformation.

Different from measurement selection, measurement frameworks have their own unique and contextual attributes that need to be considered for implementation, as there is no one size fits all solution. Comparable to literature regarding metric selection, the field of identification and discussion of metric frameworks is highly oversaturated. Many classical macro-level approaches to performance measurement use an interrelationship of performance criteria, such as the seven depicted in the Sink and Tuttle (1989) model (Rolstadas, 1998; from Sink et al., 1989).

- Effectiveness: right job at the right time.
- Efficiency: resources consumed.
- Quality: throughout the enterprise perspective.
- Productivity: ratio of output to input.
- Work Life Quality: needed for performing systems.
- Innovation: to sustain and improve performance.
- Profitability/Budgetability: the ultimate goal.

Other methods used for deriving performance measurement frameworks involve breaking top business process into groups – such as (i) primary processes, (ii) support processes, and (iii) development processes – and then nesting detailed metrics within each category (Rolstadas, 1998). Another common derivation of this performance measurement categorization style has been to segregate economic considerations from the rest of the system – perhaps by using (i) economic factors, (ii) external relations, (iii) internal relations, and (iv) ability to change – as primary corporate analysis units (Rolstadas, 1998). Common issues practitioners often incur when evaluating their performance measurement system pertain to either configuring a typology for performance measurement management similar to those above, or vertically linking performance metrics to value and corporate strategy.

Considering these common issues, many disciplines draft their own professional guidelines to forge communities with specialized contextual knowledge. For example, to synthesize the most relevant concepts in the field of systems engineering, the INCOSE Measurement Working Group prepared the Systems Engineering Measurement Primer (1998). This primer serves as an introduction to the process of how to consider metrics from the more focused lens of the systems engineering practitioner. Thus, this section provides a brief look into: commonly used cross-disciplinary measurement frameworks and their respective attributes.

Measurement Frameworks & Attributes

Performance measurement frameworks can help an organization determine measurement boundaries, direct measurement dimensions or views, and provide insight regarding relationships amongst the performance measures themselves (Rouse et al., 2003; from Folan et al., 2005). Burgess et al. (2007) performed an extensive literature review within the field of performance measurement discussing the difference between "traditional" and "contemporary" performance measurement systems – wherein the eventual shift was generated by the desire of many to move away from older financial-based measures in favor for more balanced systems that incorporate an array of non-financial metrics (Burgess et al., 2007). Other research suggests that popular high-level financial metrics such as return on investment capital can be used to compare a company's overall strategy to net income, but concedes that this metric (and similar financial ones) is often inappropriately applied to evaluate project performance or employee appraisal (Kessler et al., 2003).

Similarly, some research supports this suggestion and notes that aggregate financial-based metrics (such as economic value added) fell out of favor with many operational decision makers for a variety reasons, notably: they are too complex, they provide little or incomplete information on key drivers of future performance, they make it difficult to consider softer metrics like human or intellectual capital, and they often do not correspond to shareholder return as hoped (Ittner et al., 1998). Generally, human capital and softer metrics are associated with higher performance when an enterprise's strategy is market differentiation based, the product line is complex, the environment is uncertain, the industry is knowledge based, or core human capital is scarce (Huselid et al., 2003). Since most industries are faced with some combination of

these factors, non-financial performance measures will be relevant in most measurement contexts.

Noting this objection to financial measurement and the existence of other objections, it is acknowledged that non-financial measurement systems are not without flaw. Many opponents of non-financial measures believe that financial metrics facilitate trade-offs in decision making most objectively, and fear that measurement systems will begin to rely on flawed subjective metrics among other things (Ittner et al., 1998).

In addition to the shift from financial to non-financial measurement focus, other analytical work identified the evolution of two types of performance measurement frameworks – (1) structural frameworks, which specify a typology for performance measure management, and (2) procedural frameworks, which are step-by-step processes for developing performance measures from strategy (Folan et al., 2005). These types of frameworks when used in conjunction with each other form a more complete performance measurement system. However, the authors note from their studies that the development of structural frameworks is maturing faster than procedural frameworks. Helping close the maturity gap between structural and procedural frameworks, an extensive amount of research and implementation has indeed been performed this past decade, for example considering the proliferation of Six Sigma's DMAIC (Define, Measure, Analyze, Implement, and Control) procedural measurement framework (De Feo et al., 2005). It is also suggested that the steps to metric selection identified above can be used as an example of a procedural framework when applied in a systematic manner.

Furthermore, some commonly used frameworks referenced already in this section include: the Practical Software Measurement (PSM) approach's Measurement Construct that provides a structural framework for managing high-level performance measures (McGarry et al., 2001); and the GQM approach that embodies a procedural approach by directly linking measures through strategy in just three steps (Basili et al., 1994). Mahidar (2005) identifies four additional structural frameworks and two procedural frameworks, which are described through their respective strengths and weaknesses in Attachment B for reference. A breakdown of these frameworks from Attachment B with some others discussed in this chapter is seen in Table 3.2.

Table 3.2 – Performance Measurement Framework Typology

Structural	Procedural	Both
Strategic Measurement & Reporting Technique (Cross et al., 1988)	A Framework for Design & Audit (Medori, 2000)	The Balanced Scorecard (Kaplan et al., 1992)
The Performance Prism (Neely et al., 2001)	A Framework for Factors Affecting Evolution (Kennerly et al., 2003)	Extended Enterprise Balanced Scorecard (Structural) and Procedural Frameworks (Folan et al., 2005)
European Foundation for Quality Management – EFQM (Jackson, 2001)	Define-Measure-Analyze-Implement-Control (De Feo et al., 2005)	-
PSM's Measurement Contstruct (McGarry et al., 2001)	GQM (Basili et al., 1994)	-
Value Stream Mapping (Murman et al., 2002)	Steps to Metric Selection	-

Considering the frameworks above and performance measurement needs articulated through literature, there are five common attributes to a complete performance measurement system.

1. Alignment of metrics, both (i) vertically from corporate vision to operational execution and (ii) horizontally to consider the stakeholder satisfaction (suppliers, customers, community, etc…).
2. Improvement of internal processes.
3. Innovation, learning, and growth.
4. Feedback from all levels of the organization.
5. Temporal tense – depicting historical performance, the present state, and predicted future direction.

To supplement the first four attributes more directly empirically derived from the listed frameworks, the fifth was inspired from the most pressing need identified from other literature. Brown (1996) identified the need for three temporal perspectives to be conveyed through performance measurement systems – portraying the historical, current, and future performance of the company (Brown et al., 1996). Dixon (1990) shares a similar sentiment, noting that performance measures need to be dynamic to keep pace with the ever changing business

environment. Melnyk, et al., (2004) furthers this common theme by asserting that metrics have a temporal "tense." The two tenses the authors identified here are: (1) outcome-oriented (lagging) indicators from which by analyzing the past one can improve the future (most financial metrics); and (2) predictive (leading) indicators that are likely to correlate strongly to outcomes of interest. Some of the non-financial measures considered in the frameworks discussed above can be used as meaningful leading indicators, such as customer satisfaction.

Although not explicitly referenced in the five attributes, financial concerns should be embedded into frameworks one develops to provide the right balance. The identified attributes should be viewed as general driving factors to consider when developing or using a performance measurement framework. Given these critical performance measurement framework attributes, some simple universal methods and tools are offered for practical implementation regarding attributes one through five.

With respect to vertical alignment, the GQM method for aligning corporate strategy to all levels of the organizational hierarchy would be an effective method of alignment. For horizontal alignment, lean principles provide methodologies and frameworks for determining critical stakeholders and value stream mapping to coordinate organizational movement to that of customers, suppliers, and other stakeholders (Murman et al., 2002). LAI's aforementioned X-Matrix tool could also assist with both horizontal and vertical alignment processes, as it facilitates linking metrics to strategic objectives, stakeholder values, and key processes – identifying gaps in the process where metrics could be implemented (Nightingale et al., 2008). In addition to assisting with value stream mapping and alignment, lean principles and the proactive pursuit of continuous improvement could be used for improving internal processes. With respect to innovation, companies in all business environments need to pursue value opportunities – "the lure of greater success via market and/or technology opportunities prompts transformation initiatives" – before being in a position of a value crisis – "steadily declining market performance, cash flow problems, etc., prompt recognition that transformation is necessary to survive" (Rouse, 2005). A commitment to innovation could be demonstrated in a variety of ways, perhaps by fostering a culture of employee innovation and engagement, or by investing in research and development. Lastly, the existence of a feedback loop gives the performance measurement system evolutionary life and promotes continuous improvement (as referenced in section 3.1). Over time, iterations of stakeholders input regarding how the system

enables or inhibits operations can be considered in parallel with the information needs of senior leadership to improve system utility.

Implications of Implementing Bottom-Up & Top-Down Measurement Frameworks

Evolving from "traditional" to "contemporary" performance measurement systems, the integration of "structural" and "procedural" models, and considering the temporal aspect of measurement frameworks – Gomes, et al., (2007) provide an in depth review of performance measurement literature, proclaiming the emergence of two distinct implementation themes: (1) the "universal" theme, which includes approaches to performance measurement and implementation methodologies which advocate transferability across organizational context and operating environments; and (2) the "contingency" theme, which includes approaches which stress the unique characteristics of organizations, functions, and/or business units in relation to performance measurement and implementation methodologies. From the generalized conversations of metric selection and performance measurement, discussion has gravitated towards the "universal" concept, as the themes and principles discussed are transferable across multiple contexts. The "contingency" approach has focused on implementation issues, focusing on three dimensions: (i) individual performance measures; (ii) performance measurement systems; and (iii) the relationship between the performance measurement system and the environment in which it operates (Gomes et al., 2007; from Neely et al., 1995). As insight has already been provided on the first two dimensions, the relationship between the system itself and a specific contextual environment is now discussed – the implementation of measurement frameworks, recommendations, challenges and benefits. However, the best insight regarding measurement systems in their contextual environment can be derived from case studies, which are ultimately performed in Chapters 5 and 6.

In the practical context of a large company, measurement systems are traditionally implemented from two contrasting perspectives: (1) a macro (top-down) perspective by executives striving to align the company to a corporate strategy; or (2) from a micro (bottom-up) perspective by mid-level managers trying to manage the day to day operations of programs, matrix organizational function departments, or perhaps a factory site. In designing a measurement system for implementation (micro or macro), Burgess et al. (2007) identifies the following critical characteristics for success:

- linking to the business strategy (Dixon et al., 1990; and Keegan et al., 1989);
- linking measures hierarchically from strategy through to operational detail (Dixon et al., 1990; and Lynch et al., 1991);
- balanced measures such as financial and non-financial (Feurer et al., 1995) and internal and external (Waggoner et al., 1999);
- the system should be easy to understand, be simple to use and provide timely information (Dixon et al., 1990; and Lynch et al., 1991);
- providing a feedback mechanism to enable the corrective actions and flow of information to decision-making function of the company (Bititci et al., 1997); and
- allowing ongoing updating and changes as needed (Ghalayini et al., 1997).

Additionally, as performance measurement trends grow to include more of an extended enterprise, including the supplier base and other stakeholders, problems such as these will become increasingly highlighted. Other challenges for growing extended enterprises pertain to:

- decentralized reporting structures;
- deficient insight in cohesion between measures;
- uncertainty about what to measure;
- poor communication between reporters and users; and
- dispersed information technology infrastructure (Folan et al., 2006; from Lohman et al., 2004).

In short, as one considers what measurement framework they desire to adapt to their organization, or how to design their own performance measurement system, it is most imperative that they consider: (1) lessons learned from previous implementations; (2) the opportunities and challenges of measurement frameworks; (3) any necessary adaptation to the organization to implement a system that is consistent with their goals and working environment – be it structural or procedural, traditional or contemporary, past or present, or even macro or micro. To reiterate, examples of the potential impact one can achieve with a performance measurement system will be shown in Chapters 5 and 6.

Last, to help further depict the value implementing measurement systems, one study sought to investigate if the implementation of a measurement system would actually leads to

conclusive performance improvement. To explore this inquiry, financial successes of companies that built causal models linking metrics to strategy were examined compared to those who did not (a total of 157 companies) (Ittner et al., 2003). As expected, the companies that used such models (23%) did significantly better with respect to both return on assets (+2.95%) and return on equity (+5.14%) than their counterparts.

It should be warned that although this study infers that implementing performance measurement systems corresponds to significantly better financial performance than non-using competitors, it is highly plausible that the previously higher performing firms would have been more likely to adopt these contemporary measurement methods (York et al., 2004). Thus, the need to explore similar and more focused studies regarding whether this relationship can be attributed to causation or covariation would be needed for definitive conclusions. However, regardless of the strength of causation, the positive correlation indicates that one should expect more benefit than harm from implementing a performance measurement system.

3.3 Metrics for Decision Making

Metrics and measurement frameworks have no meaning if they are not used to make decisions. The practical reality is that managers have to make decisions with imperfect information. In light of this problem, modern management techniques are beginning to emphasize "management by means" and the evaluation of relationships and processes as opposed to traditional "management by results" that focuses on the outcomes of processes (Johnson et al., 2000). Johnson and Broms (2000) warn that traditional quantitative thinking limits the perception of the decision maker to one dimension, despite nature having many alternative dimensions oft forgotten. The authors argue that traditional quantitative analysis stems too much from the study of mechanistic systems with definitive properties, whereas organizations are living entities with interactions and relationships that traditional methods cannot quantify. Thus, denouncing traditional mechanistic quantification techniques, managers are faced with the difficult task of determining what modern quantification methods work best and identifying the role of metrics in decision making. Considering this quandary, in this final section of the chapter two final themes for decision makers are expanded on: tying decisions to the right problem and being confident in making decisions with minimal or imperfect information.

Focusing on the Right Problem

In the metrics selection discussion, the idea of mapping metrics to part of a greater ideal was presented. Specifically, one needs to ensure that metrics correlate to the decisions they are supporting. In practice, managers currently commonly use three methods for understanding value drivers: (1) intuition; (2) standard classifications – financial, internal business processes, customer, learning and growth; and (3) statistical analysis of leading and lagging indicators of financial performance, which can allow decision makers to identify statistically supported weights for the most important metrics with regards to how they relate to financial performance (Ittner et al., 2000).

Before using one of these methods; however, decision makers need to step back, explore the problem space, and ensure that they are focussing on the right problem regardless of the method chosen. Thus, Hubbard (2007) proposes questions decision makers should consider before measuring to help them focus on the right problem, and Nightingale (2007) identifies questions for assessing a performance measurement system to ensure that it is focussing on the right problem as well.

Questions to consider before measuring (Hubbard, 2007):

1. What is the decision this [measurement] is supposed to support?
2. What really is the thing being measured?
3. Why does this thing matter to the decision being asked?
4. What do you know about it now?
5. What is the value to measuring it further?

Questions to asses a measurement system (Nightingale, 2007):

6. Is the right information received at the right time?
7. Are the metrics tied to the organization's goals?
8. Does it identify root causes?
9. Does it consider all stakeholders and their needs?
10. Does it motivate individual or group action as intended?
11. Does it accurately portray progress?
12. Is it easy to use?

The first set of questions focus on exploring the problem space, ensuring decision makers consciously consider if there is a causal nature between the measure and desired action or if there is just an association confounded by other factors. Once the problem space has been explored and one has verified that their metrics are focussing on the right problem, the second set of questions should assist in ensuring decision makers are gathering the right information for effective decision making (representative of the right problem, actionable, timely, etc…). It is further suggested that one consider the granularity of detail necessary to support their decisions, as well as the cost of false positives (acting/intervening when you believe there is a problem but there is not a problem) or false negatives (not acting/intervening when there actually is a problem).

Too often, decision makers jump to solutions without understanding the causal factors – which leads to either the aforementioned false positives or negatives. Keeney (1992) considers this dilemma, first differentiating between what he identifies as "alternative-focused thinking" and "value-focused thinking." According to Keeney:

> *Value-focused thinking involves starting at the best and working to make it a reality. Alternative-focused thinking is starting with what is readily available and taking the best of the lot.*

With this thought, too often the focus is on easy-to-measure 'hard' data rather than 'soft' objectives like goodwill, quality of the product, amount to be learned, or societal benefit. Keeney identifies the sequence of decision making events in alternative-focused thinking as follows: (1) recognizing a decision problem, (2) identifying alternatives, (3) specifying values, (4) evaluating alternatives, and (5) selecting an alternative. As a generalization, in value-focused thinking, specifying values would occur before alternatives are selected. This improvement in thinking will help one avoid rushing to conclusions and hence false positives or negatives.

Decision Making with Imperfect Information

Now that ample consideration has been given to the need to explore the problem space, the phenomenon of acting on imperfect or negligible information is discussed. As will be expanded on in Chapter 5, being overloaded with information can perhaps jeopardize one's

ability to make a meaningful decision. Similarly, Gladwell (2005) conveys that often the best decisions are made by relying on a few pieces of high quality information, rather than endless databases. This theme is depicted through a war exercise, wherein an experienced Marine Officer acting as a Middle Eastern rogue combat group was able to continually outsmart his adversaries acting on behalf of the United States. The Marine Officer was able to use a few meaningful pieces of information through the "fog" of war to outsmart his adversaries who had a wealth of data, perhaps too much, to act on. Consistent with this example, some suggest that the acquisition of new data or information for the decision maker can easily lead to a more uncertain or hazardous state (Sisson et al., 1982). By moving away from the critical pieces of information traditionally relied upon in favor of databases of information, the potential to make a decision that helps or hurts the cause is expanded (Sisson et al., 1982). As it will be harder for decision makers to interpret the meaning of a larger group of metrics or some ambiguous aggregate number, the potential to focus on the wrong metrics or see a relationship that doesn't exist increases.

In order to make snap judgements with the success of the Marine Officer and avoid the decision maker's dilemma when too much information is available, research suggests that a major component of decision making lies with knowledge appraisal – the extent to which one can determine data quality (Fischhoff, 1982). In knowledge appraisal, one needs to determine the extent to which available information describes the context of concern, and evaluate if biases have been eliminated to the greatest controllable extent. Another context in which experts are often pressed to make decisions involving incomplete information and knowledge appraisal is in project management. Estimation forecasts are desired early in a project lifecycle regarding critical attributes, such as cost, schedule, and effort. Thus, managers are often left with few choices – parametric predictive models or expert opinion.

In particular, one area of great interest is in the nature of the expert opinion since there is more ambiguity and hence a greater need for direction. Using expert knowledge as the fundamental measurement strength, one needs to account for potential weaknesses – such as cognitive biases. Namely, some well studied biases include: (i) anchoring, wherein one relies on specific information or an arbitrary value and influences judgment; (ii) the "halo/horns" effect, wherein if people fist see one attribute that predisposes them to favor or disfavor one alternative, they are more likely to interpret subsequent information in a way that supports their conclusion;

(iii) bandwagon bias, wherein the presence of others and their interpretations affects one's judgment; (iv) hindsight bias, where people exaggerate what could have been anticipated in foresight and consider the outcome having been relatively inevitable; and (v) overconfidence or optimism bias, where people exaggerate the confidence and completeness of their own knowledge (Hubbard et al., 2007; Fischhoff, 1982; and Tversky et al., 1974). Although the first four biases can be systematically reduced when one is cognizant of them, the elimination of optimism bias proposes a more difficult task. In light of this problem, general calibration techniques of experts and corresponding exercises to combat this effect have been studied (Hubbard et al., 2007; and Lichtenstein et al., 1982). Additionally, Valerdi and Blackburn (2009) applied these techniques on systems engineers to understand the affects of optimism bias on the profession and provide insight regarding optimism reduction. Insight from this study confirms that systems engineers are as susceptible to optimism bias as any other profession, and that the effects can be quelled when estimators made cognizant of this bias through calibration exercises and are given advice regarding methods of bias mitigation. Simply, when managers in any field are relying on expert judgement to make decisions, simple awareness of the problem can lead to more accurate knowledge appraisal. In short, when acting with imperfect information, decision makers need to be dependent on their experts or just a few pieces of critical information to help them act appropriately. Being cognizant of the human element of decision making, including biases, will help one interpret information in the most effective manner possible.

3.4 Metrics Literature Conclusions

In this chapter, many topics have been discussed, to include: the basics of metric selection, performance measurement frameworks, and the role of metrics in decision making. Practical examples of how one can choose good or bad metrics were given, and the most commonly over-measured and under-measured attributes associated with long-term industry success were discussed. To think about value, an example from professional baseball was provided that showed how one can use non-traditional methods to link metrics to value. Next, the many classifications of performance measurement frameworks were discussed, from "traditional" to "contemporary" systems, considering "structural" and "procedural" models,

understanding the temporal aspects, and even briefly considering implementation of micro (bottom-up) as opposed to a macro (top-down) frameworks – to be expanded on in Chapters 5 and 6. Finally, the role of metrics in the decision making process was considered. This section emphasized the need to employ an open-minded value-focused approach to understanding value before engaging in measurement and discussed how decisions can be made with a marginal amount of information.

It is noted that although the majority of topics discussed in this chapter have been extensively researched before, they have not been synthesized in an organized form. This is partly due to the broad range of domains that write about metrics but fail to identify common issues in other domains. As a result of this disconnect between disciplines, the same mistakes are being repeated. This metrics literature review section can enable further integration of lessons learned from operations management, software engineering, aerospace engineering, product development, economics and accounting with respect to measurement. With this extensive metrics background unveiled, the tools and lessons learned will be used to assist in case study analysis and will be integrated into the transformation roadmap considerations where appropriate.

Chapter 4

Transformation: the Notion, Context & Tools

Before investigating individual enterprises and their transformation efforts facilitated by metrics and measurement systems, there is a need to develop a general understanding about transformation itself. Thus, the focus of this chapter is to develop insight regarding the science of transformation in the context of enterprises. There are three main sections of this chapter, which include: a general discussion of the notion of transformation, the context of the transformation that the stakeholders of interest for this thesis are experiencing, and the identification of practical tools and frameworks for understanding and facilitating transformation.

4.1 The Notion of Transformation

There are many different connotations to the term "transformation." Fundamentally, many people believe they are continuously transforming and it is a never-ending journey. Conversely, others believe change is abrupt and can be bounded by a finite schedule. Depending on the context in which the term is used, it can mean a variety of different things. For example, it is not too far fetched to proclaim that the military, sciences, and various industries will all define transformation in a different way. In fact, many organizations within one industry will probably define their understanding of transformation differently as well.

In order to gain a better understanding of the notion of transformation within the stakeholder cohort of interest for this research (the aerospace measurement community), a survey was performed. There were twenty-seven participants, mostly members of the LAI consortium. To ensure that all participants understood the questions, the survey was given after a day-long workshop, entitled "Metrics for Enterprise Transformation," wherein all subjects participated. Background information for the questions was given throughout the day, such as understanding the notion of an enterprise and the Eight Views of Enterprise Architecture (Nightingale et al., 2008) – to be described more in depth in Chapter 6. The survey had thirteen questions, multiple

choice and free response, which together served to quantitatively and qualitatively assess issues pertaining to the nature of transformation and how to measure it. Answers are used selectively throughout the thesis and this chapter to emphasize particular points of interest relevant to the topic flow – but the questionnaire and results can be seen in Appendix C and D respectively.

For executives like those at the workshop as well as many others, to stay ahead of competition one of the most significant challenges concerns how to plan for a successful future – how to handle transformation. Transformation does not necessarily entail radical changes in organizational structure or value delivery to the end consumer, but in most cases is a journey that begins with the understanding that a change in course is needed to maximize the potential of the enterprise.

In order to establish the current level of understanding in the science of transformation, a hierarchy of knowledge development is used (Dixit & Valerdi, 2007). This model can be used to depict how mature a science or discipline is, and provides a general path for researchers and practitioners to further develop the knowledge base. Understanding the evolution of the science, this research can be directed towards the level of need. This hierarchy can be expressed in seven levels, as seen in Table 4.1.

Table 4.1 – Hierarchy of Knowledge Development in Transformation, adapted from (Dixit & Valerdi, 2007)

Hierarchy Level	Description
Observation	Motivated by curiosity or the need to solve a problem, one gathers data pertaining to a subject and ultimately potential contributions to society are identified.
Classification	This level of maturity includes that organization and categorization of key principles, problems, or theories pertaining to the domain in question. Information can be simplified and patterns should be developed whenever applicable.
Abstraction	Abstraction occurs when systematic thought is used to formalize the information and concepts. To help unveil the value of the discipline, known models and principles should be used for depicting comparisons from other scientific fields that aid in the description of the knowledge base of the field.
Quantify & Measure	Make observations that can serve to quantify different aspects or characteristics of the discipline in different detectable ranges.
Symbolic Representation	Concepts and quantities are further developed for the purpose of determining protocol and standards have begun to be developed.
Symbolic Manipulation	Cause and effect relationships are modeled according to developed standards and best practices for scientific practice.
Prediction	This is the enlightenment stage in the hierarchy of knowledge development, in which one can use the aforementioned methods and models to predict occurrences in the discipline.

Previous work to date leads the field roughly into the abstraction phase. Hence, from the trajectory provided in this model, research is needed that will help provide methods, tools, and insights that propel the study of transformation into and through the quantification and measurement level of the knowledge hierarchy.

As it is mentioned above, transformation occurs in order to maximize the potential of the enterprise. Rouse's (2005) two-part theory of enterprise transformation states that "Enterprise transformation is driven by experienced and/or anticipated value deficiencies that result in significantly redesigned and/or new work processes." These value deficiencies can be identified by lower than expected financial metrics (revenue or profit) or the inability to reach an anticipated level of enterprise growth. In addition to these metrics retroactively calling for transformation, aspirations to seek new markets or increase the value offered to the end consumer – often seen in conjunction with technological innovations – promote transformation as well. The second part of this theory includes the use of work processes to enable the transformation. The three options for approaching these deficiencies are:

- to improve how work is currently performed,
- to perform the work differently, or
- to perform different work all together.

Depending on the degree of transformation being sought, different enabling solutions would fit different situations.

As these three options for approaching work processes subtly imply, transformation is not only a process that is completely technical in nature, but rather is one that involves people as well. More explicitly, Rouse (2005) states that "enterprise transformation concerns change, not just routine change, but fundamental change that substantially alters an organization's relationships with one or more key constituencies, e.g., customers, employees, suppliers, and investors." In short, transformation assuredly involves a socio-technical system, as mentioned in Chapter 2 (Cherns, 1987). It is important to note, before any actions are taken, that damaging the relationships with any of these stakeholders can be dangerous to the potential for long-term success. Reducing the work-force can have a negative morale and culture impact on employees, altering the value delivered or the manner in which it is delivered affects the customer perception, demands and expectations of suppliers affects their willingness to work with you on future operations, and the financial outcome and predicted potential worth of one's organization

as a result of the transformation affects how investors will view the enterprise. However, not all transformations have to negatively affect stakeholders. Transformation, whenever possible, needs to be viewed as an opportunity to improve relationships and fulfill the needs of the stakeholders – despite whether the nature of the transformation is innovative and voluntary or forced and involuntary.

A variety of different conditions could spur this socio-technical systems transformation, such as: change in customer values, advancing technology, market and economic conditions, competitive and regulatory conditions, etcetera. Rouse (2005) articulates that these dynamic conditions can cause a transformation to come from four different perspectives, described in the Table 4.2.

Table 4.2 – The Four Driving Perspectives of Enterprise Transformation (adapted from Rouse, 2005 and used with permission)

Condition	Description
Proactive Perspectives — *Value Opportunities*	The lure of greater success via market and/or technology opportunities prompts transformation initiatives.
Value Threats	The danger of anticipated failure due to market and/or technology threats prompts transformation initiatives.
Value Competition	Other players' transformation initiatives prompt recognition that transformation is necessary to continued success.
Retroactive Perspectives — *Value Crisis*	Steadily declining market performance, cash flow problems, etc., prompt recognition that transformation is necessary to survive.

As it is depicted in the table above, these four perspectives can be characterized by their degree of proactive or retroactive initiation of transformation. In the most proactive case, there are no threats to the enterprise, but new opportunities are sought to ensure prosperity of the enterprise. In the most retroactive case, decline has been witnessed already and failure is imminent without immediate transformation. It can be hypothesized that more proactive pursuit of transformation is the optimal way to guarantee survival. The compliment to this theme, of course, is that the later the transformation begins the higher the likelihood of failure. Thus, any contributions to the use of transformation roadmaps that can be made with this research enhance the chance for long-term survival of the end user stakeholders. In addition to the proactive and

retroactive element of these driving perspectives, it is also interesting that the only transformation perspective with a positive connotation would be seeking "value opportunities." The other three driving perspectives are seen with a negative connotation, perhaps because transformation by these perspectives is often more forced on an organization for survival or in order to maintain one's position, rather than a self-initiated opportunity-seeking endeavor. This general understanding of the notion of transformation is now expanded on to better understand the viewpoint of transformation from the perspective of the aerospace measurement community – the context of transformation for this research.

4.2 Transformation Context: the Aerospace Measurement Community

In Chapter 1, brief insight was given with regard to some of the critical results of this theory. The manner in which the aerospace measurement community defined and measured transformation was identified, as well as proposed leading and lagging indicators for its successes or failures as well. The reason for this early insight was to give the reader an understanding of the problem before getting lost in the depths of the literature backgrounds. Now, the purpose of this section is to unveil more depictive results from this survey to provide an even better in depth context of their transformation endeavors, including: motivation for transformation, success and failure rations of transformation, measurement frequency insight, level of stakeholders' lean maturity, and the perceived duration of a transformation. All of this data was established through the same survey of twenty-seven aerospace measurement community representatives early in the research design phase – such that the needs of the community could help direct the research as opposed to the research direction being imposing on them.

First, a question was created for the survey to better understand the importance of the four perspectives in motivating transformation from Rouse (2005), that is, the relevance in practice of these factors. The question directly asked participants to rate the importance each perspective in motivating enterprise transformation (on a scale of 1 to 5, 1 = Very Low, 3 = Medium, 5 = Very High). The results can be seen in Figure 4.1.

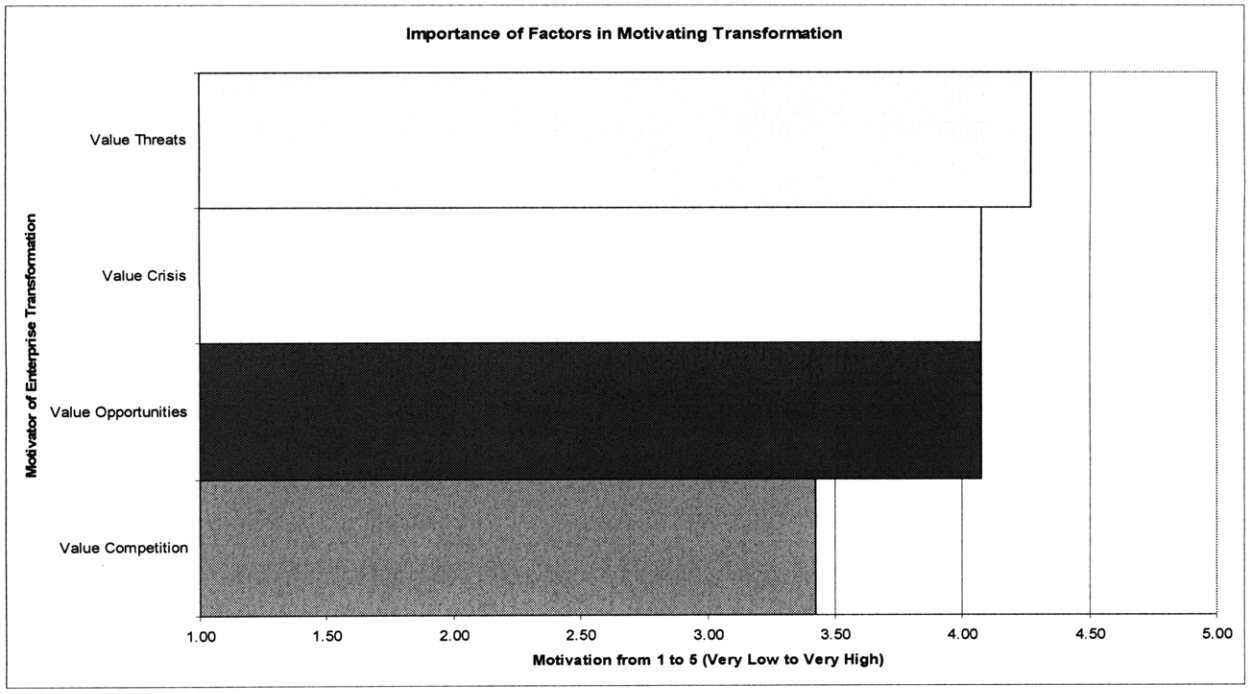

Figure 4.1 – Importance of Factors in Motivating Transformation (n=26)

Although the sample size is small, some high-level lessons and insights can be derived from these results. Currently, there is a degree of proactive transformation currently practiced, as the anticipation of threats is the biggest motivator as opposed to a visible decline in performance. Moreover, seeking value opportunities scored surprisingly high as well. This finding implies that transformation roadmaps and other techniques are more than likely being emphasized in practice as proactive means to avoid long-term failure. Another high take-away, one counterintuitive to the predetermined beliefs of many, is that competitors' initiatives are not seen as a significant motivator to transform. This result yields many potential conclusions; one hypothesis could be that organizations within an enterprise are inherently bounded by their culture and the context in which their work is accomplished, such that a blind-eye is taken to environment and external influences.

Second, understanding that there is a temporal aspect to transformation from the metrics literature review performed earlier, a question was created that addressed the periodicity of transformation measurement. The general result from this inquiry was that the measurement representatives are confident they are not measuring enough (1/3 as much as they should) – and need to increase the role and frequency of measurement in the organization. In short, it is believed that the community is not measuring more because they do not know either what to

measure, why they are measuring, or how they can use the measures to support change. This insight implies that measurement guidance in the form of a transformation roadmap layer would be well adopted – as it would provide a structured method for quelling the perceived lack of measurement.

Third, another question that became apparent when considering the perhaps rushed or chaotic nature of many transformations was "what is the ratio in practice of successful to failed transformations?" Inherently, one might believe the ratio would be about even, due to the amount of successful initiatives that are documented in literature contrasting to the fact that there were probably a fair amount of failures less talked about. Additionally, perhaps there would be more successes than failures due to a stubbornness of management to allow failure of their initiatives. To address this concern, participants were asked to provide this ratio of successful to failed transformations based on their experiences, and the results were overwhelmingly negative as seen from Figure 4.2. In this figure each row represents the response from one person, with a total of twenty replies. For example, the first row means that one successful transformation was seen per every ten unsuccessful transformations.

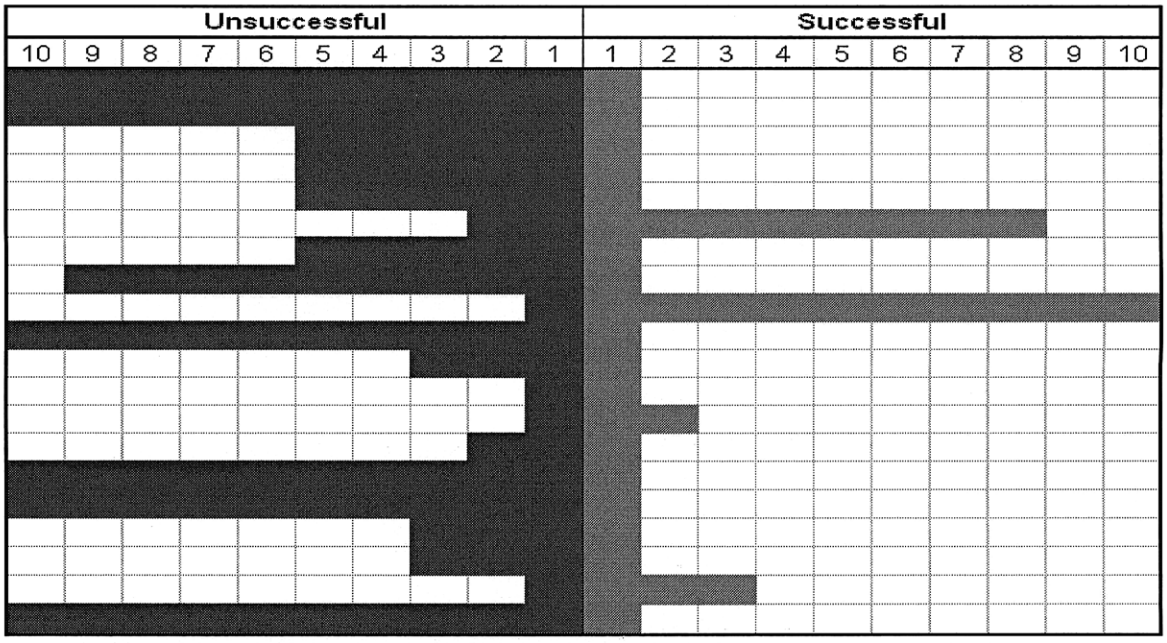

Figure 4.2 – Ratio of Successful to Unsuccessful Transformations (n=20)

These results indicate a serious problem – many of the initiatives pioneered to promote long term success are not working. Hence, this data further conveys an even greater need than expected to yield research that provides measurement insights to facilitate transformation.

Fourth, understanding the perceived inability to successfully undergo a transformation initiative, one might hypothesize a close relationship to the level of lean maturity of the group (e.g. the more lean the group's maturity the more likely it is to succeed at transformation). Since different community members represent enterprises at various degrees of lean maturity in their transformation journeys, in the survey each participant was asked to identify their respective level. The results from the survey are seen in Figure 4.3.

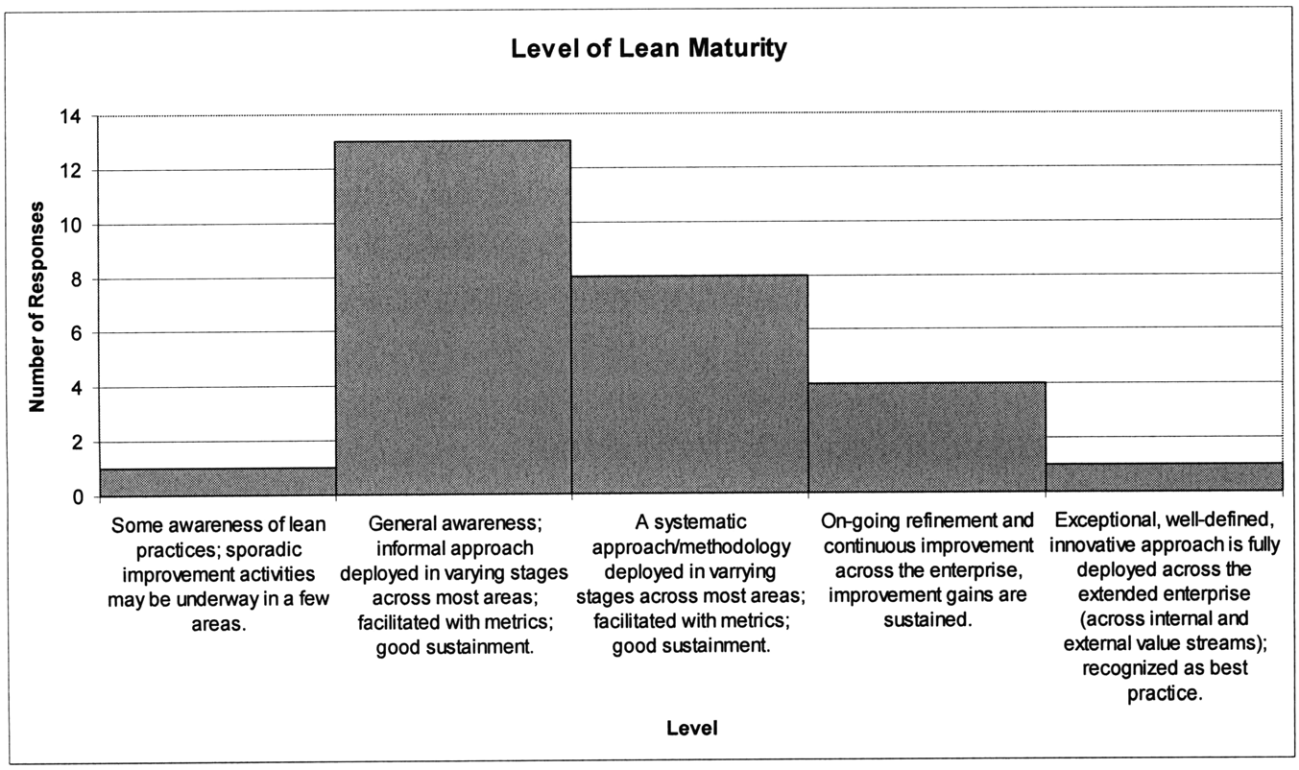

Figure 4.3 – Level of Lean Maturity from Metrics Community Survey (n=27)

From this chart, it is seen that on average groups are about at a level two or a level three (corresponding to the second and third levels from left to right in Figure 4.3), with an extreme outlier on both ends of the spectrum. Surprisingly, one might have expected even at a level two or three that transformation success would have corresponded to somewhat more promising transformation success rates. This insight implies that even with a general awareness or even a

systemic approach in place for facilitating lean transformation, there are still ample amounts of failed transformations and hence opportunity for improvement.

Finally, as mentioned at the start of this chapter, one common debate in organizational transformation science is whether or not transformation should be viewed as a continuous and never-ending journey or as a discrete event with an identifiable start and end point. When posed this question, the majority of the metrics community responded that a transformation either takes approximately five or more years – or is actually never ending at all. Despite these slanted results that transformation could be from half a decade to never-ending, it is declared that transformation experiences characteristics of duality – that it is both discrete and continuous. In short, all companies are striving to improve continuously in the spirit of lean, thus accounting for the never ending aspect of the results (more than a quarter of results said never ending). However, milestones need to be established in order to gauge accomplishments and progress over time – hence the need to set artificial milestones and discrete end points. With this furthered understanding as to some of the views of the community of interest, transformation tools and frameworks that can be used to assist practitioners are now discussed.

4.3 Transformation Tools & Frameworks

In this section, tools and frameworks for considering transformation from the eye of the practitioner are discussed. Not only are tools for facilitating transformation that have evolved out of LAI looked at (those which this aerospace measurement community has interfaced with and understands), but also other transformation methods and tools are discussed to provide a broader perspective.

General Transformation Tools

As Rouse (2005) has been cited often in this section as one of the experts in the field of understanding transformation, it is only appropriate to first unveil some of the insight offered through the aggregation of his research. Rouse (2005) suggests that there are multiple ways to go about the execution of the transformation. It is argued that a strategy-oriented approach should be pursued for addressing external opportunities and threats, whereas an operations

oriented-approach would be employed to address competitor's initiatives and internal crises, as depicted in Table 4.3.

Table 4.3 – Strategy- and Operations-Oriented Transformation Approaches (Rouse, 2005)

Strategy-Oriented Approaches for External Opportunities & Threats	Operations-Oriented Approaches for Competitor's Initiatives & Internal Crises
Markets Targeted	Supply Chain Restructuring
Market Channels Employed	Outsourcing & Off-Shoring
Value Proposition	Process Standardization
Offerings Provided	Process Reengineering
----------	Web-Enabled Processes

With these approaches of transformation as a basis, there is a complimentary framework and methodology for transformation unveiled as well. One simple model Rouse (2005) uses relates the scope, means, and ends of transformation initiatives to each other, which can be seen in Figure 4.4.

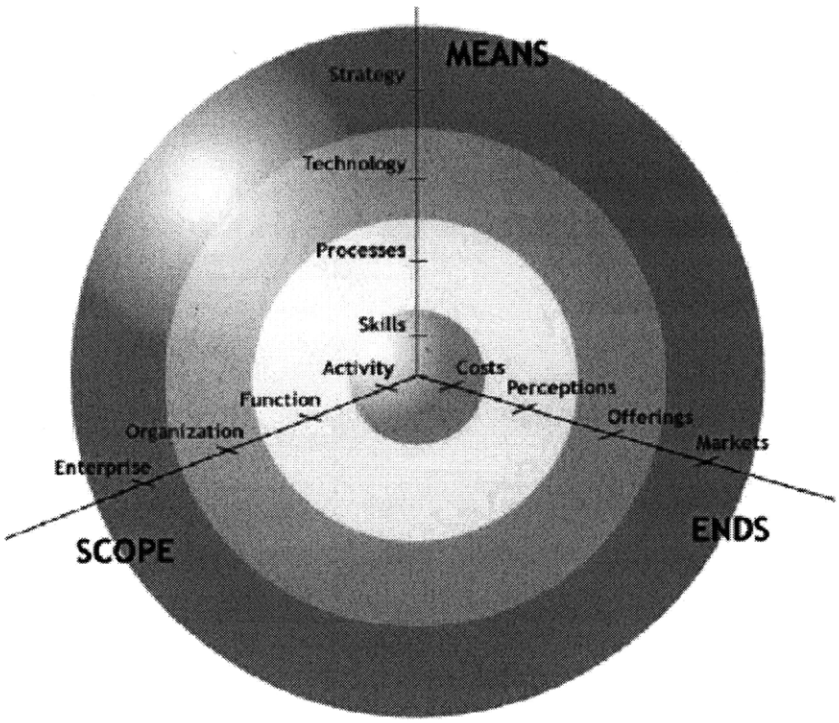

Figure 4.4 – Transformation Framework – Relating Scope, Means & Ends (Rouse, 2005)

In this figure, each ring relates to one level of transformation, with rings closer to the outside indicating the more substantial the transformation. For example, transformation can be

as minimal as the ring on the activity level enabled by new or improved skills that result in cost reduction with, or even as substantial as an enterprise transformation enabled via strategy that addresses increasing market shares or even new markets (Rouse, 2005). As the topic of this thesis is more concerned with specifying a framework for this greater enterprise transformation, another generalized framework for enterprise transformation is now considered. The next general framework presented calls for the identification of transformation processes and their purposes, capabilities, and solutions to be transformed in three distinct phases – definition, deployment, and execution – as is seen in Figure 4.5.

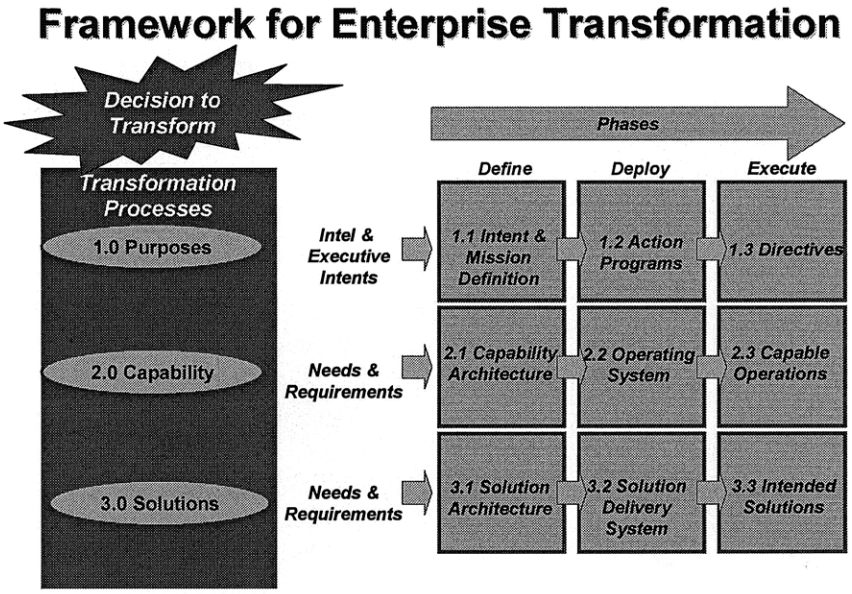

Figure 4.5 – Framework for Enterprise Transformation, (Rouse, 2006; from Kessler, 2005)

Next, another way of looking at transformation is presented that is derived from the fields of law and technology with a six-sigma spin. This next model shown helps practitioners look at transformation from three analytical dimensions: the type, rate, and nature of change. The type of change is the dimension adapted from six-sigma focused criteria for the Shingo prize, and includes determining whether or not the change is driven by tools, individual systems, or by principles imbedded into the culture. The rate or degree of change axis tackles whether or not the transformation is focused on incremental improvement all the way to perhaps a radical and fundamentally new way of doing business or executing core processes. Finally, the third dimension pertains to the nature of change, referring to whether or not the end result of the

change is sustaining the organizations operations and place in the market or could lead to an entire market disruption itself.

To depict these dimensions Figure 4.6 is adapted to show types of transformational change per the Shingo Prize for Operational Excellence's degrees of transformation to provide a simple visual means to help one better understand their transformation (Ashford & Hall, 2008; & www.shingoprize.org).

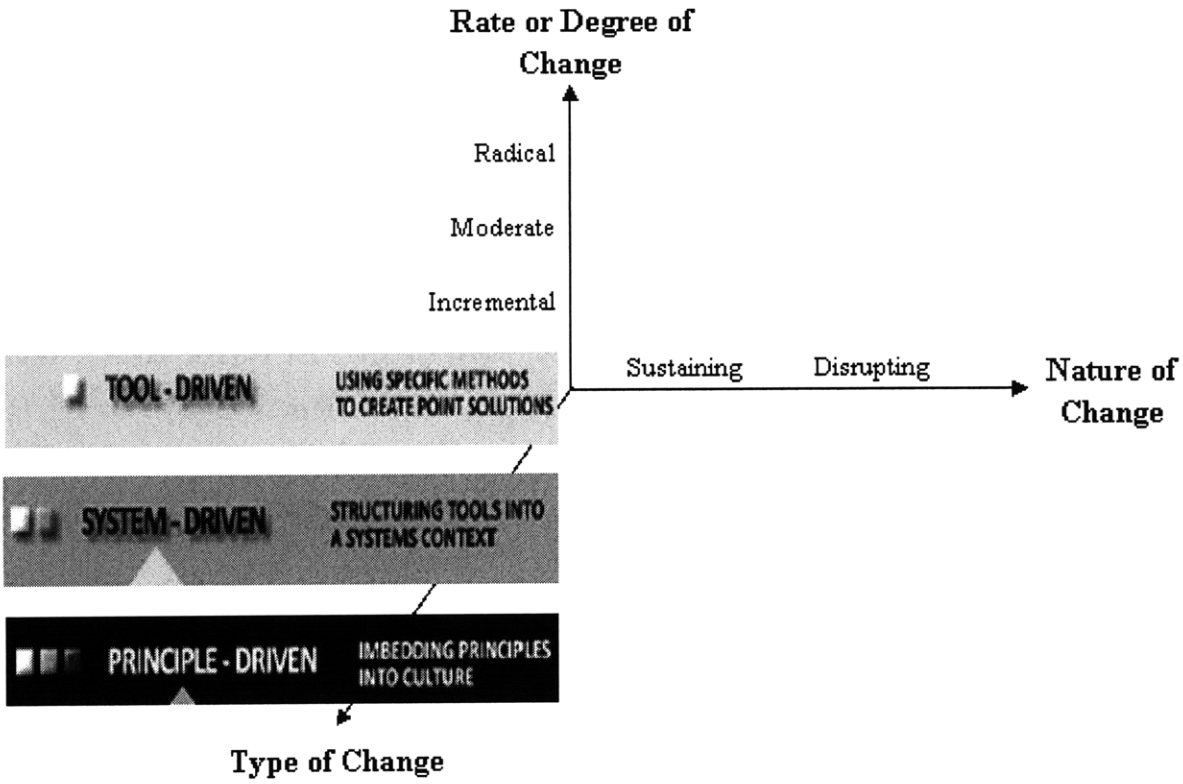

Figure 4.6 – Dimensions of Transformation, adapted from (Ashford et al., 2008 and www.shingoprize.org)

Depending on how the transformation of interest is characterized within these critical dimensions, the magnitude and aspects of measurement might be different. For example, the military transformation example from Chapter 1 might represent a system-driven change, of a moderate degree, that aimed to sustain and improve operations. This understanding would help you understand that what you really care about is system-level metrics that describe how transformed and improved operations have become as a result of the effort. Furthermore, since the change is of a moderate degree, stakeholders need to understand there will be a gap between

current and future state operations and somehow embody that altered enterprise architecture with their metrics. Lastly, since the change is somewhat sustaining (ALC will still be managing inventory) some metrics can address the efficiency of that and other fundamental objectives.

LAI Transformation Tools

With an understanding of some other methods of considering transformation tools and frameworks, the tool that the community is most familiar with is now discussed – LAI's Enterprise Strategic Analysis and Transformation (ESAT) version 2.0 handbook and the corresponding Enterprise Transformation Roadmap (Nightingale et al., 2008). This roadmap will be used as a background for the ultimate thesis recommendations due to its higher level of familiarity and usage amongst the community. As seen from the previous section, most all of the measurement community is at least a level two in their lean maturity and is somewhat familiar with the model.

The ESAT methodology developed and refined by LAI over the past decade serves as an analytical framework for diagnosing and improving enterprise performance (Nightingale et al., 2008). In general, this methodology helps stakeholders understand enterprise value streams as well as the interactions between stakeholders, while eliminating waste and exposing areas for improvement. Outcomes of executing an ESAT consist of the creation of a future state vision, an actionable transformation plan, and a governance structure to drive the transformation. In addition to these three major outcomes, the shared mental model for senior leadership to ensure their long-term buy-in and support is invaluable as well. In short, "ESAT enables the

- identification of barriers to the creation/delivery of value to key stakeholders;
- specification of a future lean enterprise vision;
- determination of significant gaps between the current and future states;
- prioritization of enterprise-level improvement opportunities; and the
- creation of an integrated transformation plan, and associated governance structure."

Furthermore, LAI declares that the following make ESAT different from other transformation approaches:

- "a focus on the total enterprise level;

- an emphasis on enterprise-wide processes, rather than individual functions, programs or tasks;
- an emphasis on value flows between the enterprise and its stakeholders; and
- being built upon well-tested well-understood methods."

In order to accomplish these ESAT goals, there is a general roadmap that breaks the process of understanding the enterprise through the creation of the deployment plan into eight steps – as seen in Figure 4.7.

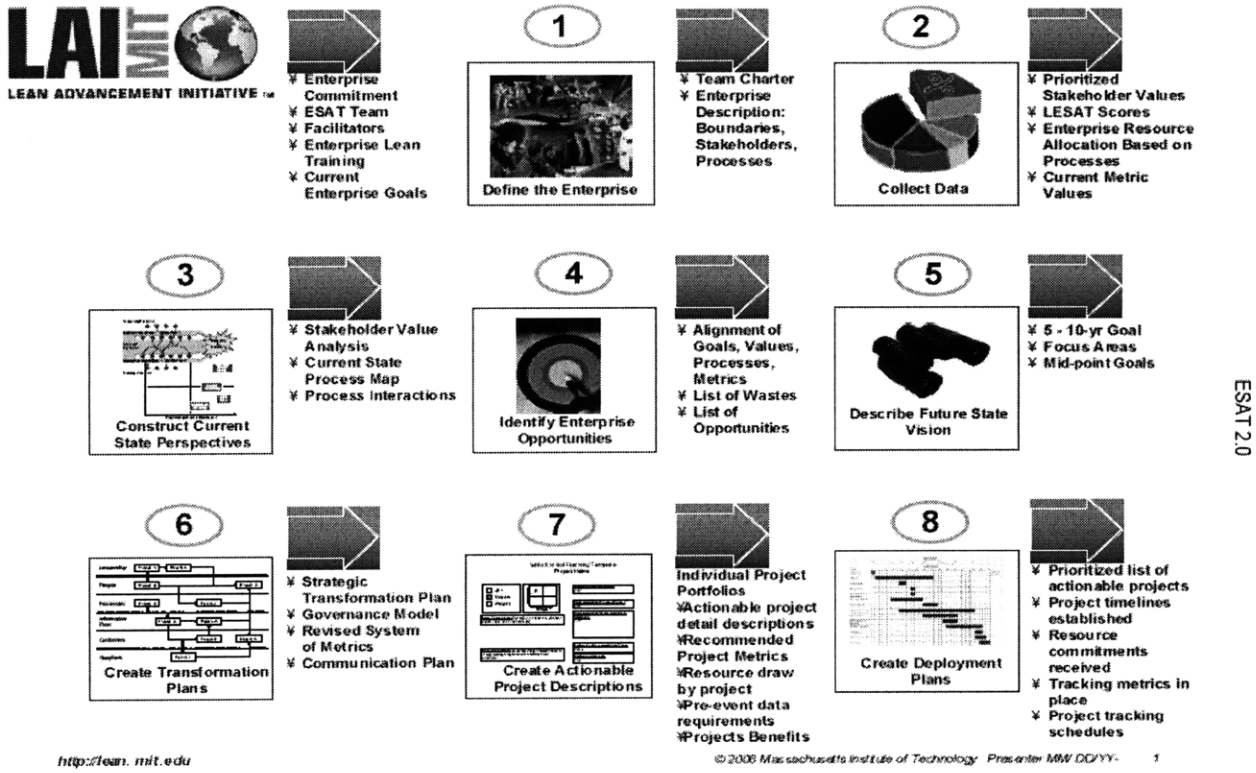

Figure 4.7 – ESAT Roadmap (Nightingale et al., 2008)

In addition to this roadmap encompassing all ESAT activities, there is a simplified Enterprise Transformation Roadmap – seen in Figure 4.8. For ease of viewing, the more explicit metrics considerations already imbedded in the roadmap have been circled. These critical areas and others will be explored more in Chapter 7.

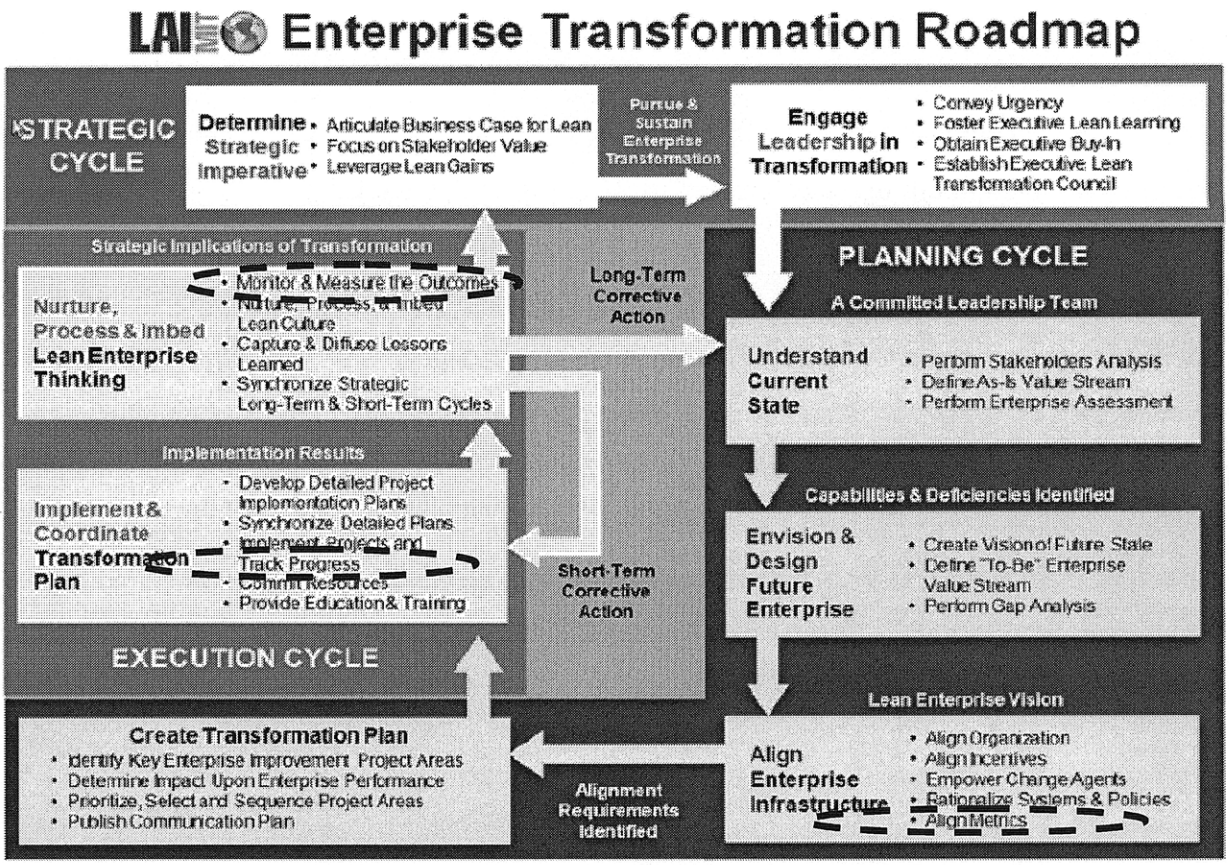

Figure 4.8 – Enterprise Transformation Roadmap adapted from (Nightingale et al., 2008)

Note that there are three main cycles – strategic, planning and execution. The transformation journey begins when leadership can articulate the business case for transformation, and arguably either never ends or ends after achieving some progress along this cycle. As one can see from the diagram, some of the most challenging metrics considerations arise after the creation of the transformation plan – during the execution cycle. Thus, in Chapter 5 and Chapter 6 two separate case studies of different aerospace measurement community members' systems in practice are now presented. Insights from these case studies will serve as grounding for a portion of the analysis in Chapter 7 – the identification of major measurement considerations for the execution of the transformation plan.

Chapter 5

Case Study 1: Implementation of a Bottom-Up Measurement System

The focus of the first case study and this chapter is to describe a case study of an effective implementation of an enterprise measurement system in a large company for the purpose of organizational transformation. The affect of enterprise measurement systems is looked at on not only managers, but factory floor workers as well. To relate to practical experiences representative of the aerospace measurement community, a case study is provided of a major aerospace defense contractor that has recently undergone a significant transformation whose success has been at least partially accredited to an enterprise measurement system. This chapter is organized in four main sections: (1) the organizational background and *burning platform* that incited the transformation, (2) the *development and adoption* of the enterprise measurement system, (3) the *practical implications* of an enterprise measurement system on the transformation, and (4) the *direction, challenges, and future considerations* in sustaining an enterprise measurement system throughout the ongoing journey of continuous improvement.

First, the notion of transformation causes and the concept of the *burning platform* is explored, which allows one to better understand the conditions and organizational sense of urgency that serve as a catalyst for transformation. The boundary of the enterprise under consideration is also identified, and there is a discussion of the enterprise measurement systems' sphere of influence in affecting the structure, function and value delivery of this enterprise.

Second, the *development and adoption* of an enterprise measurement system is described by highlighting results of an in-depth case study that considers all stakeholders involved in the creation and adoption of the system, which is derived from two plant tours, a one-day workshop, three other site-visits and fifteen interviews of employees with different functional positions and experience levels. By openly considering the needs of all the stakeholders in the development of an enterprise measurement system, it will be shown how the development and adoption of the system can succeed with minimal hurdles.

Third, the *practical implications* of an enterprise measurement system on enterprise transformation are discussed – from themes which are identified as a product of the interview process. This discussion will focus on positive implications, regarding: (i) the wealth and freshness of data, (ii) visibility of data, (iii) providing constant communication and feedback, (iv) employee accountability, (v) fostering a culture of continuous improvement, and most importantly (vi) employee engagement. From Chapter 1, recall that employee engagement is proposed to be a proxy for transformation progress – a concept from which critical insights will be revealed in this section.

Fourth, the current *direction and challenges* are considered, which allows one to hypothesize the *future* potential of using an enterprise measurement system as a tool to gauge transformation progress. The direction of the enterprise measurement system is inferred from two current system expansion projects, and interview insight unveils implementation challenges.

Through the consideration of the burning platform, development and adoption, practical implications, challenges, and future direction of enterprise measurement system implementation and use – a unique foundation of insight on how measurement systems can be developed and used to guide future enterprise change. The critical insight extracted from this chapter will provide a solid foundation for the measurement considerations in the transformation roadmap.

Before discussing measurement systems and their role in facilitating enterprise transformation, one needs to first understand the market forces and environmental conditions that highlighted the need for change. A variety of different conditions could spur transformation, such as: change in customer values, advancing technology, market and economic conditions, competitive and regulatory conditions, etc. As described in Chapter 4, Rouse (2005) identified four driving perspectives of enterprise transformation – value opportunities, value threats, value competition, and value crises. In particular, this case study describes a company that had been experiencing a value crises –previously defined as "steadily declining performance, cash flow problems, etc.," (Rouse, 2005) wherein recognizing the necessity of imminent transformation was paramount for survival. A case study of Raytheon's Integrated Defense Systems (IDS) is now introduced, considering their company background, the context of their value crises (burning platform), and the stakeholders and enterprise boundary relevant to their enterprise measurement system implementation.

In architecting the following case study, the techniques from Yin (2003) identified in Chapter 1 are again employed. To review, Yin (2003) identifies five critical attributes to consider in case study methodologies: "(1) a study's questions; (2) its propositions, if any; (3) its unit of analysis; (4) the logic linking the data to the propositions; and (5) the criteria for interpreting the findings." The two focal questions of this particular case study were as follows:

1. *How was VBS implemented (developed and adopted) and what have been seen as the short-term and long-term advantages of this enterprise measurement system?*
2. *What is the future direction of VBS, considering both past challenges and those likely to arise?*

Considering these questions, the proposition is that although the short-term improvements brought front and center by real-time information and visual displays is understood, the long-term challenges associated with organizational change and employee motivation is understated. Unveiling the roots of these challenges in a proactive manner will not only assist in preventing decreasing levels of employee momentum, but can also be used to help facilitate the future expansion of the system. The unit of analysis studied relates to the business segment using the enterprise measurement system and the stakeholders that interact with it. This proposition will be supported through input from interviews of stakeholders within this unit of analysis, which will be used to extract a clear understanding of both these perceived benefits and challenges over both the short-term and long-term. Results from these interviews will be interpreted based on emerging themes or trends that arise through exploratory questioning.

5.1 Background of Raytheon IDS & Virtual Business Systems (VBS)

Raytheon Company was founded in the 1920s, and currently is a prime contractor or major subcontractor for United States defense programs. This role supported more than 80% of company sales in 2006, which were on the order of $20 billion. Raytheon employs around 80,000 workers; some 15% are unionized (Antoniou, 2008).

This case study describes one of Raytheon's locations in Andover, Massachusetts. Operations at the Andover site are specific to one of their six main business segments: Integrated

Defense Systems. At this more than 1 million square foot facility there are approximately 3,500 employees, with an approximate union representation around 40%. The organizational hierarchy in Andover is influenced from two perspectives – program related and value stream related activities (Antoniou, 2008). For example, one who manufactures circuit boards will not only be interacting with the circuit functional area, but with the specific projects that incorporate the circuit boards into the final delivered system as well.

Not long after the turn of the millennium, Raytheon was experiencing a value crisis, as the economic performance of many of its business units and programs was in sharp decline. For the first time ever, the United States government had not ordered any of Raytheon's flagship defense system products – seriously jeopardizing the future of the Andover facility. In addition to laying-off employees, it became clear that the facility would need to be shut-down if significant improvements were not made.

Around this time an enterprise measurement initiative, known as Virtual Business System (VBS), was introduced. VBS has been described as "an IT enabler for lean principles" that extracts data from various legacy systems and provides customizable reporting capabilities drawing on real-time data that can be projected onto visual dashboards – visible to everybody, everywhere throughout the facility (Antoniou, 2008). One of the original goals of VBS was to change the culture of the decision makers from a "reactive problem solving attitude to a proactive problem solving attitude" – thus facilitating the identification of risks before they became crises (Ho, 2008).

VBS did not begin as the widely-used enterprise management tool it has grown to become today, but rather evolved over time – from responding to the value crises in 2000 as a lean implementation tool to eventually a more broadly used continuous improvement tool. In 2000, the measurement initiatives grew out of the need to cut cost for survival, in response to the bold goal of reducing cost by as much as 10% annually thereafter. Building from process improvement trends of the time, VBS was originally a factory-floor level initiative that aimed at employing lean principles – embodied in manufacturing by the Toyota Production System (Womack et al., 1996) – throughout Raytheon's manufacturing value streams. Ultimately, VBS played a significant role in assisting Raytheon's manufacturing facilities, generating savings of almost $150 million between 2005 and 2007 (Ho, 2008).

Shortly after the value crises had been averted with the help of this proactive cost-cutting mentality, employees began to evaluate how they could modify their lean facilitating measurement system in the spirit of continuous improvement. This proactive managerial shift of focus was comparable to what Rouse (2005) would classify as in pursuit of value opportunities, wherein "the lure of greater success via market and/or technology opportunities prompts transformation initiatives."

In the spirit of further pursuing value opportunities through VBS, 2004 marked one of the first significant extensions of VBS in a project that considered how decision making could be "improved through the automation of data for real-time display on the factory floor" (Ho, 2008; from McCaghren, 2005). One of the major contributions of this project for VBS was the concept of collection and display of data in real-time on the factory floor. Additionally, the presentation displays were modified to not only present current process metrics, but to also help identify improvement opportunities of non-conforming processes.

After this and other successful improvements to VBS over time, Raytheon instigated a second major improvement initiative in 2007 when they architected new dashboards for assessing the performance of various reviving manufacturing programs – specifically aimed at using visual analytics to assist decision makers at the program management office level (Antoniou, 2008). However, this improvement initiative was not entirely proactive, as the government's significant increase in demand of a particular system as the "burning platform" – the event that made the need for change clear – which expedited the development and adoption of this particular project (Antoniou, 2008).

In 2008, Raytheon engaged in a third extension of VBS. This project specifically targeted the engineering group, as it attempted to analyze engineering metrics in a manner that facilitated proactive decision making for the early identification of risks and opportunities. Moreover, Raytheon then supported another project aimed at bringing the advantages of visibility and communication further upstream in the production process – wherein it could be used to manage uncertainties in the supply chain (Ho, 2008).

VBS is a bottom-up measurement system – meaning that it measures operational activities at the factory floor level and aggregates them to metrics that are visually and analytically useful for decision makers. Depending on a specific touch-laborers' function, information may be collected in a variety of ways – ranging from technologically automated

methods to manual user input. For example, progress measurement for widget building could be facilitated by scanning items to indicate that work has passed through a station. Conversely, for other items users may input information on their computers to indicate the progress of a widget's work flow through their stations. Either way, this raw data is fed to the development team in one of the many Raytheon databases. VBS developers then take this raw data and compile it into metrics that can be used to depict a visual snapshot that can be displayed on a dashboard. These snapshots commonly indicate typical manufacturing metrics, such as work-in-progress (WIP), cycle time, etc. It is argued that this VBS tool can be viewed as a diagnostic for transformation, with the unique capability of both discovering value opportunities and preventing value crises. As the implications of VBS on enterprise transformation are discussed in this chapter, one will understand how this system can be interpreted to identify indicators that help guide Raytheon towards successful transformation.

The boundary of the VBS enterprise has evolved considerably over time, not only increasing in cumulative users but in scope as well, as can be seen in Figures 5.1 and 5.2. The scope that VBS originally influenced pertained principally to specific manufacturing cells, and over time it has expanded to management offices, engineers, and even suppliers.

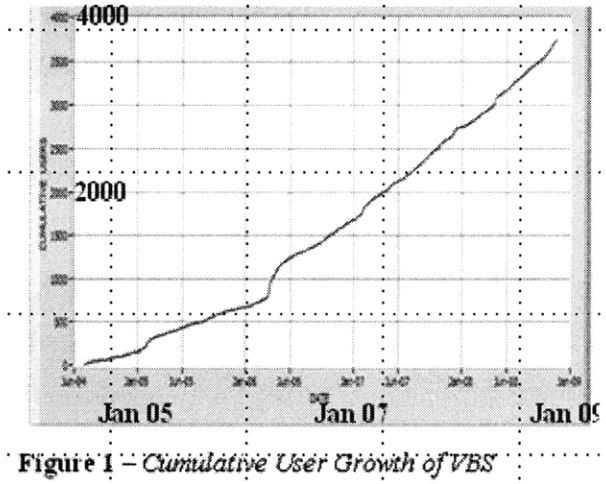

Figure 1 – Cumulative User Growth of VBS

Figure 5.1 – Cumulative User Growth of VBS (Day, 2006)

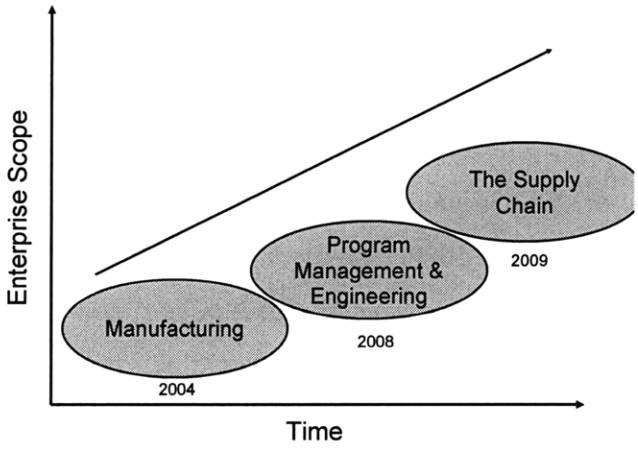

Figure 5.2 – Growth of Raytheon's VBS Boundary

Bringing in more stakeholders into the enterprise helped foster an environment of transparency and communication, ensuring the actions of one subset of stakeholders was not

counteracting the intentions of others and impeding value flow. VBS facilitated the growth of the enterprise from an exclusive modular state to a more integrated enterprise. All these stakeholders contribute to the value stream and information feedback loops; however, in its current state the suppliers and customers have been more passive rather than active in their involvement with the VBS system. It should be noted that the VBS and Information Technology (IT) groups are not at the heart of this enterprise, but rather are enabling departments that facilitate information, communication and value flow amongst all stakeholders – directly or indirectly.

To analyze this enterprise, the method suggested from Chapter 2 is employed – the structure, function and value delivery lens analysis. As a reminder, the definitions of these attributes are as follows:

> *(1) structure – pertaining to the organizational hierarchies and how different departments interact, (2) function – pertaining to how people within the enterprise establish relationships and interact to get work done and (3) value delivery – pertaining to how value is created and maximized for a specifically-defined group of stakeholders.*

As it was briefly mentioned above, the structure of Raytheon is focused around not only programs, but value streams as well. VBS leverages the existence of this dual-purpose hierarchy by providing both program related performance information to the program managers, as well as inter-program related value stream information to manufacturing operations leaders. Functionally, VBS interacts with a variety of stakeholders and is a strong tool to allow employees to build closer relationships, from those who input data to those who analyze the data. Understanding how all stakeholders interact with VBS is paramount in considering its effectiveness. With respect to value delivery, it is imperative to consider the implementation of the enterprise measurement system and its effects on employees and decision makers – to ensure data over collection or misinterpretation are not hindering value flow.

5.2 Development & Adoption

As the development and adoption of VBS are considered, it is necessary to first point out one critical factor pertaining to its structure and the VBS Development Team. In particular, the VBS group does not report to IT, engineering, or any other functional body – creating an unusual organizational dynamic, with several advantages and disadvantages. One important advantage of being an independent group is that VBS's improvements, advancements, and recommendations are not automatically labeled or discounted. If it was associated with a department such as engineering, many might believe it operated with biases or an underlying agenda. Additionally, the VBS group can draw from a variety of different resources for funding or technical support. The disadvantages of being an independent group are also significant. Most notably, multiple stakeholders have different requirements that need to be met. At times, these stakeholders might not necessarily have visibility into some of the more specialized tasks VBS is helping other programs or functional areas with. This management structure could lead to frustration of various stakeholders, as they are less likely to understand why the VBS group cannot help them with what they perceive to be a simple feature or improvement – not understanding the needs of other stakeholders. The general resistance to measurement also poses problems at times. Since decision makers oft believe they know an answer in advance, results are oft only taken seriously if they verify their pre-existing assumptions and intuition. Thus, the structural dynamic of the VBS enterprise presents a unique dynamic not present in most many traditional organizational structures.

Development of VBS

Understanding the background of VBS, it is now discussed how the system was developed and adopted in conjunction with all stakeholder needs. The VBS core team is the organization in which the system is developed and maintained. To reiterate, it is important to note that although the VBS and IT groups draw from similar resources (databases) and have a similar function (improved communication), they are independently funded groups. However, VBS draws from more than forty databases within Raytheon, many of which are managed by IT.

The VBS development team has consisted of only two full-time employees, the lead and the chief engineer, in addition to perhaps four part time assistants at any given point in time (Ho, 2008). VBS was developed with National Instrument's LabVIEW© product for visual analytics and controls. This program was not only affordable, but more importantly Raytheon believed it

provided a scalable infrastructure that was consequently familiar to Raytheon engineers that would be needed to manage the project (Antoniou, 2008). LabVIEW's graphical programming style allowed for the user interface to be developed prior to coding, a valuable characteristic to ensure operator needs are not ignored in the development process. Another advantage of graphical programming is its simplicity for non-programmers, which allows novices to reuse modular parts of the programming structure and quickly make changes. This modular architecture allows for rapid prototyping of new visual dashboards as well – critical for obtaining immediate stakeholder feedback throughout the development process, prior to investing significant resources in the development of a non-validated dashboard.

Adoption

In order to achieve successful implementation of an enterprise measurement system, one needs to gather support, in both the form of management and end-users. When the system was first visually introduced on a large-scale level, there was immediate resistance. Developers turned off the system after a day of use, and informed everyone that the system would be turned on again in a month or so – giving leaders enough time to provide immediate feedback or perhaps address any embarrassing red metrics. Visually, the stop-light philosophy was implemented on the dashboards. Red metrics were used to indicate current problems and unsatisfactory performance, yellow highlighted risk areas, and green metrics were those in which satisfactory progress was being made. In the following month, the VBS system was again turned on and employees became increasingly more accepting of its existence – as management was not abusing the system. Many employees even openly advocated for the system since it helped them show management where in the value stream problems were occurring. In essence, one could use VBS to articulate to managers that a problem was occurring further upstream, which was in turn affecting their own performance.

When interviews were conducted at Raytheon's IDS site in Andover to understand the role of VBS, one of the goals was to develop insight regarding why adoption of this system was successful. With 40% of the work-force being unionized, one would expect heavy resistance to any measurement system that showed defects or productivity. Originally, acceptance of VBS was motivated by the company's eminent shut-down, and hence some 3,500 employees had their jobs on the line. However, as the company's financial situation grew more stable, development

and adoption progressed – but why? Interview results yielded a variety of factors, including: (1) Fostering a non-blame oriented culture, (2) considering the needs of all stakeholders, (3) holding managers and engineers responsible for considering employee feedback, and (4) being proactive in teaching the community how to use the tool, with the help of various employee advocates within cells. Some of these factors will be reiterated in the implications discussion.

First, the VBS group fostered a culture identifying the root cause of problems, without blaming individuals or groups. As employees understood and became less threatened by VBS, adoption came with less resistance. Second, stakeholder input was sought out and actively integrated into the systems. Due to the rapid prototype potential of VBS dashboards, developers were able to rapidly seek out feedback and incorporate not only user "needs," but user "wants" as well. Third, when employees made comments or suggestions, engineers or managers were assigned to address their inquiries and made accountable for ensuring they had been followed up on. Thus, factory floor level employees knew their voices were being heard, and felt empowered to speak up about proactive process or environmental improvements. Last, developers actively engaged in holding classes to teach employees how to use VBS, and even venture into their workspace to help troubleshoot whenever possible. Moreover, the early adopters were empowered to teach their peers how to use the system and demonstrate subsequent advantages. Considering these factors, all stakeholders were able to adopt the system over time and participate in its continuous improvement.

5.3 Implications of VBS on Enterprise Transformation

With strong employee involvement and a high-level leadership support, adoption of the VBS system fostered a culture of getting things done. As employees are inputting data pertaining to material flow rates, the jobs they are working on, problems hindering productivity, and even innovative ideas for improvement – managers are equipped with an overabundance of data and information to remove waste from the manufacturing process and greatly increase efficiency.

Hallam (2003) asserts that leadership and transformation lean practices from LAI's Lean Enterprise Self Assessment Test, many relating to leadership commitment, employee engagement, and other themes expressed in this study, can be used as leading indicators to

measure lean maturity in both enabling infrastructure and lifecycle processes. In short, by measuring an organization's leadership in driving lean change (with consideration and support of employees) one can predict success or failure in the change initiative and its subsequent positive or negative affect on revenue generation. In Chapter 1, this theme is complimented by mentioning that employee engagement should be considered as well. Thus, in this section the implications of the VBS on transformation are explored by examining the leadership and employee factors that facilitate driving lean change. Six major managerial, cultural, and organizational benefits are identified – especially investigating the possibility of using employee engagement as a leading indicator for enterprise transformation. Additionally, not only every day operations considered, but enterprise transformation as well.

VBS can be used as a diagnostic for enterprise transformation, as it provides lagging indicators that provide insight regarding the pursuit of value opportunities and the avoidance of value crises. It is hypothesized that many atypical intangible factors – such as employee engagement, morale, and behavior – can be measured as a proxy for transformation by means of pursuing value opportunities. As follows is a discussion on general advantages VBS provides, as well as daily and holistic transformation implications of an enterprise measurement system in general.

In order to understand the implications of VBS on enterprise transformation, fifteen interviews were performed at Raytheon – with a population that consisted of end users, managers, engineers, and various champions. The advantages of using VBS were clear, articulated from the interviews into six points, including: (1) the wealth of fresh data it provides, (2) the visibility of that data, (3) providing fluid and constant communication (4) holding people accountable to ensure action items are followed-up on and the feedback loop is closed, and (5) fostering a culture of continuous improvement. In addition to these articulated advantages, there was a clear latent advantage that was continuously identified as critical with the advent and promotion of VBS within the Raytheon community: (6) employee engagement and empowerment.

The first three advantages of using VBS – (1) fresh data, (2) visibility of data, and (3) facilitating communication – are fundamental pillars of the VBS system and enablers for proactive improvement. Fresh, visible data gives decision makers confidence that they are acting on an accurate representation of real time events, and hence understand that quick and decisive

actions can often prevent disruptions in the system. Since managers can identify problems proactively or in real time, corrective action and root-cause analysis can be performed immediately, allowing for factory floor level workers and managers alike to communicate future prevention or improvement methods.

In addition to these fundamental advantages of VBS, there are more specific implications as well. Two of the most notable implications of the system on daily operations are (4) the rise of accountability and (5) encouragement of incremental improvement ideas. Not only do managers have the necessary information to make decisions, but any external customer or internal executive can see high-level metrics and how each individual cell is performing against their goals over time. This high level of visibility has created an intriguing phenomenon: individual and group accountability. As it is alluded to above, for every complaint or suggestion entered by a factory floor level employee, an engineer or manager is charged with following-up on the issue and ensuring the action item is addressed and feedback is given to the source as to the actions taken and why.

The other notable daily improvement VBS provides is the fostering of a culture that proactively seeks out incremental improvement ideas, in the spirit of lean. One way to look at the implications of the VBS is best explained by one of the pioneering architects of the system, John Day, who emphasizes that VBS is a continuous incremental improvement tool wherein "one-million and one $1 ideas are more valuable to the company than one $1 million idea." VBS does not suppress large-scale disruptive ideas for improvement; however, there is an inclusive environment that encourages all employees to share to provide input – regardless of the margin of value it is directed towards.

In addition to other notable implications of an enterprise measurement system on enterprise operations, there are other holistic transformation related advantages as well. Although the advantages discussed above provide critical insight regarding the implications of an implementing an enterprise measurement system, (6) employee engagement and empowerment is perhaps most important as a proxy for the proactive pursuit of enterprise transformation by means of value opportunities. This metric is paramount in measuring enterprise transformation since it depicts the momentum of the workforce. Thus, with an employee base of 3,500 in Andover, general trends in engagement could provide quite telling information.

Aside from depicting each individual's involvement in the organization, employee engagement activities provide a means for any worker to voice concerns at the factory floor level that might not be as clear as from management's perspective. By providing a mechanism for voicing these concerns early in the process, problems can be caught before negative consequences are felt. For management at Raytheon, understanding not only the population's engagement level, but their synergized ideas as well could prove quite useful.

Supporting Raytheon's reach into the heavily populated factory floor level of the workforce for insight, some research suggests that the cumulative knowledge of a population is greater than many perceive and much can be determined from their actions (Surowiecki, 2004). In this study, both researchers and practitioners comply with the grounding of this theory of crowd knowledge and converge to predict that more engaged cultures of greater size, which are empowered to identify value opportunities, will not only discover the $1 opportunities but will be more likely to unveil the $1 million dollar opportunities as well. Although engineers and managers have the tools to inspire change, it is naïve to underestimate the intelligence of thousands of highly engaged and specialized individuals.

Considering this justification for considering employee engagement as a proxy for enterprise transformation, it is important to consider what employees believe to be the critical characteristics that define engagement. Interview responses identified five characteristics of employee engagement that VBS provides: (i) giving people the desire and motivation to enjoy going to work every day, (ii) making employees feel valuable, (iii) having leadership support floor level operations and not just impose a "flavor of the month" type initiative on its employees to sporadically create interest, (iv) building trust based relationships and (v) providing employees with the level of training necessary to understand the value of the system in place and how to use it.

Emerging themes from these responses correspond to the "'4 P' model of the Toyota Way," embodied by the "four principle categories of Philosophy, Process, People/Partners, and Problem Solving" (Liker, 2004). In particular, the category most closely relating to employee engagement is the focus on *people and partners* – which emphasizes growing relationships through trust, mutual respect and teamwork. A depiction of the common themes extracted from interviews and how they relate to Liker's model is seen in Figure 5.3. At the base of Liker's

figure, "employee engagement" has been added – which, as will be portrayed, was ultimately accredited as one of the driving factors for success.

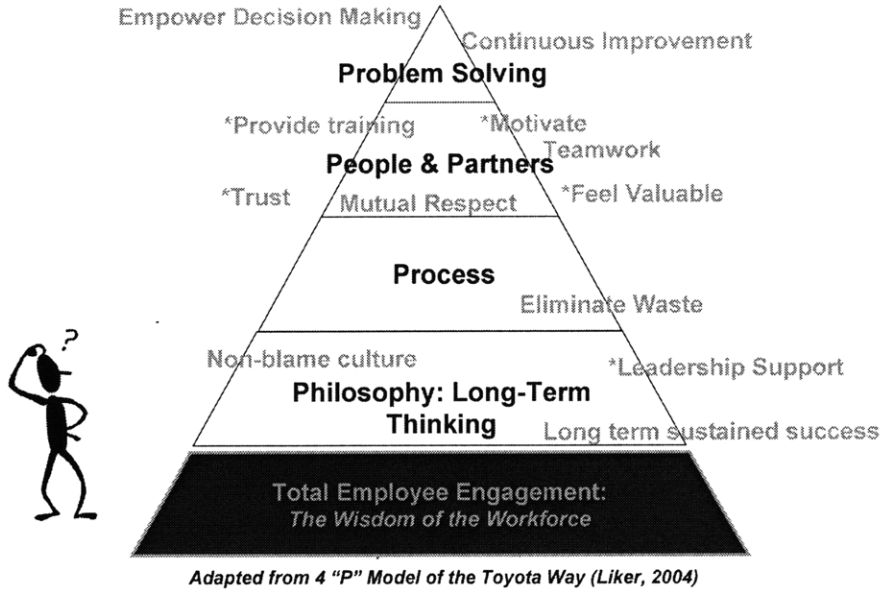

Figure 5.3 – Themes from Interviews Relating to Liker's 4 "P" Model of the Toyota Way

Furthermore, by using VBS as a tool for challenging employees in a supportive fashion, they are reinforcing their: *philosophy* of long-term sustained success; *processes*, by eliminating waste; and *problem solving* capabilities, from the continuous improvement and learning that results from employee engagement projects.

To ensure both a positive atmosphere and support from employees, Raytheon attempts to measure this oft considered intangible – employee engagement. Measuring employee engagement helps create a culture that fosters innovation and improvement amongst all employees, not just select motivated or chosen individuals. To ensure employees are actively – but not excessively – learning about VBS and innovating improvement ideas, this metric ("Total Employee Engagement" or TEE) is based on their participation in one improvement activity per month. This limitation ensures a degree of engagement for most can be achieved with negligible inconvenience, since one activity per month has the possibility of not being considerably time consuming. Additionally, this metric does not give incentive for people to manipulate the system

since it is binary, which means that one has either been engaged (can be just one event or hundreds) or has not. By rolling up this level to certain manufacturing cells or programs, decision makers can gather an understanding about the involvement levels of certain areas. Information about over-involved or under-involved sub-populations could reveal valuable insights to management, such as what programs have significant improvement needs, what programs have lost the support and interest of their workforce, or which programs are understaffed or overworked. Either way, this leading indicator can be used in a variety of manners for decision makers to proactively investigate value opportunities and prevent value crises.

5.4 Future Direction & Challenges of VBS

Now that some critical insights have been discussed from observations regarding the implications of an enterprise measurement system on enterprise transformation, this section discusses the future of the measurement system and challenges in sustaining it. Future opportunities include current extensions of the system to other elements of the organization such as engineering and suppliers, whereas the discussion on challenges of sustaining an enterprise measurement system is derived from factors identified by employee interviews.

In the spirit of continuous improvement and employing lean principles outside of the manufacturing world, Raytheon embarked on a project in 2008 with the goal of creating a dashboard for engineering progress. Ultimately, this dashboard should be adopted to assist engineers in both defect containment and defect prevention (Ho, 2008). Some of the critical metrics included: (1) out-of phase and in-phase defect reduction (phase with respect to the product development life-cycle "phases"), wherein defects found out-of-phase are costlier to address and ultimately all defects should be eliminated; (2) root cause identification, wherein engineers document the systemic problem, such as dimension and tolerance concerns or documentation concerns; (3) change notification (CN) first past yield, which is an indicator of if engineering work is adding value to the project; and (4) engineering work-in-progress (WIP) (Ho, 2008). As the impact of this initiative cannot be seen yet, it is hypothesized how these metrics will influence the VBS enterprise in Table 5.1, in terms of structure, function, and value delivery. In italics, one can see some of the generally anticipated positive consequences of these

new metrics. Capitalized, some issues to look out for are identified. Identifying the negative consequences ensures introduction of these well-intended metrics does not produce unexpected adverse effects. Although this exercise is by no means precise or exhaustive, it provides a simple method decision makers could use for analyzing the effect of the introduction of new metrics on the VBS enterprise.

Table 5.1 – Hypothesized Implications of VBS Engineering Annexation

		Structure	Function	Value Delivery
Engineering Metrics	**Out-of-Phase & In-Phase Defect Reduction**	*Engineering departments will communicate more, with themselves, the customers, and manufacturing – in hopes of preventing problems before their weaknesses are exposed*	*More incentive for workers to ID defects proactively*	*Less re-work is needed, cost of product decreases*
	Root Cause ID		*ID areas of improvement & discrepancies*	*Confusing or contradictory documents or issues can be addressed*
	CN 1st-Pass Yield		HESITATION TO CONSIDER MINOR CHANGES	*Higher quality CNs*
	Engineering WIP		*All issues considered in a timely fashion*	QUALITY DECREASE (NOT ENOUGH TIME SPENT ON EACH ITEM)

From this exercise, it is evident that Raytheon's VBS group has identified metrics focused at identifying and eliminating waste. The only possible negative consequences are with respect to: (1) high rates of CN 1st-Pass Yield could lead to hesitation to produce a CN for fear of rejection, which could result in the loss of insight regarding various concerns; and (2) quick turnover of Engineering WIP, which could put pressure on engineers to forgo quality and perfection just to have an action item completed.

The second extension of the VBS system was aimed at bringing in closer relationships with suppliers, allowing them greater visibility into relevant program data that affects their respective supply stream. The implications of success could be monumental, integrating the value stream to allow for complete transparency and synergy in operations. However, there have been road blocks to the success of this project as one might expect, with issues regarding trust, exposure, and security. According to one of the Raytheon project leads, "We significantly

underestimated the organizational and security hurdles we'd need to overcome to make our application accessible by suppliers outside of Raytheon's network." Hence, while it is important to spread the benefits lean thinking and tools outside the organizational scope, it is important to understand that suppliers with different levels of lean maturity might face higher barriers of adoption than others.

Challenges & Recommendations

Although the development, adoption, and success of VBS have been well articulated, there are still many challenges inherent in this and any measurement system. As it is acknowledged that employees will often find creative ways to manipulate any measurement system, some of the critical flaws are identified up-front in order to minimize their potential to undermine the initiative's momentum. Thus, in this section recommendations for improvement are provided for the four most commonly articulated weaknesses with VBS as determined through employee interviews, which consider:

(1) employee engagement and the aging workforce;
(2) resistance to measurement;
(3) information misinterpretation or allowing management by numbers to prevail; and
(4) information saturation for managers and touch laborers.

In general, challenges (1) and (2) provide a threat to the structure and the function of the enterprise, as not addressing these issues could lead to a breakdown in interdepartmental communication or corroding relationships amongst employees. With respect to challenges (3) and (4), managing by numbers or information over saturation could lead to impedance of value flow as managers are not sure which information to act on or act on the wrong information.

First, one current demographic trend that will continue to have an increasing influence on the United States as a whole in years to come is that of the aging workforce (DeLong, 2004). With the age of the average worker already higher than ever, there are many problems companies begin to face, such as: (i) workforce turnover rates rapidly increasing, leading to significant knowledge loss; and (ii) motivation decline. The amount of knowledge lost when workers retire can be considerable. Delong (2004) points out the following example, in consideration of the defense industry.

When a senior nuclear weapons designer retires from the Los Alamos National Laboratory after 30 years he leaves no one in the lab who understands the design of missiles built in the 1950s and 1960s, which are still deployed in military bases worldwide.

With a turnover in the workforce, there is also an increase in pension resources that begin to be drawn from the company. As experienced employees retire, new-hires will come in that have minimal knowledge about how to perform their job and are unfamiliar with the Raytheon culture. Hence, this high-turnover leads to significant training that needs to be performed. To an extreme, when the founders of VBS leave, without thoroughly trained champions of the system it could be easily used incorrectly, or not adapted over time to meet the needs of the dynamic enterprise.

In addition to the turnover itself, there is a general motivation decline that occurs with many older employees. Currently, the average age of the worker at Raytheon that interfaces with VBS is approximately fifty-five years old. Even though some of these workers may have ten or so years left in their careers, many have been there for an extended period of time and are not as motivated to learn a new skill compared to some of their younger counterparts. From the results of the interviews, it was clear that although many workers cared about VBS and wanted to see it succeed, they were not motivated or put any extra effort into the system since they were more concerned with performing the job they knew how to do the way they new how to do it – then going home when they could to take their minds off work. Understanding the inevitable monotony that is often closely associated with staying in one or a few similar jobs over the course of a career, such a phenomenon can be understood.

Recommendation 1: In order to counter the potentially negative consequences of an aging workforce, programs can be tailored to their veteran employees. One method of counteracting these negative affects would be to provide incentives for workers to continually improve their skill set – perhaps by adding or emphasizing the criteria of learning a new skill in performance reviews. Some research suggests that "older workers may be reluctant to go for training because they feel it's demeaning for them to find themselves in a classroom," but points out that managers need to make sure their employees "understand that training is essential and ongoing –

not a sign that people don't know what they're doing" (Zetlin, 1997). In addition to being cognizant of encouraging these training activities, the author also points out that (a) extra training needs to be provided for new technologies, and (b) that management needs to both formally and informally ensure older employees pass along their unique knowledge prior to retirement. Considering technological training, one recommendation for promoting adoption amongst elder employees is simply providing them ample time to experiment with systems and equipment hands-on. Management can also avidly promote documentation of continuity – in the form of job responsibilities and processes that help get the job done every day. In fact, actively participating in the documentation and dissemination of this tacit knowledge could be seen as positive employee engagement and credited toward their personal engagement metric.

Moreover, research suggests that older employees "respond more to intrinsic rewards such as a pat on the back for a good job or a feeling that work is a meaningful activity," and also that "extrinsic rewards such as pay and promotion seem to be less important for older workers" (Kauffman, 1987; from Bourne, 1982). This heuristic is consistent with interview results, as one older employee emphasized the desire to have "VBS Day" as a reward to employees. For this event, it was proposed that employees could have a barbeque or relaxed social environment in which they could both learn more about the system and also feel positive reinforcement from management for their efforts in assisting in the adoption and successes of VBS. Although not all interviewees had the creativity embodied by "VBS Day," they all similarly articulated the relative of importance of similar intrinsic rewards as opposed to the extrinsic ones management often considers as the primary motivational factors.

Second, with a system that intensely collects massive amounts of data at frequent intervals across the enterprise, the business units, and even individuals; it is possible that many employees would feel paranoid that the governance structure might be watching over them too closely. Such a fear leads to an increased stress level in the workplace, and ultimately higher numbers of unsatisfied employees.

Recommendation 2: One way to mitigate this potential harm to the system and its authority is to show, by actions, over time that the data will not be used for perverse or ambiguous reasons. Without establishing this trust, many will feel the "BIG BROTHER IS WATCHING YOU" paranoia George Orwell (1949) articulates can manifest in a population when governing bodies act in a totalitarian manor and abuse available information. As long as

employees have input as to how the metrics are being used to make decisions, this potential threat can be minimized. To avoid employees from becoming too paranoid about management watching over them, strict policy regarding information use needs to be developed. By never punishing individuals for poor performance strictly determined by VBS and continuing to develop a culture oriented around finding solutions as opposed to dwelling over problems, this possible negative implication can be contained.

Third, there are second-order effects that might occur when management has such a tool at the fingertips, to include becoming overconfident in the system and perhaps blind to the environment. For example, in one interview an employee stated they were able to infer from another business unit's efficiency chart (efficiency in tasks completed as a function of time) that external pressures had been put on the unit and they may be facing bad news soon. However, to the VBS pioneers and many others, such an assertion may seem absurd with only a day or so of productivity data available at a glance. Although this example is arguably an extreme regarding how one can use data available to make uninformed assumptions, it portrays how workers may gain a false confidence in their ability to see numbers and interpret their meaning within a dynamic environment.

*Recommendation 3: D*ecision makers will need to maintain a strict level of discipline in never becoming too dependent on the data available and also maintaining close relationships with their employees. These actions will help prevent management by numbers, and will allow a continued understanding of the context from which the information is drawn. To address the negative second-order management effects, one simply needs to reaffirm the company standard of acting with proper information. If there are abnormalities in metric reporting, managers should inquire and gather knowledge before determining root causes. With this recommendation, it is suggested that a thermostat approach be employed (as discussed in Chapter 3), wherein periodic feedback informs management which metrics to emphasize based on the enterprises current performance and where historical data dictates they need to be to ensure short-term and long-term success (Hauser, 2001).

Fourth, even when management is carefully implementing a thermostat approach the problem of having an information overload may occur in instances when vast quantities of data are available – a phenomenon often describes as either management by numbers or analysis by paralysis. In these situations, management could easily fall victim to the performance

measurement sin of inanity, wherein companies "seem to implement metrics without giving any thought to the consequences of metrics on human behavior and ultimately on enterprise performance" (Hammer et al., 2007).

Recommendation 4: In situations such as these, it is critical that decision makers remember to measure the critical few things that matter, as opposed to the trivial many (Hubbard, 2007). In addition to the benefits of simplicity from focusing on a few critical metrics, employees will be able to mentally manage their metrics without feeling overwhelmed. By only emphasizing a few metrics, managers can easily avoid inanity by considering how their metrics affect their employees' behaviors. Although these simple recommendations may encounter implementation resistance in practice, they nonetheless provide a basis for proactively avoiding considerable challenges commonly observed in practice.

The Future of VBS & Transformation

As with any emerging technology, VBS is susceptible to the myopia phenomenon – wherein near term effects are exaggerated and long-term effects are understated (Oye, 2008). With VBS, the short-term improvements are brought front and center through the use of visual displays while the long-term challenges associated with organizational change and employee motivation may be understated. This result could assist in getting near term buy-in but may increase the risk of acceptance of use due to the neglect of organizational dynamics. As another example relating to the expanding scope of VBS, although the ability for VBS to improve enterprise transparency and value delivery by introducing supplier networks might be exaggerated due to unforeseen organizational and bureaucratic hurdles, its ability to be used as a long-term leading indicator of organizational transformation may be understated.

Understanding the strategic direction of VBS extensions and the challenges at hand, one of the next steps could ultimately be the proactive monitoring of transformation to obtain a real time gauge that indicates if one is in the mode of opportunity exploration or crises containment. Although transformation cannot absolutely be measured by just one or two metrics, Raytheon can draw from the wisdom of the crowds by using an employee engagement dashboard and the wealth of employee knowledge.

5.5 VBS Case Study Conclusions

From analyzing the Raytheon Company's VBS system, insights have been gathered about challenges and recommendations for how to develop and implement an enterprise measurement system. Additionally, a wealth of insight that confirms the ability of a bottom-up measurement system to drive enterprise transformation has been found, with the help of the atypical employee engagement metric. However, investigation of whether or not a top-down measurement system can be used to drive enterprise transformation still needs to be performed – which is covered in Chapter 6. Ultimately, understanding the practical implications of how an enterprise measurement system can assist organizations to increase: adoption potential; success of the system itself; and determining leading indicators, such as employee engagement, for transformation. After both case studies have been completed, a more holistic and generalized enterprise level analysis of metrics considerations in transformation can be performed.

Chapter 6

Case Study 2: The Corporate Enterprise Metrics Dashboard

One of the measurement trends identified in Chapter 3 was the traditional to contemporary shift, wherein corporations are moving away from older financial-based metrics in favor of more balanced systems that incorporate an array of non-financial metrics (Burgess et al., 2007). In order to gain a holistic understanding of measurement systems in practice, one of these contemporary macro level systems in practice is now explored. With this shift, there has been increasing pressure on researchers and practitioners to articulate that value of initiatives or metrics that cannot be easily converted to a dollar amount depicting its contribution to the bottom line. Although many successes in balanced scorecard and non-financial measurement approaches have been documented, skeptics note that it is highly plausible that previously higher performing firms have been more likely to adopt these contemporary measurement methods (co-variation as opposed to causation, also mentioned in Chapter 3). Thus, in this case study a holistic analysis is performed of a macro-level and contemporary measurement systems' effect on the enterprise – with the end desire of depicting how such a system can be leveraged to drive transformation. This chapter now describes: the background for the case study, internally identified measurement issues, and a holistic analysis of the system and its relationship with the enterprise.

6.1 The Corporate Metrics Dashboard & the Measurement Community

To perform research that helps fill the knowledge gaps identified, a case study with ACME Corporation was performed – a primary aerospace defense contractor with revenues of over $20 billion (USD). This case study involved partaking in a two day intra-corporation measurement community workshop and multiple interviews with the corporation's Enterprise Measurement Lead. In order to gauge corporate health, this measurement community oversees a non-financial based enterprise measurement system that provides leadership with actionable metrics for decision making.

Every month, ACME leadership is shown the corporate metrics dashboard that displays their top-level metrics (similar to the one shown in Figure 6.1.). There are thirteen top-level metrics, nine of which are shown per month as metrics are rotated in and out of the dashboard.

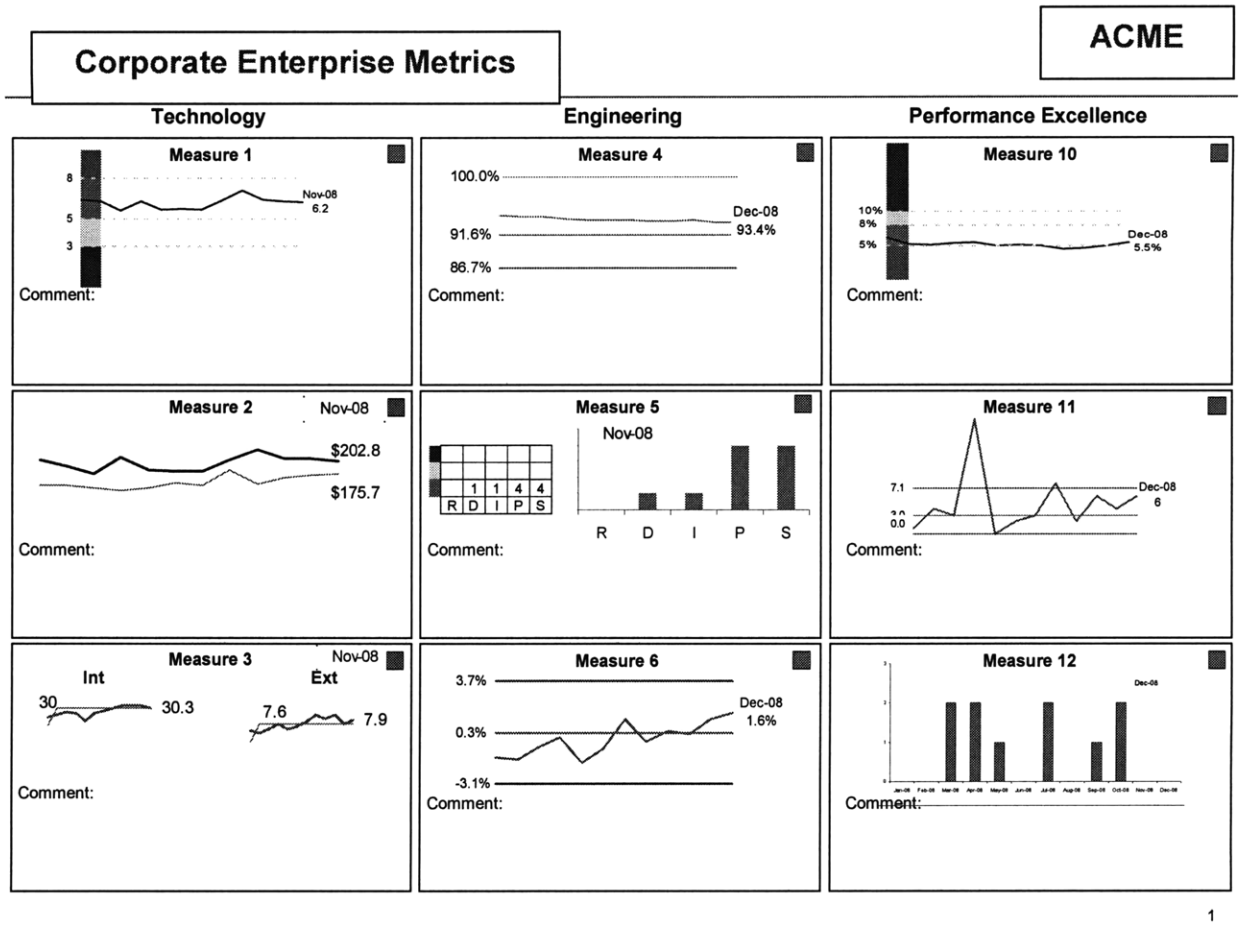

Figure 6.1 – ACME Corporate Metrics Dashboard

These metrics consider a broad range of enterprise activity, including metrics for: technology, engineering, operations and manufacturing, and quality, and performance excellence. As it is the corporate policy that the measurement system should mature over time with the enterprise, new metrics can be stood-up and older metrics can be removed from the dashboard if they become no longer useful.

For new metrics to be implemented, the process can be quite time consuming. First, it could take up to three months to communicate amongst all of the business units and functional areas to gain acceptance of a standard definition. After an initial definition is presented, six months of collecting and refining data is necessary to form a more concrete and supported

redefinition of the metric. Such an intensive process may seem redundant, but is necessary to ensure enterprise-wide understanding of the meaning of the metric and data integrity. In fact, there are often fundamental terminology misunderstandings from the executive level to the factory floor that can lead to an array of problems. For example, the term "defects" can commonly be misunderstood amongst software or hardware products, different projects, or even different business segments. Rework is another metric that tends to be misunderstood since certain business segments or functions may interpret definitions differently. In short, if decision makers can't trust the roll-up of the information, there is no value in presenting the metric. Thus, an intensive process needs to be in place to ensure data integrity, common agreement and understanding of a metric.

When the metrics are presented in their dashboard format, they are color coordinated with a derivation of the stoplight philosophy – blue indicating better than expected progress, green indicating that nothing is wrong, yellow foreshadowing a potential bottleneck or problem in the system, and red indicating a problem in need of immediate attention. For yellow and red metrics, causal analysis are available that will detail what has happened, the business impact, and the plan for corrective action. Keeping the number of metrics in this typology down, leadership can thoroughly review their core metrics to gather a holistic understanding of the health of the enterprise and its future trajectory. However, if there is an issue or point of interest regarding one of the out-of-phase metrics it is discussed regardless, in support of the "let there be no secrets" management philosophy.

A cross-functional measurement community of practice (MCOP) within the enterprise engineers and maintains this effort, with representatives spanning six business segments and six functional areas (approximately 150 people). In support of this corporate enterprise dashboard, the MCOP partners with business leadership to be responsible for the *"development, establishment, and execution of a high-maturity, industry-leading common measurement strategies enabling improved bottom line performance for [ACME] and customer."* Furthermore, the MCOP has identified seven methods to help accomplish this goal:

- defining, deploying, and evolving company level measures for roll-up and analysis by business and executive leadership;
- creating a measurement communications network;
- building a data savvy culture across ACME;

- supporting company & business level leadership team's measurement initiatives;
- fostering a continuous improvement culture based on measurement;
- analyzing and sharing core measurement data across businesses; and
- recommending company wide measures to the ET&MA sponsored councils.

Before one can analyze how the MCOP as a sustaining corporate measurement system influences the enterprise as a whole, it is necessary to develop an understanding of the mechanisms of the community and the issues that face them on a day-to-day basis. This next section takes a deeper dive into self-identified topics of interest to the measurement community.

6.2 Internally Identified Measurement System Issues

In support of executing this mission identified above, the MCOP meets twice per year in person and also engages in bi-weekly meetings or even more frequently as needed. These meetings identify and discuss high-level enterprise measurement challenges, which are examined to provide insight as to why such an overwhelming majority of high-level metric-facilitated transformation efforts appear to be unsuccessful (as seen in Chapter 4). In order to understand the MCOP culture and the issues that they are faced with on a daily basis, insight is used from participation in one of their semi-annual meetings. Thus, section will briefly discuss some of the most current and pressing topics, to include: (1) agility and flexibility; (2) failure modes; (3) the relationship between measurement systems and information technology (IT); and (4) other current issues of interest.

Agility & Flexibility of Measurement Systems

In the consideration of any measurement framework or corporate measurement dashboard, there is almost an implied degree of rigidity. The question of importance to measurement communities often becomes, how much flexibility can we add without over-complicating the system or obscuring the data and making it non-actionable? Too much flexibility could cause dangerous challenges, since if every business segment began to define each metric in their own non-standardized way a rolled-up measure would lose its value.

In general, the MCOP is exploring their hypothesis that often only a marginal cost is necessary to make a measurement system flexible. Traditional rigid measurement systems often have a large maintenance budget, only meet minimal specific reporting needs, analysis is not easy without investment of time and money, and information is only collected on what is needed today. Contrastingly, the flexible systems that decision makers need should have information for multiple reporting needs, where analysis can be performed by the user and more forward looking information is collected on what will be needed tomorrow. Ultimately, the group came up with three critical attributes for a flexible system: (i) *data integrity* – having well documented and defined metrics, owners for each metric, and a centralized method for data exchange amongst databases; (ii) *scalability and usability* – having tailorable reporting capabilities for different users with a friendly interface, and being applicable for large and small programs; and (iii) *relevance and feedback* – the ability to signal when critical thresholds have been met, determine a problems' root-cause, drive the right behaviors, depict interdependencies between metrics, and have predictive business capabilities.

Failure Modes of Measurement Systems

As mentioned in Chapter 4, many transformation and measurement initiatives fail – significantly more than those that succeed. Some of the most commonly understood root causes of failure identified by the community included: building just a reporting system, trying to automate when a system is immature, not involving stakeholders, and not having sponsorship or maintenance in place. However, in addition to these commonly understood failure modes, a unique and less understood measurement foe was also identified – the results themselves. For example, the members strongly believe that failure can be accredited to: non-actionable results, using results to punish instead of improve, not understanding the true relevance of the results (or not producing relevant results), having results that are not trusted or that lack integrity, and even not sharing cross-functional results and only looking at a smaller segment than necessary. Although most of these follies may be intuitive, in a results based corporate culture it seems only appropriate to investigate the results to determine the problem. If every measurement system is designed and maintained to give outputs that avoid the follies identified, remarkable improvements could be made to the approximate one-in-ten success ratio of transformations.

The Relationship with Information Technology

One of the third major discussion topics amongst the MCOP for this meeting was the relationship between measurement efforts and IT. In fact, the MCOP brought in representatives from IT for the workshop in order to incite more productive communication and insights regarding methods of perseverance in the face of any obstacles they could together identify.

One of the first insights between the MCOP and IT was that both groups need to be communicating together from the inception of any measurement system effort. If an operational unit creates their own measurement system, in practicality IT cannot assist in the maintenance or improvement of the system since they were not a part of the development. This struggle had occurred within one of the business segments, and all stakeholders fear similar examples could lead to sub-optimal enterprise performance. On the topic of conversation, it was noted that not only is collaboration between the right stakeholders important, but it needs to take place at the right time. For example, to scope a particular task the end user needs to be involved in a measurement system project from the concept development phase – not just the requirements phase. Starting right from the conception of the project, a cross-functional integrated product development team should also periodically review progress as they would any other program. This iterative incremental development process would help provide feedback from all stakeholder voices in a timely manner to help avoid rework.

In addition to the need to bridge the communication and collaboration channels between measurement community members and IT, there are corporate and cultural barriers that have been erected as well. With respect to corporate barriers, different business may fund IT in different ways, which can make purchasing a new tool or any joint-development project difficult. Moreover, different groups may desire to budget more for IT assistance, and since IT has limited resources some stakeholders may not be able to receive assistance in the most prudent manner possible creating sub-optimal enterprise production. Thus, many groups tend to forge a pseudo-adversarial relationship with IT, as they are often viewed more as a supplier than an internal support function. Considering the cultural barriers, many of the engineers and managers (in or interfacing with the measurement community) do no not understand IT well. IT also suggests that it is not easy to write requirements or articulate the actual need of the system, and often an initial misunderstanding can lead to cost, schedule, or capability creep due to this initial level of unfamiliarity with the process and how IT works. Ultimately, IT and the MCOP were in

agreement that: (i) a partnering relationship to reach a common solution needs to be pursued, (ii) IT needs to be viewed as an agent of change as opposed to an external supplier, and (iii) that top level requirements need to drive the solution being jointly worked toward.

Other Topics

Additional topics on the agenda for the semi-annual meeting considered the business case of measurement systems, the role of sponsors and stakeholders, governance, vision and requirements, planning, life-cycle management, and design. Due to time restraints and momentum of working groups, not all topics were dissected in as much detail as those above, but nonetheless were discussed. This section notes some of the highlights corresponding to these themes.

Foremost, throughout all discussion exercises the general problem of role identification appeared of paramount concern. In particular, the relationship between sponsorship, stakeholders, and governance was found to have a unique organizational dynamic that can prove tense at times. The role of a sponsor will often depend on the size and cost of the project, with sponsors more likely to engage in hands-on oversight of high profile projects whereas they may just sign-off on less visible projects. However, most scenarios are not as clearly defined as this statement may imply. Often the role of the sponsor is uncertain and could result in hold-ups during gate or status reviews if they are not kept informed. In addition to the role of the sponsor, stakeholder uncertainty presents problems as well. For instance, how is one to design a system considering potentially high turnover of stakeholders or a broad user base? In fact, many times IT is forced to design systems for users they haven't met and cannot communicate with (especially future users).

Despite these issues, many proactive risk mitigation techniques can be performed. For one, by executing an incremental development style IT should be able to frequently pilot the system to receive feedback and evaluate deployment options – similar to the development seen in Chapter 5. Furthermore, continuity between organizational positions and responsibilities needs to be more fluid – to include the transfer of ownership of a metric or a system when appropriate. On the point of ownership, governance of a metric or measurement system was identified as a complex issue. In the strict sense of the word, does a specific business segment own a system (and hence have editing and other powers) that they have paid IT to create? Intuitively yes, but

if the system draws from databases in other areas of the corporation, some of which IT may own and maintain, there will be ambiguity. Being an aerospace defense contractor there will also constantly be a steady stream of classified and secret programs, which presents another significant barrier for data extraction and interpretation. In some situations, standing up a metric or a measurement system could unintentionally lead to the visibility of information that should not have been made available.

In considering role identification, someone needs to have the authority to decide how long a corporate metric or measurement systems stays in existence. Organizational momentum alone could leave some metrics on a dashboard well beyond their usefulness, and hence a review process needs to be in place to assure that measurement is not taking place simply to maintain the status quo. In short, a clear identification of the roles and responsibilities of sponsors, support (IT), users, and any other stakeholders needs to be carefully considered at the conception of any measurement project to avoid bureaucratic tie-ups and perhaps failure.

6.3 Influence of the Eight Views of the Enterprise

From these experiences communicating with the MCOP community, participating in this workshop, and interviewing the Enterprise Measurement Lead as a follow-up to the workshop, these insights can be evaluated in a formal manner by performing a proper analysis of the impact of the corporate enterprise measurement system on the enterprise. The enterprise, as defined for this analysis, consists of ACME Corporation's six business units and six functional areas. To perform a holistic analysis, an enterprise architecting framework developed by the LAI is used to help researchers and practitioners in understanding complex high-level enterprise interrelationships. This method, known as the Eight Views of the Enterprise, provides an array of different perspectives to analyze interrelationships, ensuring any analysis considers how each of these broad factors influences the enterprise. The eight interactive views referenced in this method are strategy, process, knowledge, product, service, IT, information, and policy – seen in Figure 6.2 below (Nightingale & Rhodes, 2009).

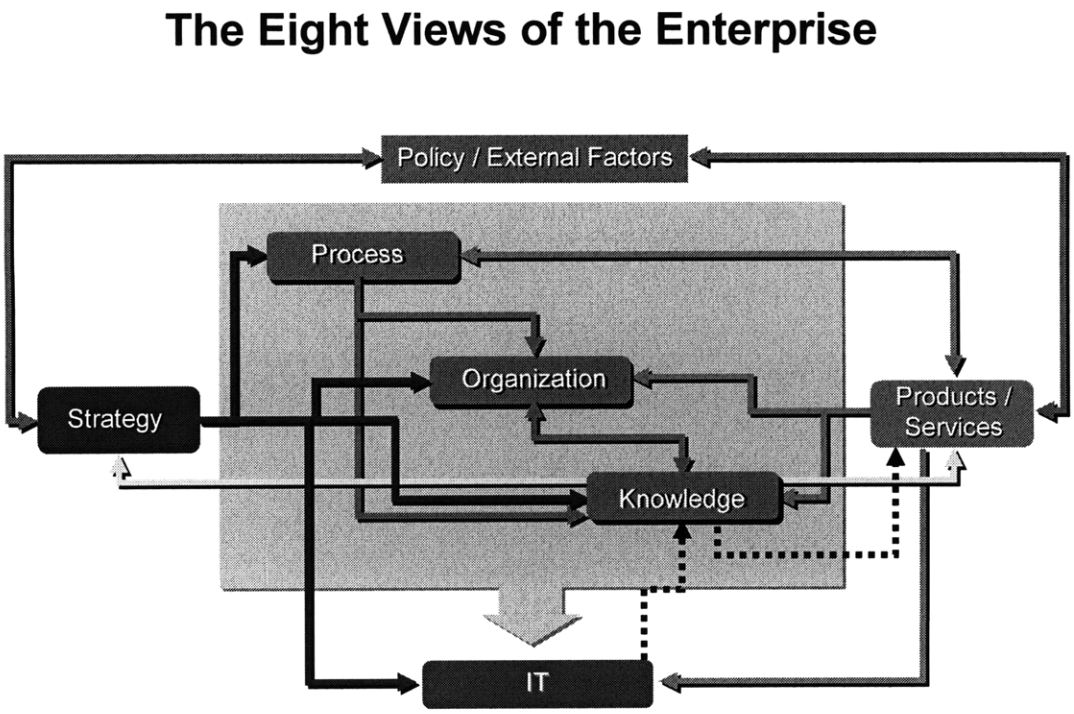

Figure 6.2 – The Eight Views of the Enterprise (Nightingale & Rhodes, 2008)

Given this framework for conducting an enterprise level analysis, a start point should be determined for analysis considering all the interrelationships depicted in Figure 6.2. Foreshadowing this problem, insight had been sought insight from the greater aerospace measurement community regarding the importance of the views during the making of the initial survey conception of this research. After being taught how the eight views of the enterprise tool was commonly used for analysis, the aerospace measurement representatives that participated in the survey from Chapters 1 and 4 were asked how important they regarded each of the views on a scale of one to eight regarding enterprise transformation, one being the least important and eight being the most. The results from this exercise are seen in Figure 6.3. To use the results of this survey as a guide to the discussion of enterprise views, two assumptions are made: (i) that the cumulative aerospace measurement community voice is representative of ACME Corporation's MCOP; and (ii) that the scope of the question can be expanded to transformation facilitated by a measurement system. Due to the highly specialized nature of the community the

first assumption can be made, and since measurement systems are a tool to measure and guide transformation the second assumption can be made for the purposes of guiding a discussion and analysis.

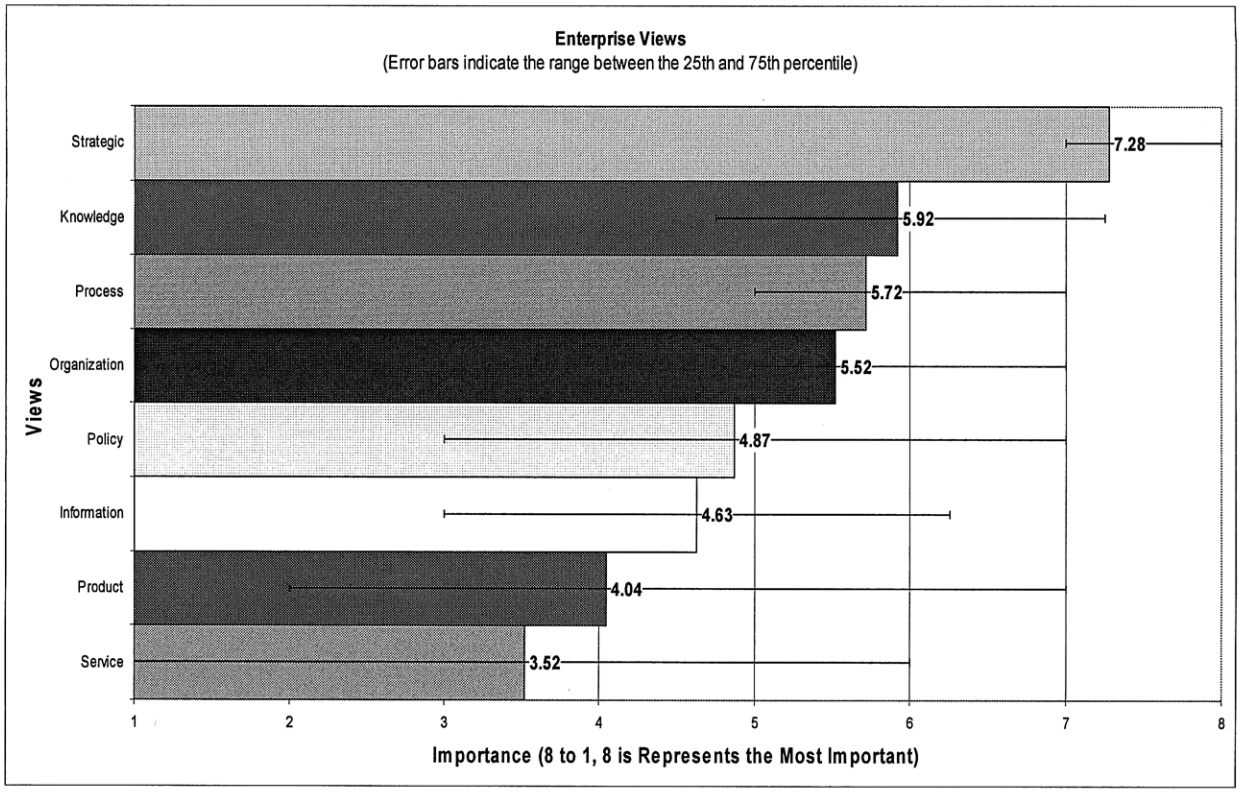

Figure 6.3 – Importance of the Eight Views of the Enterprise (n=25, 1=least & 8=most)

For simplicity, the following discussion is segregated into two groups: (1) the views with the top four scores – strategy, knowledge, process and organization; and (2) the views with the lower four scores – policy, information, product, and service.

Strategy, Knowledge, Process, Organization & the MCOP Enterprise

Strategy. First, the greatest highlight from the measurement community's answers was the unequivocal importance of strategy on enterprise transformation. This result could have been predicted, since many corporate measurement systems align strategy through their measures, and ultimately their high-level metrics serve as the only gauge a company may have for determining corporate health, nonetheless transformation progress. When interviewing the Enterprise

Measurement Lead, it was confirmed that the corporate metrics dashboard is primarily considered a broad mechanism for strategic execution. In addition to helping improve capabilities by becoming smarter, better, faster, and cheaper – some dashboard metrics are used to help identify growth potential and ensure a diversified portfolio of projects as well. Strategically, the dashboard helps foreshadow future areas of concern as well. For instance, if the percentage of research and development expenditures paid for internally continues to increase over time, decision makers will need to consider which areas of the enterprise will have the greatest need for the scarce resources. With the dashboard covering a broad range of enterprise dynamics, it is a holistic gauge of strategic corporate health.

Knowledge. Second, the measurement community has a unique bond around their ability to create and disseminate knowledge. At the two-day workshop which identified the issues in the previous section, a plethora of specialized knowledge about the corporate measurement system was shared amongst the community. Moreover, the MCOP can be viewed as a mechanism for sharing data and communicating across traditional organizational boundaries (communication by only project or functional areas). With 150 people in the MCOP actively sharing information and representing all business units and functional areas – it is easy for knowledge to be disseminated throughout this large enterprise in an expeditious manner. In addition to the inter-community knowledge considerations, the metrics dashboard provides decision makers with all the knowledge they need to make decisions. For example, for all yellow and red metrics on the dashboard, a causal analysis brief is available that details: what the problem was, who was involved, the business impact, the schedule impact, and other pertinent details. This information provides executives with the common knowledge to determine how under control situations of concern are and the subsequent progression back towards normality. Thus, the MCOP plays a critical role in not only disseminating information across the enterprise horizontally, but their actions and decisions also provide corporate executives with the knowledge needed to maintain control over the health and direction of the enterprise.

Process. Third, process is discussed. In the strictest sense of the word, measurement is engrained in corporate processes. For example, all projects have critical metrics that need to be considered at every gate in the development cycle, internal auditing considers progress against expected metrics, etc. However, the importance of process is much more explicit than these typical examples may indicate. At the beginning of the two-day metrics workshop, one of the

participants asked the Enterprise Measurement Lead "should we be looking at people metrics, financial metrics, or…?" Without hesitation, the response was "we focus on processes." In fact, ACME reiterates that all enterprise metrics ultimately relate back to core business processes. When the MCOP defines a metric, all of the business adapt to it by integrating its collection and utility into their own internal processes, documentation, and business infrastructure. Thus, whenever any new corporate metric is under review the MCOP needs to consider deployment challenges – the effort needed to have the metric adopted in the manner intended without causing sub-optimization. Finally, as the maturity of the enterprise evolves over time, the corporate measurement system needs to grow in tandem. As communication and technological networks grow and become more complex, measurement systems can help convey critical information regarding enterprise health and trajectory. Furthermore, just like any product, a metric has its own lifecycle. When the utility of a measurement proves negligible or outdated, the system in place should be adaptable to remove ineffective metrics.

Organization. The matrix style organizational structure plays a critical role in enabling the measurement community to collect and disseminate information throughout the enterprise. Cognizant of this role of the community, it was architected to parallel the company structure, as can bee seen in Figure 6.4.

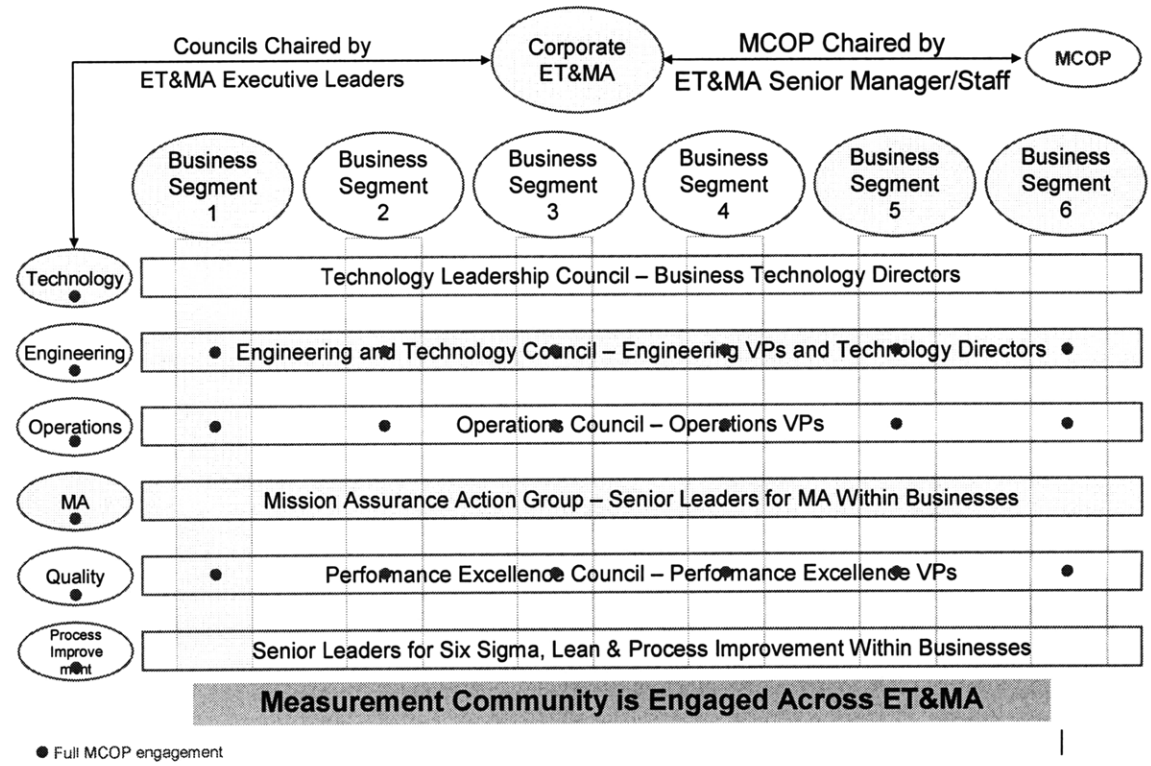

Figure 6.4 – ACME MCOP Structure

In addition to the knowledge sharing benefits already elaborated on, this structure facilitates the community's logistical needs as well. Like any organization the MCOP needs resources to function, in the form of personnel support, financial support and even facilities to conduct workshops. As businesses support the MCOP as overhead, support varies depending on the functional area. For example, engineering supports the effort without hesitation since they deal more with enterprise level issues that correlate strongly to the corporate measurement, but operations is more hesitant since there are no true corporate measurement specialists within their functional domain. Proportional to their degree of support, different functional areas have varying degrees of involvement. Thus, the Enterprise Measurement Lead has noted he needs to change his leadership and teaching styles depending on the group. However, this is not a negative result of the structure, since some functions may be significantly smaller than others (in personnel and resources) and hence do not need to be as involved as others, but rather need to be kept in the loop regarding the health and trajectory of the enterprise. Although this

organizational structure has worked well to support the enterprise, recommendations for improvement have been considered. In particular, when asked about what he would change from the current structure, the Enterprise Measurement Lead suggested three areas for improvement, namely: (i) fostering even more involvement at the Chief Executive Officer level; (ii) expanding the enterprise boundary by bringing supply chain considerations to the dashboard; and (iii) integrating the core financial metrics that are currently considered separately. A quick review of insights and their relation to the enterprise architecture framework for the top four scoring views can be seen in Figure 6.5, as the next four views are now discussed.

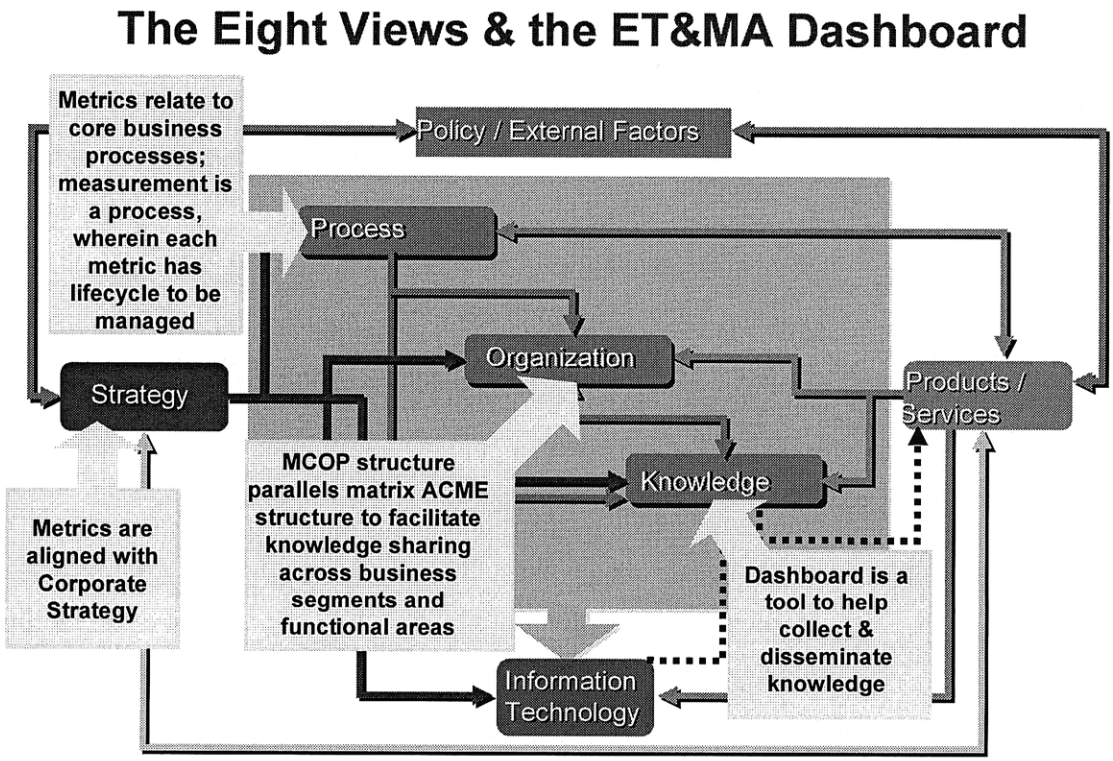

Figure 6.5 – Strategy, Knowledge, Organization, Process & the MCOP Enterprise

Policy, IT, Product, Service & the MCOP Enterprise

Policy. Moving into the views that appeared to be less of a consideration for measurement representatives, the policy view provides insights regarding enterprise activity as well. In general, there are four reasons for deploying policy – equity, security, liberty, and efficiency (Stone, 1997). From understanding the nature of a private, large-scale, national

defense related corporation – one might predict that security and efficiency would be the driving factors of policy in the enterprise. Policy implemented for security reasons would inherently be mainly driven through external parties (the United States or other governments) and would serve to restrict freedoms, whereas policy implemented for efficiency reasons would be driven by ACME management and would promote freedoms.

Regarding security-focused restrictive policy, ACME is subject to the International Traffic in Arms Regulations (ITAR) that controls the import and export of defense products and services. Additionally, in order to bid for defense related work from the United States government, ACME needs to maintain a Capability Maturity Model Integration (CMMI) Level 3 status, (processes are characterized for the organization and are proactive) which requires a great deal of overhead, corporate training, and ultimately oversight. Since CMMI is inherently a process improvement approach, however; this restriction does provide for a degree of process transparency that exists despite not being seen through the dashboard.

Conversely to security-focused external policies that set restrictions in place and dictate what needs to be done, ACME has its own internal policies that emphasize efficiency by allowing freedoms and encouraging innovation. For instance, the corporate policy of becoming more innovative drives the existence and support of technology metrics on the corporate dashboard. However, one could make an argument that there are efficiency-focused internally driven policies that are restrictive in nature. For example, to harness information across the enterprise the MCOP needs to standardize some aspects of metric reporting and collection. Any internal policies of this nature need to be watched closely to ensure they are indeed promoting efficiency by avoiding uncertainty and confusion at the corporate level, as opposed to imposing unnecessary bureaucratic hurdles in the ways of employees pursuing alternative means of productivity. These policy considerations and others are considered further in Chapter 7.

IT. In addition to the IT and MCOP communication and collaboration problems discussed in the two-day workshop, the Enterprise Measurement Lead expanded on the constant role identification struggle amongst these groups. There is a struggle between system ownership, wherein IT has a claim of systems on the basis that the information in the dashboards comes from their source systems, and the measurement community would argue that they paid for the system and are responsible for seeing it through the lifecycle. Fundamentally, one would think these groups should be able to work together in most situations to avoid sub-optimization. The

primary source of tension, however; stems from when the measurement community desires begins to use their own business infrastructure (BI) tools or commercial off-the-shelf (COTS) software for their dashboards. In these situations, the tension breeds from the fact that IT will lose some of their value and capabilities as home-grown tools become less frequent or useful. Although IT will almost undoubtedly always maintain their core capability of working best with large scale technical systems, over time it has been found that often the individual business segments themselves are better in dealing with sub-systems and smaller isolated endeavors.

Product & Service. Although the end result of ACME's efforts is often mission capable defense systems and services for the war fighter, the measurement community displayed a clear bias against this view through their survey results. This is not to say that the products and services resulting from their efforts are not important, but rather that their role as measurement representatives in facilitating transformation is a support role that is somewhat removed from the products and services themselves. Even despite this views' less-emphasized importance, many of the top level metrics relate specifically to the products themselves, such as defects, lead time, and others. In short, the insight from this view is that measurement does not drive the technology, but rather the products and the services are the starting point. Thus, with the core traditional metrics in place, the measurement community serves the support role of enabling the enterprise to produce their high quality products and services on time and under budget. Insights from the four lower scoring views are seen in Figure 6.6.

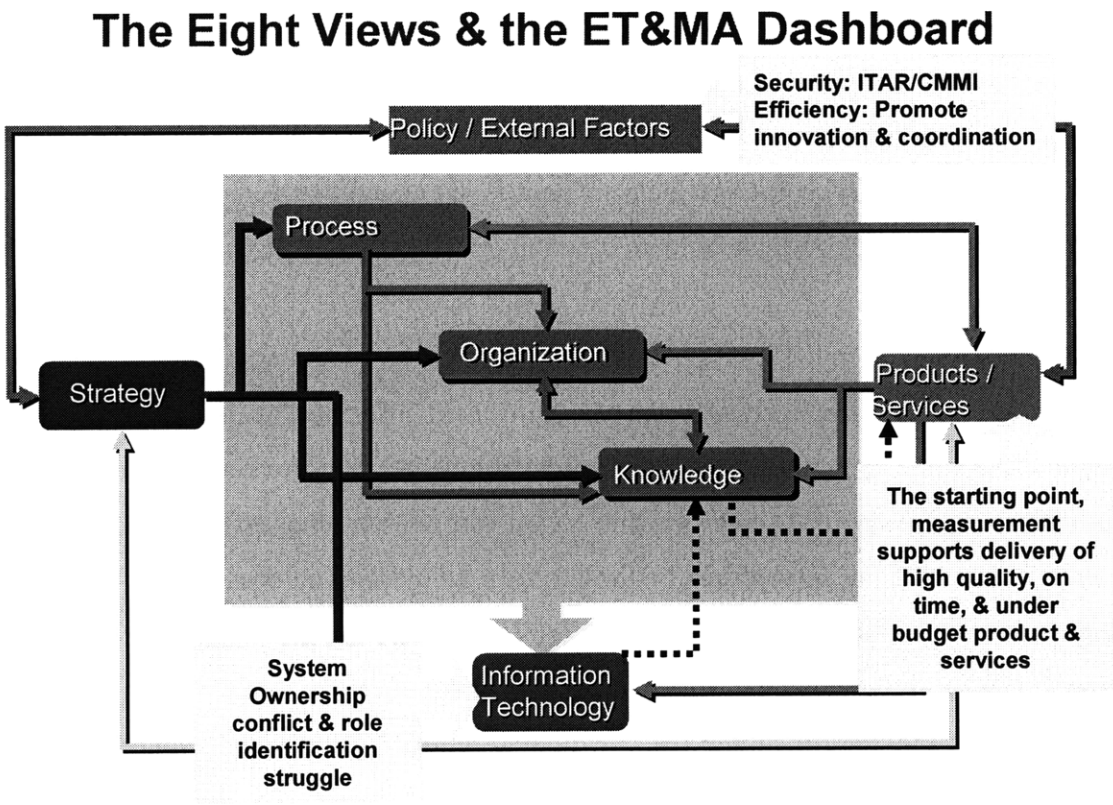

Figure 6.6 – Policy, Information Technology, Products, Services & the MCOP Enterprise

6.5 Corporate Enterprise Metrics Dashboard Case Study Conclusions

To complement and summarize this view analysis, information from these findings has been translated into the following into simplified structure, function and value delivery considerations.

Structure

The matrix set-up of the *organization* facilitates great communication amongst the enterprise. Additionally, by structuring the measurement community of practice parallel to the enterprise structure, it allows *knowledge* generation and sharing amongst a plethora of diverse individuals spread across the enterprise. However, one gap in the structure of the enterprise is with respect to *IT* and the MCOP. To quell this dilemma, the two departments need to further engage in role identification and interface management – keeping all stakeholders stable and content.

Function

As metrics align corporate *strategy* vertically from the executive to the operational level, change in strategy will lead to the emphasis of different metrics and ultimately will affect the way the organization functions – the way it acts and the relationships that are developed to get work done. Additionally, corporate measurement is engrained in business *processes* throughout the enterprise, affecting how stakeholders function on a monthly or perhaps even daily basis.

Value Delivery

Policy and External Factors have a significant influence on maintaining steady flow throughout the value stream. In large enterprises, policy and measurement play an important role in both balancing operational security while consequently promoting efficiency. Finally, the role of measurement and the importance of these views would be irrelevant if the enterprise value stream could not produce *products and services*. Ultimately, the structure and the function of the enterprise need to be architected, maintained, and manipulated in a manner that maximizes the flow of value to the enterprise and the customer – producing the highest quality products in a timely and cost efficient manner.

Insight from this view-focused enterprise analysis has now provided significant insight regarding the challenges facing macro-level contemporary measurement systems. In the next chapter, it is further discussed how this insight can be leveraged to help similar systems drive enterprise transformation.

Chapter 7

Integrating Metrics & the Transformation Roadmap

As introduced in Chapter 4, there are certain metrics considerations embedded throughout LAI's transformation roadmap. However, in its current form the understanding of metrics considerations in the roadmap is limited to some acknowledgement late in the planning cycle and in the execution cycle. For aerospace industry measurement community members, a more in depth picture of micro, macro, and general considerations is desired. Thus, in this chapter insight from the metrics literature review and the two case studies is used to provide a more holistic depiction of the metrics layer of the transformation roadmap. To present this insight, the roadmap will be walked through from the conception of the strategic imperative to the end of one full cycle – execution and the realization of the strategic implications of transformation – in the eight step structure seen in Figure 7.1.

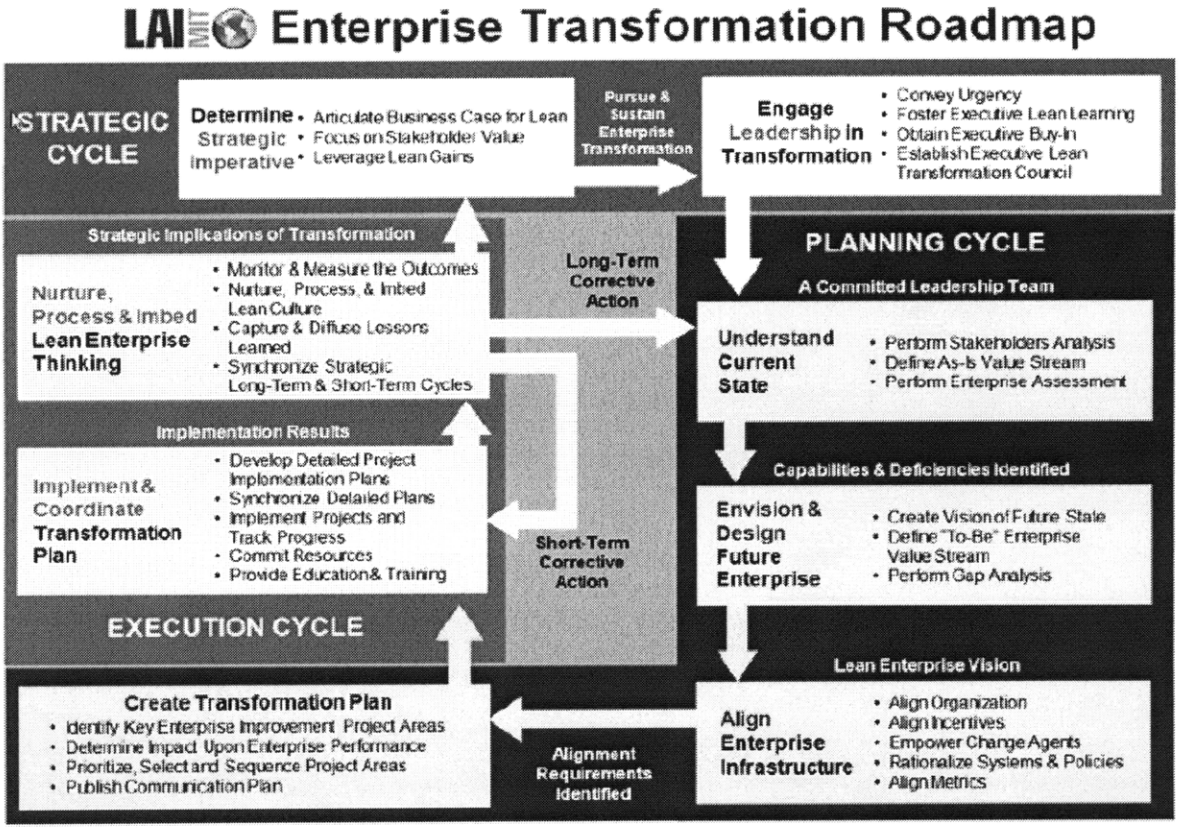

Figure 7.1 – Enterprise Transformation Roadmap (Nightingale et al., 2008)

7.1 Strategic Metric Considerations

Throughout the metrics literature review, survey feedback and the case studies alike, there has bee constant feedback regarding the importance of metric alignment with corporate strategy. As identified in Chapter 6, *"corporate measurement systems align strategy through their measures, and ultimately their high-level metrics serve as the only gauge a company may have for determining corporate health, nonetheless transformation progress."* In this section, relevant information collected thus far is related to the two steps of the strategic cycle of the transformation roadmap: (1) determining the strategic imperative and (2) engaging leadership in transformation.

Determine Strategic Imperative

In particular, at the commencement of a transformation initiative the Enterprise Transformation Roadmap is concerned with the ability to articulate the business case for transformation and lean, and the focus on stakeholder value. As far as determining the strategic imperative is concerned – metric considerations are somewhat limited. At this juncture, it is imperative that leadership understands the most general role of metrics in transformation, that metrics properly manipulated can help one motivate, monitor, coordinate, control and improve, ultimately acting as one of the core tools for facilitating enterprise wide improvement (Mahidar, 2005). Additionally, to help articulate the business case for transformation and lean prior LAI work and the literature review can be pointed at, which revealed how return on investment capitol (ROIC) and similar metrics can be used at a corporate level to articulate the value of lean (Kessler et al., 2003). ROIC depicts the value of lean enterprise transformation by its twofold inherent nature: (i) increasing the numerator (return), which is gauging how well the enterprise is *adding value*; and (ii) decreasing the denominator (investment capitol), which gauges how well the enterprise is *eliminating waste*. By convincing leadership that the transformation will add value to all stakeholders while also eliminating waste – the strategic imperative will be realized.

Engage Leadership in Transformation

Once the strategic imperative is realized, leadership needs to become actively engaged in the transformation initiative. Prior work from LAI identified in the literature review has shown that leadership engagement scores from Section 1 of the Lean Enterprise Self Assessment Test

(LESAT) serve as a leading indicator that can ultimately predict the success of a lean transformation (Hallam, 2003). However, insight from the MCOP case study has shown that, at least from the measurement perspective, stakeholders need to be more than engaged from the start. In order to leverage measurement systems that can facilitate transformation during this step, it is imperative that sponsorship and all stakeholders actively communicate to identify roles, responsibilities, and a structure of governance. Leadership can be engaged, but without coordinating amongst end-users, system architects, and management – misaligned efforts will result in marginal improvements at best. The aforementioned structure of governance should outline each stakeholder's authority and responsibility in leading or contributing to the initiative. Ultimately, it is the role of the sponsor to bring the stakeholders together, facilitate this communication, and following-up to ensure accountability.

Thus, the strategic considerations identified in this section for leveraging metrics and measurement systems to facilitate transformation can be seen in Figure 7.2.

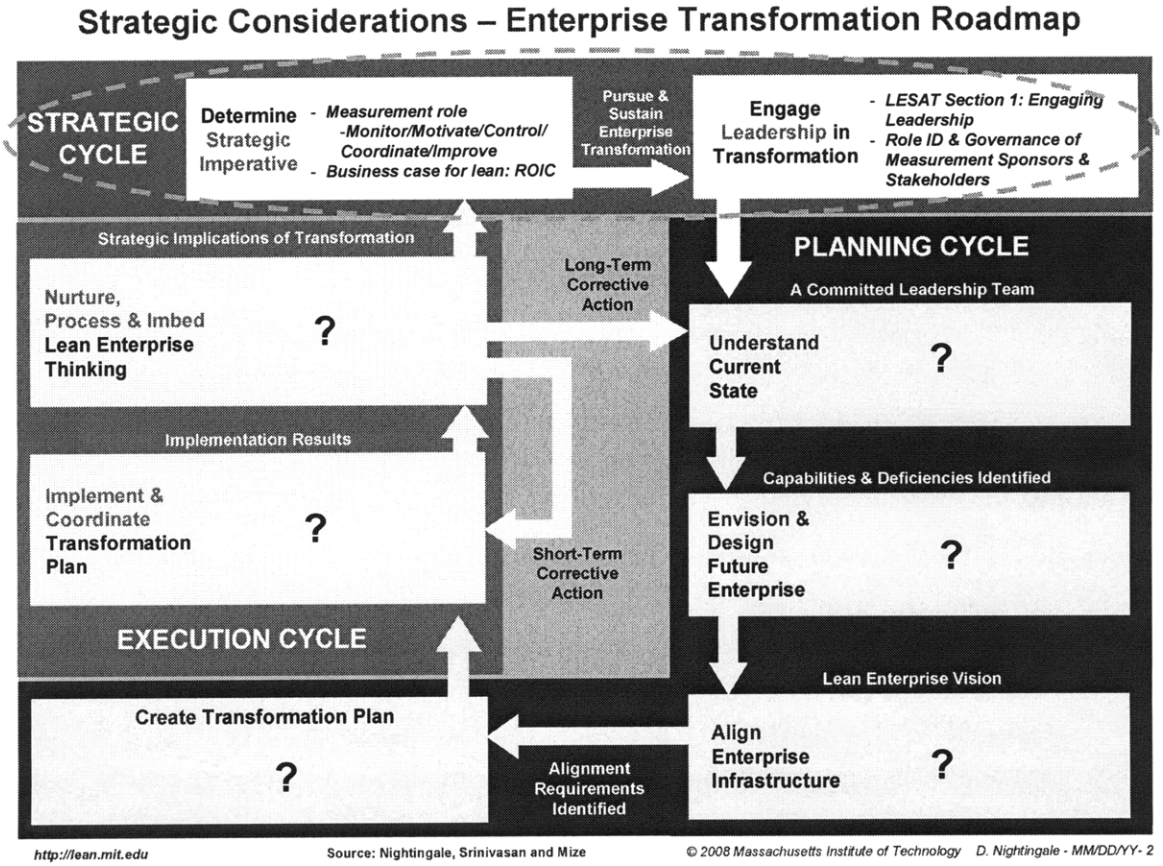

Figure 7.2 – Strategic Metric Considerations in the Enterprise Transformation Roadmap

7.2 Planning Metric Considerations

Although the measurement considerations on the strategic cycle are fairly basic, the maturity of metric considerations increases as one gets further along the transformation roadmap. In the planning cycle, the measurement layer's four steps are now investigated: (1) understanding the current state, (2) envisioning and designing the future enterprise, (3) aligning enterprise infrastructure, and (4) creating a transformation plan.

Understand Current State

In performing an initial enterprise assessment, there is an array of tools at one's disposal that can assist in understanding measurement considerations. First, an Eight Views analysis –as performed in Chapter 6 – will help unveil unique challenges within the enterprise that should influence transformation planning and execution, such as organizational tensions regarding measurement and IT representatives or the benefits of having a focused measurement knowledge development and transfer community. Next, from the insight in Chapter 2 regarding performing research with the enterprise as the unit of analysis, one needs to understand the current state in form of the enterprise's structure, function, and value delivery. Although these two steps are not explicitly metric-centric, they are paramount in ensuring measurement considerations are truly on an enterprise level. Once this enterprise understanding is achieved, LAI's X-Matrix tool can be used as an effective enterprise assessment tool to help measurement leads and stakeholders understand how metrics are related to stakeholder values, key processes, and strategic objectives (Nightingale et al., 2008).

Envision & Design Future Enterprise

Just as the aforementioned X-Matrix tool is used to understand the current enterprise, for measurement representatives it can be an effective tool for envisioning and designing the future enterprise. If there are no metrics that relate to certain stakeholder values, key processes, or strategic objectives – these gaps will need to be bridged in the planning of an effective transformation plan. In conjunction with use of this X-Matrix tool, at this step in the transformation roadmap one needs to consider Step 1 of the Four Steps to Metric Selection: identifying value and metrics that support decision making. In addition to this step and the X-Matrix tool that serves as a visual aid for this task, the five questions for exploring the problem

space identified in Chapter 3 can help one gain a more focused understanding of their future state measurement goals and if the current metrics suffice. As a refresher, these questions are as follows (Hubbard, 2007).

- What is the decision this [measurement] is supposed to support?
- What really is the thing being measured?
- Why does this thing matter to the decision it supports or the question asked?
- What do you know about it now?
- What is the value to measuring it further?

Align Enterprise Infrastructure

Once Step 1 of the Four Steps to Metric Selection has been completed, the second and third steps assist to align enterprise infrastructure. Step 2 corresponds to determining what you know, what you need to know, and the value of the information needed to support the decisions identified in Step 1. If the value of information does not exceed the value of the decision it supports, one can proceed to Step 3 by considering how chosen metrics will impact behaviors of stakeholders and align metrics amongst the various organizational levels. LAI's aforementioned work performed by Mahidar (2005) further provides a depiction of how to align a lean enterprise performance measurement system.

Complimenting these steps, insight from the ACME MCOP case study depicted the value of aligning an organizational measurement team with a structure parallel to that of the organization. In a matrix organization, this includes ensuring ample representatives from all functional areas and programs are recruited. In a traditional hierarchal silo-based organization, aligning efforts will include breaking down departmental barriers and facilitating conversation amongst the various value streams in the same manner of a matrix organization. Even if the contribution from each area of the organization is not equal, proper alignment will facilitate communication and serve as a catalyst to the eventual transformation. Note that when the organization was not aligned to involve all stakeholders – as with the MCOP community and their IT partners – conflict arose over miscommunication and lack of role identification.

While aligning the enterprise infrastructure, the Enterprise Transformation Roadmap calls out the need to rationalize systems and policies. From the Eight Views analysis of the MCOP case study, one has learned that the four reasons to implement policy are: security, efficiency,

liberty, and equity (Stone, 1997). Thus, at this point in the transformation journey one needs to consider these four areas. With respect to security, any externally imposed regulations – such as ITAR restrictions and CMMI requirements – need to be accounted for in the measurement picture. Second, efficiency is most often the end result of imposing metric or measurement system policies. Albeit through some manner of standardization or coerced alignment, the transparency desired from metric policies ensures data integrity at the higher organizational levels, allowing decision makers to execute more effective and efficient actions. Next, the Raytheon VBS case study provided an example of measurement system policies being implemented for the purpose of liberty for the workers at the shop floor level. Dictionary.com defines liberty as "freedom from arbitrary or despotic government or control," which is exactly what workers were concerned with maintaining from their interviews. The workers were afraid that, with everything around them being measured, they would be persecuted at the sign of any problem regardless of the causal nature of the root cause. By implementing policies that ensured blame would never be placed on individuals and by maintaining a policy of proactively working together throughout the measurement process, most employees were able to overcome their "Big Brother is Watching You" fears (Orwell, 1949). Last, equity is another essential reason for the implementation of policy. With metrics and measurement systems, equity is maintained by ensuring all stakeholders have equal say in the measurement lifecycle – from conception of the system or the metric to determining how a metric should be acted on. For a bottom-up system, this could include developers, end users, floor workers, senior management, engineering, and perhaps even customers or suppliers. For a top-down system, this could include all functional and project areas of the organization in addition to the stakeholders in bottom-up measurement systems.

Create Transformation Plan

After aligning the enterprise infrastructure, the final phase of the planning cycle commences – creating the transformation plan. By this point, the detailed outline for the plan is in place, and key stakeholders need to be engaged and buying into the governance structure developed in the strategic cycle. Since alignment has been achieved and also organizational and policy concerns have been addressed, it is appropriate to reassess the governance structure to ensure responsibility and accountability lie with the stakeholders necessary to facilitate

execution. Any feedback regarding the measurement tools and considerations should be discussed amongst all stakeholders at this phase, as they brace for the actual execution of the planning efforts.

With this insight, the planning considerations identified in this section for leveraging metrics and measurement systems to facilitate transformation can be seen in Figure 7.3.

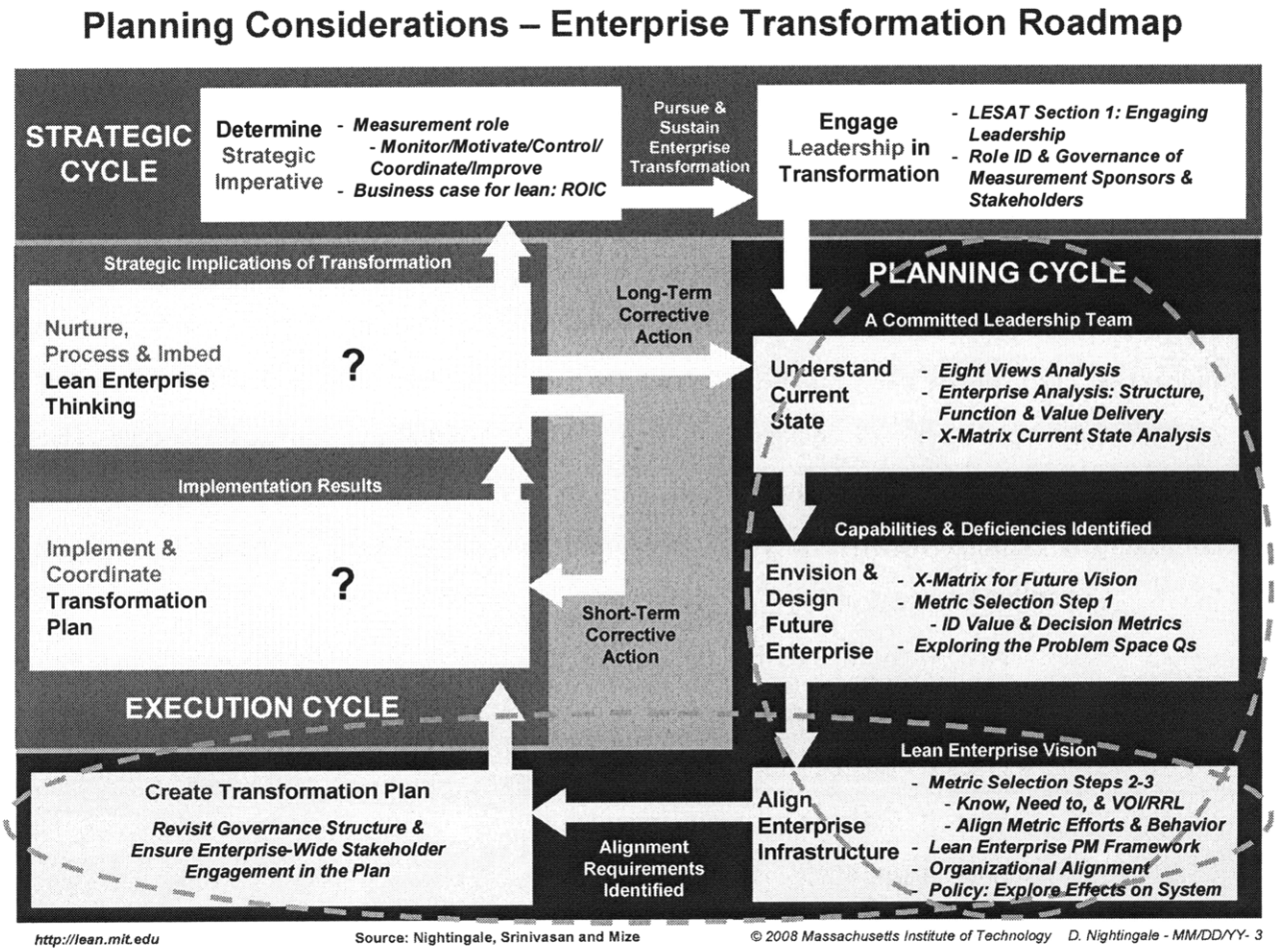

Figure 7.3 – Planning Metric Considerations in the Enterprise Transformation Roadmap

7.3 Execution Metric Considerations

As noted in Chapter 4, two of the more explicit metrics considerations in the transformation roadmap are called out in the execution cycle: "implement projects and track progress" in the implement and coordinate transformation phase; and "monitor and measure the

outcomes," in the nurture process and imbed lean enterprise thinking phase. Since most of the strategic and planning findings discussed thus far were fairly common in the literature, the knowledge gap of interest to measurement community members lies in the execution cycle, where so many transformation initiatives end in failure. Thus, findings from the case studies now provide insight regarding how execution metric considerations can help improve transformation success.

Implement & Coordinate Transformation Plan

Once the transformation initiative is under way, the metrics and measurement systems play a unique role in tracking and facilitating transformation progress. First, at this phase in the transformation practitioners need to be cognizant of Step 4 of the Four Steps to Metric Selection – having systematic processes in place for measurement feedback and fostering a measurement friendly culture. As mentioned in Chapter 3, one of the most common and logical feedback mechanisms is the thermostat approach, wherein periodic review informs management which metrics to emphasize based on the enterprise's current performance and where historical data dictates they need to be to ensure short-term and long-term transformation success (Hauser, 2001). In addition to thermostat mechanisms in place to monitor metric progress, one can continuously evaluate their metrics and measurement systems based on the questions identified in Chapter 3 (Nightingale, 2007).

- Are the metrics tied to organizational goals?
- Does it identify root causes?
- Does it consider all stakeholders' needs?
- Does it motivate action as intended?
- Does it accurately portray progress?
- Is it easy to use?
- Is the right information delivered at the right time?

These simple seven questions serve as a quick short-hand guide that floor level workers and management can use to constantly evaluate the effectiveness of the system in place. If the answer to any of these questions is no, undoubtedly there is a value stream impediment or process waste that can be eliminated by adjusting the metric or measurement system.

From the bottom-up perspective, this instantaneous and effective feedback was catalyzed by continuous stakeholder involvement and incremental improvement. Recall, from Chapter 5 there were four main factors that contributed to the adoption of the VBS: (1) Fostering a non-blame oriented culture, (2) considering the needs of all stakeholders, (3) holding managers and engineers responsible for considering employee feedback, and (4) being proactive in educating and training the community in how to use the tool, with the help of various employee advocates within cells. By meeting these criteria, which have been accounted for mostly in prior transformation steps, one significantly increases the chances their measurement effort is adopted and hence transformation is successful. Additionally, two other specific factors that were essential for the success of VBS were (1) the modular system architecture and (2) the presence of dashboards for real time information. The modular architecture of the VBS system made it easy for developers to rapidly change characteristics of the system, and the plethora of dashboards ensured everybody could see real time information. These two aspects of the system in particular made it exponentially easier for continually improving the usability in terms of the seven questions above.

With respect to the top-down perspective, all the considerations that have been discussed in this section thus far apply: a thermostat approach is used to depict progress on corporate enterprise level metrics; the system is flexible to add new metrics and eliminate metrics of decreasing importance; stakeholders need to be engaged, accountable, and educated and trained; and visual dashboards can quickly depict all relevant information to all stakeholders. It is noted that one primary difference between this perspective and the bottom-up perspective is that real-time updates are not as necessary or beneficial due to the slower speed of organizational momentum (the enterprise measurement lead suggested monthly reporting is optimal) and there are greater coordination challenges since the system spans not only project and functional areas – but geographical areas as well. Measuring more frequently than monthly at the corporate level could result in over-reacting (false positive), and hence people might begin to lose faith in the robustness of the system.

Nurture Process & Imbed Lean Enterprise Thinking

At the end of the transformation cycle, the Enterprise Transformation Roadmap calls out the need to monitor and measure the effects of the effort. In short, the best metric to convey how

well the lean enterprise thinking has been imbedded in the enterprise is employee engagement. As it was seen at the conception of the strategic cycle, leadership engagement and involvement is paramount to get the initiative moving in the right direction. It only makes sense that the end result is how well those efforts translated into positive momentum amongst the masses.

For the short-term corrective actions that takes place in the execution cycle, it is also important to continually engage in knowledge appraisal, eliminating biases and any activity that can facilitate decision making. At this level, it is also important to avoid the challenges that manifest with measurement systems over time identified in Chapter 5:

(5) employee engagement with the aging workforce;

(6) general resistance to measurement;

(7) information misinterpretation or allowing management by numbers to prevail; and

(8) information over saturation for managers and touch laborers.

Finally, the Enterprise Transformation Roadmap also emphasizes the need in this step for capturing and diffusing lessons learned. In all of the VBS enterprise, the ACME enterprise, and the cross-industry aerospace measurement community alike, tight-knit teams of highly skilled individuals exist that provide their departments, organizations, and enterprises a means of effectively and efficiently collecting and disseminating the lessons learned.

Thus, at the completion of the execution cycle one will have completed a full lap around the never ending journey that is the Enterprise Transformation Roadmap. The execution considerations identified in this section for leveraging metrics and measurement systems to facilitate transformation can be seen in Figure 7.4.

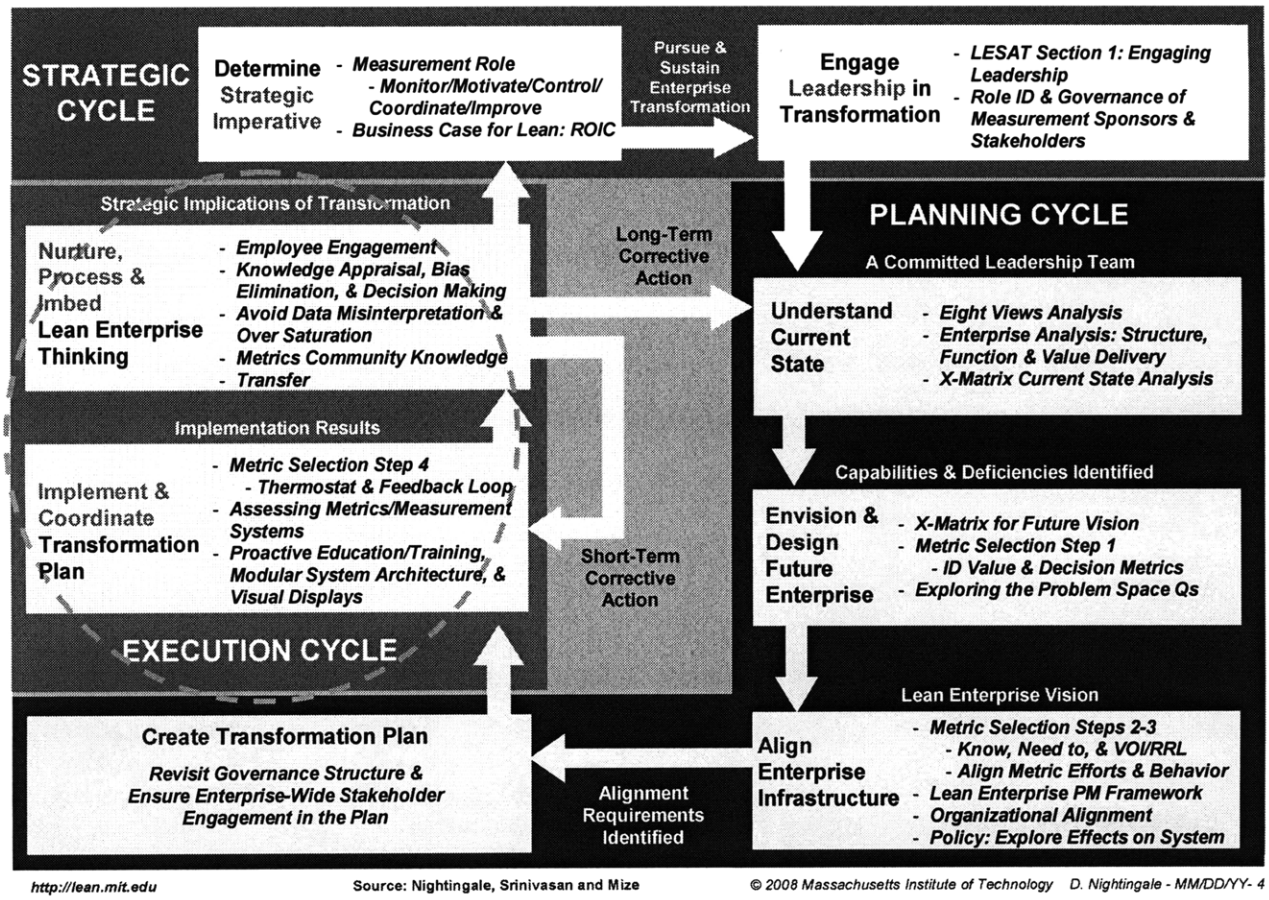

Figure 7.4 – Execution Metric Considerations in the Enterprise Transformation Roadmap

Chapter 8

Implications, Conclusions & Future Research

As discussed in Chapter 1, much of confusion amongst aerospace community existed around three factors – how transformation is defined, how it is measured, and what leading and lagging indicators for enterprise transformation success or failures are. This led to the question of *how can top-down and bottom-up metrics and measurement systems be leveraged to drive enterprise transformation?* A mixed-method research approach was used involving surveys, case studies, and interviews to validate the main hypothesis – that *top-down and bottom-up metrics and measurement systems can be leveraged to drive enterprise transformation.* To summarize the results this section includes a discussion on the implications of this research, general conclusions from the case studies and the original propositions, and insights regarding potential areas for follow-on research.

8.1 Implications

The implications of research in metrics for enterprise transformation span across thee areas: (1) the academic contribution of the extensive literature reviews; (2) providing practitioners a language and framework for exploring measurement problems; and (3) connecting the gap between the measurement and transformation that can be leveraged to increase transformation success.

First, the extensive literature reviews of enterprise research and metrics research provides a background for researchers and practitioners to understand the implications of enterprise research and the vast landscape that entails metrics research. Prior to this work, few of the publications on metrics provided the overarching picture that helped describe the entire measurement problem space – mainly focusing on common mistakes associated with metrics selection, measurement frameworks, and the process of decision making.

Second, this research focused on providing concrete evidence about enterprise measurement by documenting two case studies of large organizations undergoing transformation. This extended anecdotal examples and theories by validating them on real organizations and

documenting the impact of metrics on their enterprise. In particular, these case studies provided a context from which the academic perspective could provide a fresh perspective. For example, in the first case study findings regarding performing research with the enterprise as the unit of analysis were leveraged to depict advantages and disadvantages of some of the business unit's newly proposed metrics. Additionally, the second case study leveraged a theoretical enterprise architecting approach to analyze how corporate metrics and measurement systems can affect the enterprise. Furthermore, both case studies depicted how policy related to metrics and measurement systems can be effectively implemented.

Finally, the most important implication of this research is the effect it can have on successful transformation planning and execution in large enterprises. When exploratory interviews and surveys were performed two main findings emerged: (1) a true disconnect between measurement and transformation existed, and (2) most organizations reported an overwhelming failure rate of transformations. After the literature reviews provided academic grounding of this body of work and case studies were performed to gather practical insight about the role of measurement in facilitating transformation in practice, a connection was established between enterprise *measurement* and enterprise *transformation* by defining a measurement layer within the Enterprise Transformation Roadmap. This roadmap can be used by enterprises of all types to strategize, plan, and execute a transformation enabled by their measurement capabilities. Ultimately, as the measurement community follows this prescribed roadmap, the level of employee engagement will increase which is expected to have a positive impact on the success rate of transformations. An emphasis on measurement will help enterprises avoid past threats of predatory value crises and lead them towards proactively engaging value opportunities.

8.2 Conclusions

With the implications of this research and the conclusions of individual case studies and analysis discussed, this section now reflects on the propositions brought forth in Chapter 1. Specifically: (i) metrics and measurement systems can drive transformation; (ii) employee engagement is a proxy to gauge transformation progress; and (iii) measurement can enable enterprise transformation when systematically executed through a transformation roadmap. For the first proposition, it was seen that both top-down and bottom-up measurement systems could be used to drive enterprise transformation. The exploratory VBS case study unveiled how the

system had helped the company transform from a company going out of business due to a value crisis to a thriving lean enterprise. Additionally, the most threatening four challenges to maintaining effective metrics and measurement systems for driving transformation were identified, and corresponding recommendations were articulated. In the ACME corporate enterprise dashboard case, it was shown how corporate metrics could impact the enterprise, from the perspectives of the Eight Views of the enterprise as well as Structure, Function, and Value Delivery.

For the second proposition, the idea of employee engagement was investigated in the VBS case study. As identified from the case study methodology outlined in Chapter 1, the exploratory analysis was aimed at identifying whether employee interview results converged on this factor as a significant driver of transformation, and if so what the tangible advantages were. Ultimately, it was found that employee engagement was paramount in driving transformation success and it could be used effectively as a proxy to gauge transformation progress. The characteristics of employee engagement were expanded on in Chapter 5.

For the third proposition, results from the literature review and case studies was integrated into the Lean Advancement Initiative's Enterprise Transformation Roadmap – providing visibility to a layer of the roadmap that had previously not been described from the measurement perspective. Prior work and findings from literature reviews provided the background for the strategic and planning cycles, whereas guidance extrapolated from the case studies provided a strong basis for identifying measurement considerations in the planning and execution of a transformation plan. Regardless of whether insight was derived from literature reviews, case studies, or both – these findings are thought to individually and collectively enable transformations. With a systematic method to highlight metrics as a key element of the Enterprise Transformation Roadmap, the success rate of transformations should increase by motivating the right behaviors among stakeholders.

8.3 Future Research

Throughout the research process and as work on a particular topic concludes it is common for future research areas and directions to have been unveiled along the way. With the results from this body of research now presented in completion, two particular potential trajectories for future research have emerged: (1) the further study of employee engagement and

how enterprises have harnessed or can harness the wisdom of their workforce; and (2) the further study of the measurement layer of the Enterprise Transformation Roadmap, by engaging enterprise measurement leads at the conception of a transformation initiative and gathering feedback regarding more in depth implementation benefits, challenges or perhaps gaps that have not yet been identified. Judging by the motivation and interest of the aerospace measurement community, the exploration of either of these areas could lead to significant findings that can further add value to the ever growing knowledge base that is – metrics for enterprise transformation.

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Appendix

Attachment A: Sampled Metrics Selection Methodologies

	Steps to Creating Effective Metrics				
	Hubbard [6]	Huser & Katz [10]	Hammer [12]	Harbour [17]	Kitterman [7]
1	What are you trying to measure? What is the real meaning of intangible?	Listen to the customer, who is it and what do they need, what outcomes are metrics trying to improve	Decide what to measure	Accurately measure key performance variables (productivity, quality, timeliness, cycle time, resource utilization, and costs)	What decision are you trying to support?
2	Why do you care - what is the decision you are trying to support	Understand the job - what do managers and employees value, how do decisions effect metrics and outcomes?	Decide how to measure - precision: carefully and well defined (units, range, etc...)	Include a comparative basis to assist in understanding the performance level	Is it possible to take action and what actions are necessary
3	How much do you know - what ranges or probabilities represent your uncertainty	Understand the relationships - internal customers/suppliers, tradeoffs. Make sure everyone is considered	Decide how to measure - accuracy: any metric is a fraction of an ideal (customer satisfaction), close gap between metric and reality	Metrics need to be collected and distributed on a timely basis	Would the action create a change?
4	What is the value of information? Consequences/chance of being wrong? Justify measurement effort	Understand the linkages. Align actions and decisions with long-term company goals	Decide how to measure - overhead: inexpensive and simple works	Metrics need to be analyzable on both a macro and micro basis	If the change occurs, will it show up in a future value of the metric
5	What observations can confirm/eliminate possibilities?	Test Correlations and Manager/Employee Reaction	Decide how to measure - robsutness: Design around manipulation and unintended behaviors	Metrics cannot be manipulated to achieve desired results	-
6	Account for avoidable errors, value of information	Involve Managers and employees - gather input and feedback, do not use information for attacks	Use metrics systematically - embed in a disciplined process	Ensure measres are SMART - Specific, Measurable, Action-Oriented, and Timely	-
7	-	Seek new paradigms - Focus on Ouputs not Inputs. Look at policy and understand the enterprise perspective.	Create a measure friendly culture - don't use for infighting or blame. Personal role modeling, reward, implementation, commitment, articulation	-	-

Attachment B: Structural & Procedural Measurement Frameworks (from Mahidar, 2005)

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.

Attachment C: Metrics for Enterprise Transformation Survey

Responses should represent prevailing consensus or practice in your organization rather than your personal opinion.
Please return survey to Craig Blackburn [cdb@mit.edu]

Name (optional) _____

Role/function/title _____

Organization _____

1. Indicate the enterprise(s) you are interested in evaluating (mark all that apply):

- ☐ National/International enterprise (e.g., United Technologies Company)
- ☐ Multi-program enterprise (e.g., Sikorsky Military Products)
- ☐ Single program enterprise (e.g., Blackhawk Helicopter)
- ☐ Department or functional organization (e.g., Manufacturing)
- ☐ Other (please describe) _____

2. How is the term ***Transformation*** defined in your organization?

_____

_____

_____

_____

_____

3. Identify the relative importance of these perspectives in terms of *Enterprise Transformation*
(1 = most important; 8 = least important). Ties are allowed.

____	Strategic	____	Knowledge
____	Policy	____	Information
____	Organization	____	Product
____	Process	____	Service

4. How does your enterprise of interest (from Question 1) currently measure its transformation progress?

_____

_____

_____

_____

_____

5. In your organization, how long does the transformation of an enterprise (as defined in Question 1) typically take?

- ☐ < 1 year
- ☐ 1-3 years
- ☐ 3-5 years
- ☐ 5-7 years
- ☐ > 7 years
- ☐ Other (please specify) _____

6. In your organization, how often does progress on enterprise transformation need to be measured? How often *should* it be measured?

Current measurement frequency	Desired measurement frequency
☐ Daily	☐ Daily
☐ Weekly	☐ Weekly
☐ Monthly	☐ Monthly
☐ Quarterly	☐ Quarterly
☐ Annually	☐ Annually
☐ Other (please specify) _____	☐ Other (please specify) _____

7. What level of lean maturity would your organization consider itself to be at?

- ☐ Some awareness of lean practices; sporadic improvement activities may be underway in a few areas.
- ☐ General awareness; informal approach deployed in a few areas with varying degrees of effectiveness and sustainment.
- ☐ A systematic approach/methodology deployed in varying stages across most areas; facilitated with metrics; good sustainment.

☐ On-going refinement and continuous improvement across the enterprise; improvement gains are sustained.

☐ Exceptional, well-defined, innovative approach is fully deployed across the extended enterprise (across internal and external value streams); recognized as best practice.

8. What indicates that a transformation has been complete?

_____

_____

_____

_____

_____

9. From your experience, what is the typical ratio of successful to unsuccessful enterprise transformations?
_____:_____

10. What are good leading indicators of enterprise transformation success/failure and why?

_____

_____

_____

_____

11. What are good lagging indicators of enterprise transformation success/failure and why?

_____

_____

_____

_____

12. From your own experience, how often have you seen the following objections given as a reason not to measure enterprise transformation (1=Not Often, 3 = Sometimes, 5 = Very Often)?

Not Often		Sometimes		Very Often	
1	2	3	4	5	a. Economic – Measurement is too expensive
1	2	3	4	5	b. Usefulness/Meaningfulness of measurement – Anything can be proven or supported using statistics

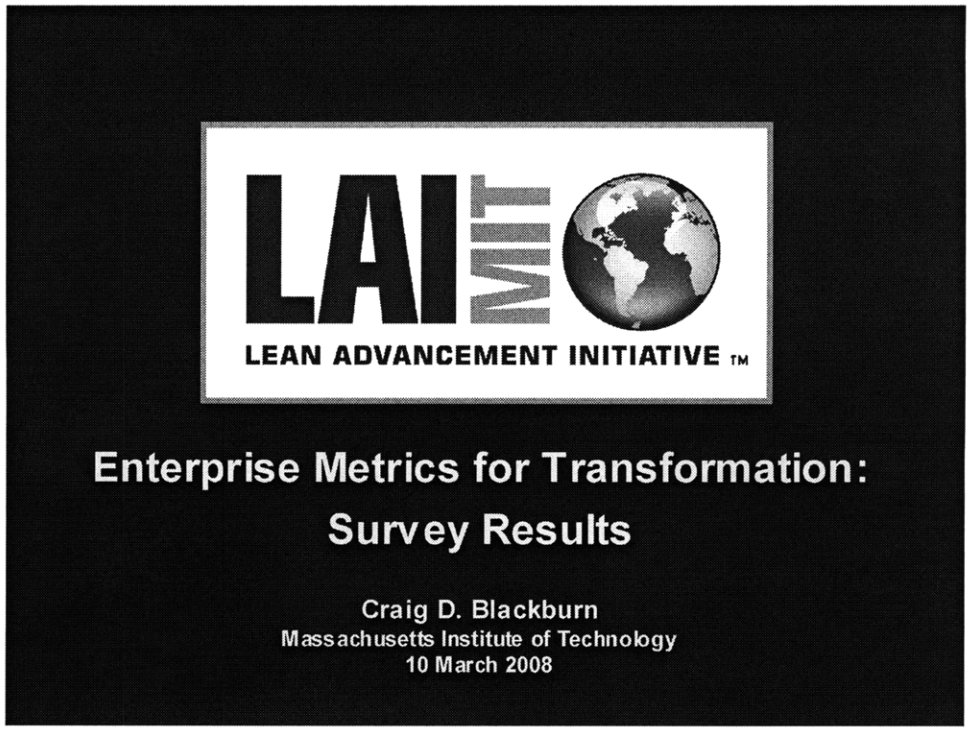
1	2	3	4	5	c. Ethical – It is immoral to measure (such as the value of life) or
1	2	3	4	5	d. Resistance – employees/organizational culture is resistant to it
1	2	3	4	5	e. Other (please specify and rate)_____

13. From your own experience, please rate the importance of the following factors in motivating enterprise transformation (1=Very Low, 3 = Medium, 5 = Very High).

Very Low		Medium		Very High	
1	2	3	4	5	a. Value Opportunities (the lure of greater success)
1	2	3	4	5	b. Value Threats (potential market failure and technology threats)
1	2	3	4	5	c. Value Competition (competitors' initiatives)
1	2	3	4	5	d. Value Crisis (steadily declining market performance, cash flow problems – transformation is necessary for survival)
1	2	3	4	5	e. Other (please specify and rate)_____

END

Attachment D: Summary of Answers to Metrics Survey



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Participants

Number	Name	Role/Function/Title	Organization
1	John Gill	Director of Horizontal Integration	BAE Systems
2	John Day	VBS Broker	Raytheon Integrated Air Defense Center
3	Mark Bowie	Lean Engineering	Boeing IDS
4	Todd Kibler	Lean Six Sigma Deployment Leader	Lockheed Martin Aeronautics
5	Cristie Ditzler-Smith	Chief Aquistions Strategic Planning	United States Air Force (SAF/ACPO)
6	N/A	Transformation Manager	N/A
7	N/A	Operations Manager	Sikorsky Aircraft
8	Prince Andoh	Strategy Analyst	Defense Finance and Accounting Service
9	David Martin	Engineering Quality Specialist	Pratt & Whitney
10	Tim Burrows	Productivity Manager IDS Boeing	IDS Boeing
11	Mark Edmondson	Senior Director of Lean Strategy	Raytheon Co.
12	Len Wojcik	Manager	MITRE
13	Dave Ratzer	Systems Engineer	Rockwell Collins
14	Jim Stubbe	Enterprise Measurement Lead	Raytheon
15	Charles Tappan	Strategy Deployment	United Launch Alliance
16	Carl Wirth	Project Manager/Process Improvement Metrics Lead	Sikorsky Aircraft
17	Jeff Green	Director Six Sigma	Bell Helicopter
18	Heather Vickers	Process Improvement Analyst	United States Air Force (Ogden Air Logistics Center)
19	Larry Lewis	Lean Consultant	Boeing IDS Supplier Development
20	Robert Dubois	Process Manager	BAE Systems
21	N/A	N/A	N/A
22	Deborah True	Global Quality Director	Praxair Surface Technologies
23	Robert Brown	Senior Manager, Best Practices	LMSSC - Michoud, New Orleans
24	Timothy Pavlo	Program/Project Manager	Lockheed Martin Corp.
25	N/A	N/A	N/A
26	Margo Rush	IT	Sikorski Aircraft
27	Kenneth W. Sullivan	Director, Office of Supply Chain and PLM	Univ. of AL - Huntsville, AMCOM (Army) Point of View

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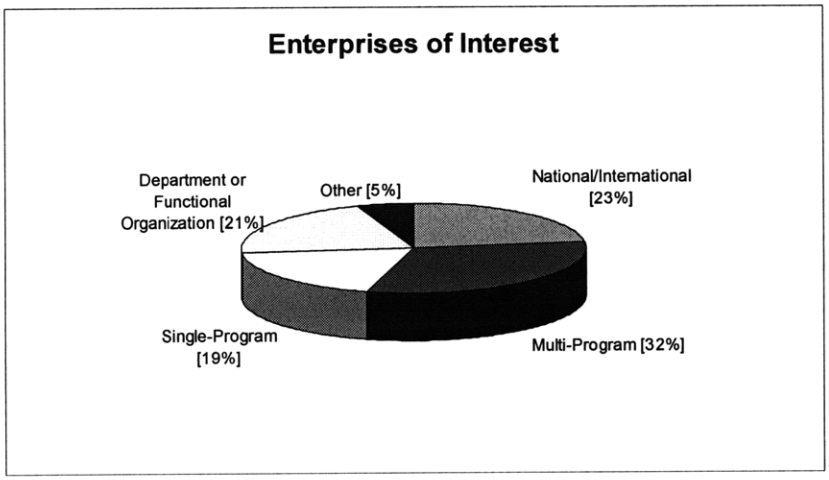
Question 1 - Indicate the enterprise(s) you are interested in evaluating (mark all that apply):



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Question 2 (Representative Answers)

- Question 2 - How is *Transformation* defined in your organization?
  - *To change the process, culture, organizational mindset, and values to improve the work output and value to the customer*
  - *A radical shift in individual and organizational behavior that is driven by an urgent need to change (or reposition) an organization for breakthrough performance or competitive advantage*
  - *Adapting behaviors and practices to a changing market*
  - *From: Collection of individual business units, To: Networked enterprise, leveraging best practices to become the premiere multi-industry company*

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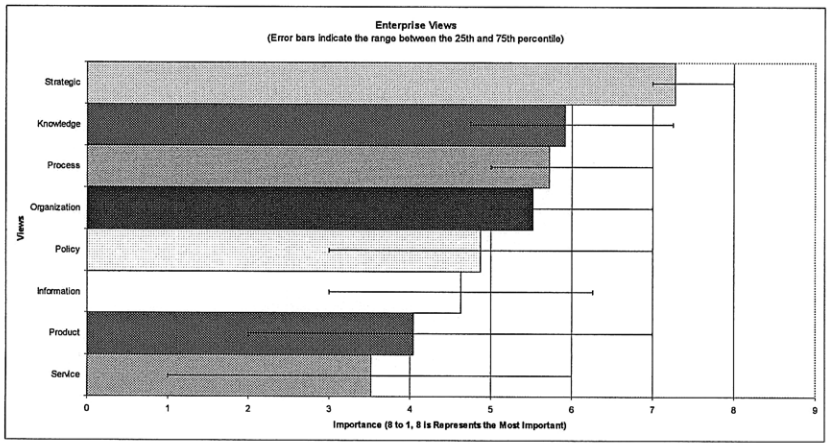
Question 3 - Identify the relative importance of these perspectives in terms of Enterprise Transformation (8 = most important; 1 = least important). Ties are allowed. (n=27)



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Question 4 (Representative Answers)

- **Question 4 – How does your enterprise of interest (from Question 1) currently measure its transformation progress?**
  - ***Too vaguely, sporadically, inconsistently. That said, we tend to break our measurements into small pieces (like good Systems Engineers) and never re-integrate back into a big picture.***
  - ***There are strategic level (enterprise) metrics at the top, then lower level metrics. However, these metrics have no target goals and they don't align well at all.***
  - ***Incrementally – many different measures can drive the same transformation, the initiatives that are launched drive more.***

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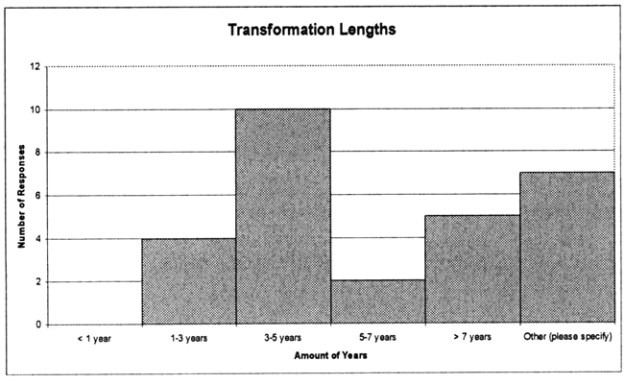
Question 5 - In your organization, how long does the transformation of an enterprise (as defined in Question 1) typically take? (n=27)

1. Transformation takes 4.75 years on average (mean, not including "other" responses
2. 26% indicated that transformation is never ending



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Question 6 (n=26)

- **Question 6a. In your organization, how often does progress on enterprise transformation need to be measured? How often should it be measured?**

On average, people are currently measuring 3 times per month

- **Question 6b. In your organization, how often does progress on enterprise transformation need to be measured? How often should it be measured?**

On average, people would like to measure 8 times per month

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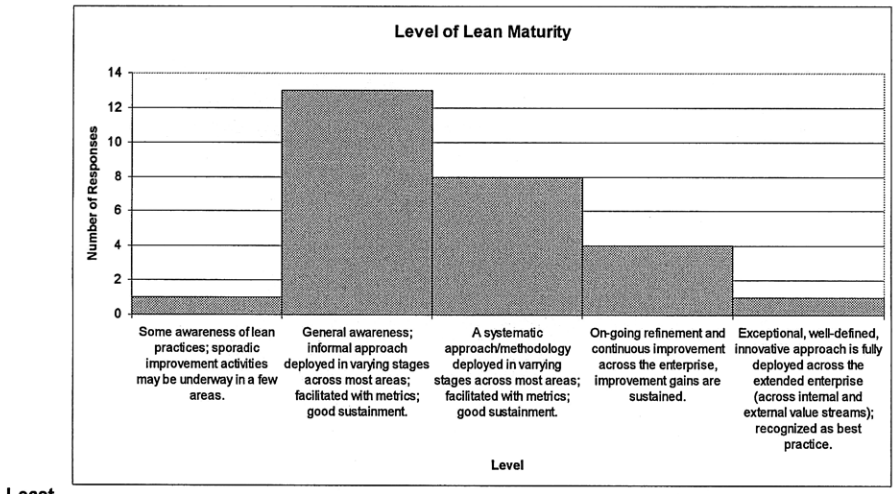
Question 7 - What level of lean maturity would your organization consider itself to be at? (n=27)



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Question 8 (Representative Answers)

- **Question 8 – What indicates that a transformation has been complete?**
  - ***There is never a moment when an organization is "transformed," per se; however, an organization will see signs of improvement when a transcendent shift in organizational behavior begins to manifest itself in a significant increase in customer and stakeholder/shareholder satisfaction.***
  - ***In air traffic management operations, transformation completion occurs when all the stakeholders are on board in terms of how they operate.***
  - ***I do not believe it can be complete, transformation is dynamic, business morphing. Business constantly requires process improvement efforts, "transformation," to adjust one's business model to remain competitive and meet your customers' needs.***

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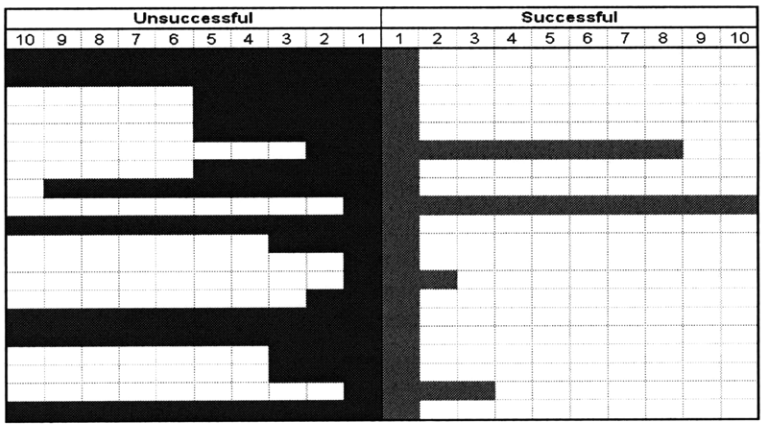
Question 9 - From your experience, what is a typical ratio of successful to unsuccessful enterprise transformations? (n=20)



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Question 10 (Representative Answers)

- **Question 10 – What are good leading indicators of enterprise transformation success/failure and why?**
  - ***Success indicators: leadership involvement, employee understanding and buy-in, linking compensation to organizational goals and objectives.***
  - ***Leadership promoting and leading transformation. Basically, the transformation is "something we are working toward" rather than "something being done to you."***
  - ***When the new techniques become part of the language and culture of the enterprise.***

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Question 11 (Representative Answers)

- **Question 11 – What are good lagging indicators of enterprise transformation success/failure and why?**
  - ***Estimating factors for bidding new work. Earnings. Returning customers. Positive weightings by customers on past performance as related to new business proposals.***
  - ***Sabotage. Lack of commitment from managers using a breakfast analogy (bacon & eggs – chicken is involved, but the pig is committed).***
  - ***Customer satisfaction, profitability. These tell you the value streams are operating "well."***

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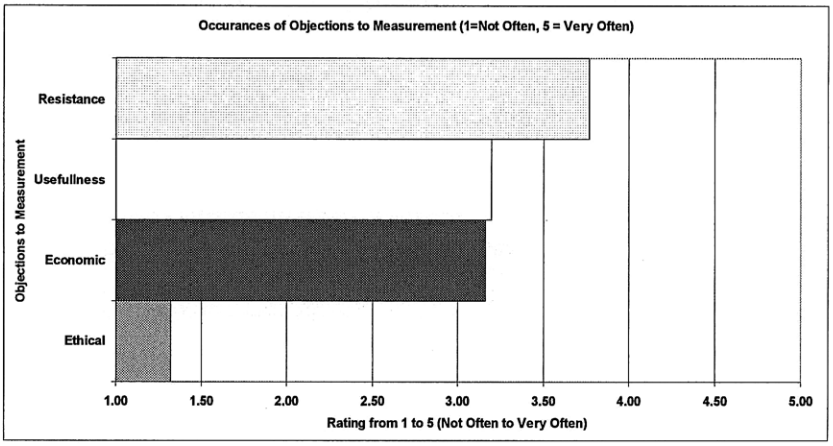
Question 12

- **12. From your own experience, how often have you seen the following objections given as a reason not to measure enterprise transformation (1 = Not Often, 3 = Sometimes, 5 = Very Often)? (n=26)**



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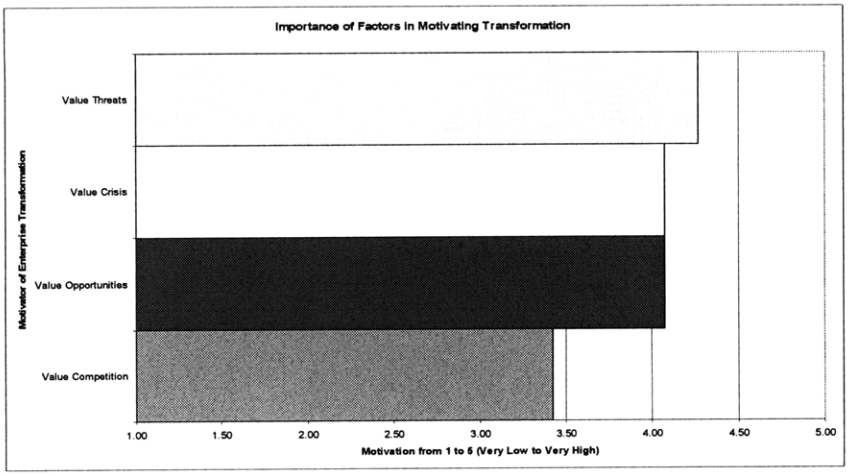
Question 13

- 13. From your own experience, please rate the importance of the following factors in motivating enterprise transformation (1 = Very Low, 3 = Medium, 5 = Very High). (n=26)



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End of Survey

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