ASSESSING THE MATURITY OF INFORMATION ARCHITECTURES FOR COMPLEX DYNAMIC ENTERPRISE SYSTEMS

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ASSESSING THE MATURITY OF INFORMATION ARCHITECTURES FOR COMPLEX DYNAMIC ENTERPRISE SYSTEMS

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To Amy

My wife and best friend .this journey would never have been possible without your tireless support, encouragement, and love. I can't thank you enough for your patience, sacrifice, and generous gifts of time…

And to Emma and Grace who inspire me every day…

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LIST OF ABBREVIATIONS

BPM	Business Performance Management
CMM	Capability Maturity Model
CPM	Corporate Performance Management
DoD	Department of Defense
EA	Enterprise Architecture
EBITDA	Earnings Before Interest, Taxes, Depreciation, and Amortization
ERP	Enterprise Resource Planning
ESA	Enterprise System Architecture
GFVs	Growth Factor Variables
IAP	Instrument Approach Plate
LSI	Lead Systems Integrator
M & A	Merger and Acquisition
NSF	National Science Foundation
OSI	Open Systems Interconnection
POG	Phase of Growth
VC	Venture Capital
ROIC	Return on Invested Capital
SEI	Software Engineering Institute
SOS	System of Systems

SUMMARY

Many factors affect the operation of complex dynamic systems such as enterprises. While change and, ultimately, transformation, are inherent phenomena within an enterprise system, the nonlinear dynamics associated with them are difficult to understand, model, and predict. Consequently, an understanding of emergent behavior and performance is currently limited. Drawing on the extant systems engineering, information systems / information technology, and complexity theory literature, this dissertation investigates the dynamics that underlie enterprise performance, and takes a significant step toward showing how it might be predicted. In a novel approach, a comprehensive Enterprise System Architecture (ESA) is developed that introduces separate layers for strategic and operational processes, respectively. A more specific model that dimensionalizes the enterprise system is also developed. The enterprise dimensions are constructed based on our literature review and from primary research conducted for the dissertation which incorporates the author's professional experience as an engineer, management consultant, entrepreneur, venture capitalist, and private equity financier.

From this synthesis, we identify four broad dimensions that contribute to and influence enterprise performance: (1) enterprise processes, (2) technology-based support of enterprise processes [denoted information systems], (3) technology structure and deployment [denoted information technology], and (4) Enterprise Architecture (EA). The concept of maturity of an enterprise system is a novel approach and therefore has received little, if any, theoretical or practical attention. In order to fill this gap, this dissertation explores the concept in further detail via interviews with ten executives, mostly from the aerospace and defense industry. A web-base, user-centered survey of aerospace and defense industry executives was also conducted. Using data collected from these qualitative and quantitative methods, we evaluate our conceptual model by empirically determining a value for each dimension of maturity and individually assessing them as predictors of enterprise performance. The maturity of our ESA is

calculated as the weighted summation of each of dimensional maturity, and is also evaluated as a predictor of enterprise performance.

Results indicate that ESA maturity, the weighted summation of process maturity, information systems maturity, information technology maturity, and enterprise architecture maturity, is a good predictor of enterprise performance. In order to provide some practical utility to our empirical results, we outline an ESA maturity assessment framework to enable decision-makers to assess the overall maturity of an enterprise system. Two other extensions of our research results, the development of a strategic layer analysis / portrayal tool, and enterprise system simulation, are also briefly described.

CHAPTER 1:
INTRODUCTION

1.1 Context and Background

For enterprises to not only survive but continue to succeed in today's business environment, they must have the ability to quickly adapt and respond to changes of all types, both endogenous and exogenous. A key attribute for enterprise adaptability and flexibility is how enterprise information technology-based systems are structured and deployed. If not properly integrated and architected so as to support enterprise business processes, information and process-related change may not be able to propagate freely throughout the enterprise (Morganwalp and Sage, 2002). The impact on enterprise performance may be dramatic. Consequently, an understanding of how to enhance enterprise performance through better human system integration and ultimately, move toward being able to predict it, has become increasing more important for executives.

We investigate various dimensions of an enterprise system via an Enterprise System Architecture (ESA); specifically, we assess the effect of each, individually and collectively, on enterprise performance. Among the key motivations for this research is that, while a number of enterprise architecture frameworks and associated theories already exist, none of them appear to sufficiently address the underlying determinants that enable prediction of enterprise performance.

This dissertation takes an inter-disciplinary approach by integrating several research streams and practitioner techniques. Much of the foundational work is embedded in the enterprise studies, systems engineering, and information technology / information systems literature. The confluence, integration, and synthesis of multiple research disciplines enable us to adopt a holistic perspective, thereby analyzing enterprise growth and performance as a continuum from the development phase of growth through business maturity.

1.1.1 Motivation

The motivation for our research approach is rooted in the fundamentals of enterprise transformation which entails the management of risk and associated uncertainties. Enterprises, particularly technology-centric ones, undergo significant change as they progress through each phase of its growth continuum. Various aspects of the phenomena of large-scale change have been addressed in multiple literature streams (Garcia, 2006). One of the most "central" issues in the entrepreneurship literature focuses on criteria for predicting successful new ventures, although there have been few consistent findings. This is corroborated by business mortality statistics that show discontinuance rates can be as high as 70% in the first five years depending on the industry under study (Gruber, 2005). Once an enterprise reaches the maturity phase of its growth continuum, "failure" is considered not in outright enterprise demise, but as the failure of strategic initiatives (Kaplan and Norton, 2004).

This might suggest that: (1) the foundation of these failures stems from the use of unstructured, unaligned architectures, or that an architecture's context has not been articulated (Whittle and Myrick, 2004), (2) integration / interoperability between processes and deployed information-based technologies is either lacking or does not exist. As a consequence, more mature enterprises lose time, money, and other resources. Hence the need exists to understand the enterprise as a system of systems (see below) along with its constituent dimensions in order to move toward enterprise performance predictability.

1.1.2 Associated Concepts

In analyzing an enterprise's growth continuum, our perspective of the enterprise is that of a dynamically complex System of Systems (SOS), defined in detail in Chapter 2. We investigate various layers of an enterprise, referred to here as 'dimensions' that can be used to describe and characterize the enterprise. In the context of our data collection and information technology and information systems research, we are struck by the dichotomy between elements of the enterprise that are tactical / operational versus those that are strategic in nature. For example, while various technologies exist to optimize the operations of a supply chain, decisions made by executives that could potentially change the fundamental direction of the enterprise seem to be made in an ad hoc manner, largely without the support of enterprise information systems. Our research reveals that, while technology can be an enabler of enterprise change, it can also impede and degrade it.

In an evolutionary sense, the enterprise and its information-related technologies are closely interrelated, as are its business processes and architecture. That is, the design and deployment of one affects the design and deployment of another. Inherently, there is a mismatch between the view/perspective of the systems developer and executive in that executives do not have the knowledge and authority to design information systems; far fewer system developers have the knowledge and authority to lead an enterprise. Succinctly, it's the difference between focusing on the answer to a specific question about the enterprise, not the larger problem of understanding it in a macro sense. As a consequence, executives are skeptical about the deployment of systems and solutions that they cannot understand (McGinnis, 2005). This dichotomy is manifested in how information-based systems interact with enterprise processes and enterprise architecture.

Despite an increased awareness of the need for information architectures and enterprise infrastructure engineering, architectures and information systems are not typically aligned (Sage and Lynch, 1998; Nissen and Jin, 2007). Nissen and Jin further state that an enterprise architecture may dislocate information systems from strategic processes and issues. In many cases, enterprises are built with inherent architectural design flaws which create inefficiencies, missed opportunities, and perhaps flawed decisions. In most cases, linkages between processes and the structure and deployment of information-based technologies are not well documented. As a consequence, the architecture of an enterprise, a unifying structure that enables the execution of the strategy through its initiatives to achieve desired performance results, is not well articulated, engineered, integrated, or adaptive enough to respond to market forces and dynamics. As such, for the majority of enterprises that have an enterprise architecture, its expected level of value has not been achieved (Whittle and Myrick, 2004).

Why is this the case? We argue that uncertainty exists about the interrelationships among enterprise processes and information technology-based systems. Also, how such relationships might be assessed is not well understood. A conceptual link appears to be missing between business processes, structure, and technical artifacts (Sproles, 2000).

These interrelationships and their individual and collective effects on overall enterprise performance are a major thrust of our research.

1.1.3 Domain of the Dissertation

While relatively new compared to many other industries, the aerospace and defense sector has been in the midst of a large-scale, complex transformation for the past decade. Such a transformation represents substantial change, the magnitude of which can be extraordinarily difficult to successfully implement. In the face of such transformation, we highlight the ability and capacity of the Department of Defense (DoD) to anticipate and respond to necessary changes in its force structure, and how it executes its concept of operations. These changes are being driven by macro and micro-level forces that include, among others: (1) the new strategic environment; i.e., the Global War on Terrorism (GWOT), (2) significant consolidation of the DoD's industrial base, (3) procurement and acquisition reform, (4), rapid fielding of equipment and systems and, (5) information technology and information systems (see Chapter 6). The implications of DoD's transformation have forced the leaders of both commercial enterprises and the DoD to reevaluate the architecture of their respective enterprises, with a particular emphasis on business processes and information-related technologies. The empirical analysis conducted in this dissertation is specific to and focused on the aerospace and defense industry (see Chapter 8).

1.2 Dissertation Objectives

Our primary research interest, and the focus of this dissertation, is to further our understanding of how to predict enterprise performance. Given the current environment of rapidly changing markets and technologies, many factors affect the operation of an enterprise. The enterprise operating in this type of environment (see Chapter 6) is characterized by a high degree of dynamic complexity, variability, and uncertainty, thereby making prediction of its emerging future extremely difficult. The academic literature and the field of management consulting, in particular, are replete with work that analyzes how enterprises attempt to grow, but largely does not address how to predict future performance.

This dissertation is first motivated by the need of an enterprise to attain competitive advantage within the context of its marketplace. We argue that our approach to understanding how to predict performance may help an enterprise sustain that advantage. Consequently, the intellectual focus here is to move the enterprise beyond dashboards used for monitoring and tactical management of the enterprise, and to move beyond the use of historical financial trends for statistically forecasting performance in the short-term. We hope to establish a foundation for modeling the structure and behavior of decision factors and decision drivers to support strategic decisions for the long-term health of the enterprise; succinctly, to move toward enterprise performance prediction.

Second, while theories of complexity and enterprise transformation provide a perspective on the dynamics that underlie the continuum of enterprise growth from development to business maturity, prediction of enterprise performance is not well understood. Third, a lack of understanding about how an enterprise is positioned to perform in the future comes with a range of organizational risks. From a practitioner's perspective, it is desirable to understand these sources of risks so that action can be taken to minimize their impact on enterprise operations and performance. By so doing, the likelihood that the enterprise will be more sustainable over the longer term should be increased.

Within the general research objective of understanding how to predict enterprise performance, the following three research questions are postulated:

1. What are the key dimensions of an enterprise system?
2. What is the importance of each relative to overall enterprise performance?
3. Are these system dimensions, taken either individually or collectively, an indicator of enterprise performance?

The first research question relates to the issue of the treatment of an enterprise as a complex system of systems, and explains the determinants that are used to investigate enterprise performance. The second question explores the relationships between an enterprise's business processes, its information technology and information systems, and the manner in which it is structured and deployed; its enterprise architecture. The third question relates to our approach to understanding how to predict enterprise performance.

1.3 Dissertation Outline

Our research methodology evolved from a cycle of idea generation, review of the extant literature, development of a research protocol, and analysis; further review of the extant literature marks the beginning of the next cycle. The dissertation is organized as follows and as outlined in Figure 1.

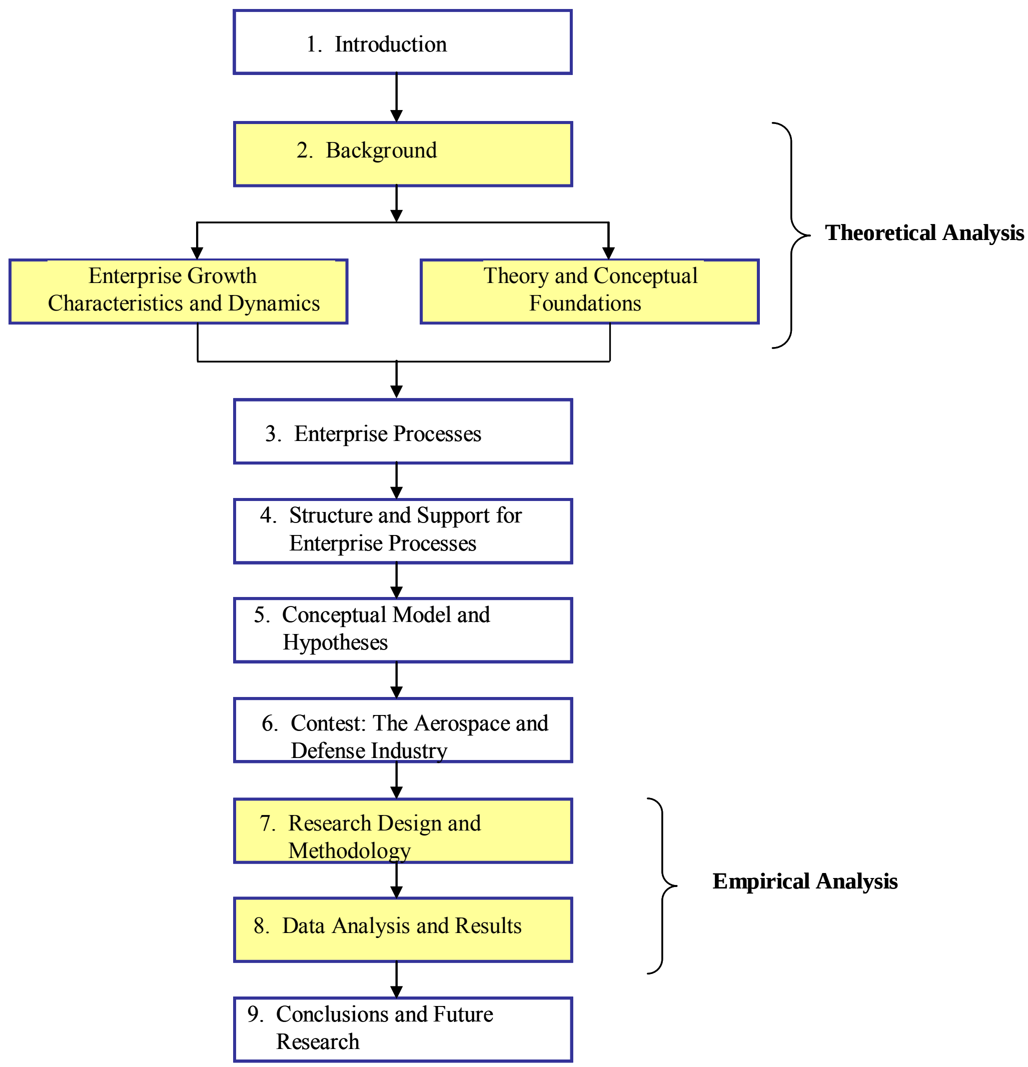


Figure 1: Dissertation Research Flow Diagram

In Chapter 2, we provide the theoretical backdrop for the dissertation. Salient theories and frameworks are summarized based on a review of the extant enterprise studies, systems engineering, and information technology / information systems literature. Our initial research effort that focused on early stage enterprises and associated growth dynamics is also presented and discussed. The purpose of Chapter 2 is to arrive at an integrated understanding of how emerging enterprises either transform into high performance organizations, or fail. Building on these concepts and analyses, Chapter 3 introduces the notion of stratifying enterprise business processes into those that are strategic versus those that are operational. In Chapter 4, we analyze several artifacts, both architecturally and technically, that provide structure, context, and support for the strategic and operational processes described in Chapter 3. An Enterprise System Architecture (ESA) is introduced and used as the basis from which to highlight the relationship between, and general interactions of several dimensions of an enterprise system.

In Chapter 5, we introduce a conceptual framework that extends the ESA by adding dimensionality to the architecture. Chapter 6 addresses transformation in the context of the aerospace and defense industry sector. Building on the theoretical and practical support provided in Chapters 2-4, we assert that DoD's transformation extends to and impacts enterprises in the sector. Chapter 7 describes the research design and methodology used to empirically validate the aforementioned ESA dimensions. In particular, the executive interview protocol is reviewed, and our approach to the design of our web-based survey instrument is presented. Chapter 8 presents the data analysis and discusses our key findings. Chapter 9 summarizes our key results and discusses our contributions to both theory and practice. In addition, limitations of the research methodology are highlighted and discussed. The dissertation concludes in Chapter 10 with suggested directions for future research efforts.

CHAPTER 2:
BACKGROUND

2.1 Introduction

This chapter is bifurcated into discrete yet inextricably intertwined parts; Section 2.3, enterprise growth dynamics, and Section 2.4, theoretical and conceptual foundations. Based on an initial review of the extant literature, Section 2.3 describes our initial research efforts focused on early stage enterprises, subsequent analyses, and the results from those analyses. The purpose is to arrive at an integrated understanding of how emerging enterprises either transform into high performance organizations, or fail. Functions that need to be completed in order to progress from one phase of growth to the next are first articulated, followed by a characterization of those functions in terms of related uncertainties, dynamics, and nonlinearities. Two analyses are conducted and briefly described as follows:

1. Enterprise Growth Characteristics: This analysis is focused on functions/uncertainties per strategic and operational dimensions, respectively, the underlying dynamics associated with growth, and Growth Factor Variables (GFVs) that affect enterprise growth;
2. Analysis of Financial Variables: The analysis is used to test the validity of predicting enterprise performance based solely on the use of historical financial data.

Collectively, these analyses are oriented toward the characterization of the underlying, nonlinear behavior inherent with emerging growth enterprises, and developing appropriate context for the study of multi-phase-of-growth dynamics. Some existing models, modeling techniques, and theories are reviewed. They might be used to help explain the mechanisms underlying complex and emergent phenomena associated with enterprise growth are reviewed. In summary, this part of the dissertation serves to lay the foundation for a more in-depth analysis of the enterprise, suggest additional research questions, and generate related issues that are explored in Section 2.4.

Section 2.4 provides a comprehensive review of the scholarly development of the literature by examining articles in leading journals, book chapters, and conference proceedings. This review, combined with the analyses described earlier and discussed in more detail in the section 2.3, server to crystallize our thinking about how to build -- and subsequently analyze – a more robust model of the enterprise.

2.2 'First Principles'

A rudimentary and shared comprehension of what is meant by "enterprise" is needed in order to create the context for the rest of the dissertation. We take the enterprise to be a for-profit entity, public or private, with the primary purpose of creating profits and value for its stakeholders. Rouse (2006a) defines an enterprise as a goal-directed organization of human, information, financial, and physical resources, usually of significant complication. The "state" of the enterprise system can be thought of in the same way that one considers the state of a physical system; i.e., by the set of variables and their associated values that facilitate the categorization, assessment, and projection of where the system is going.

The enterprise consists of both tangible and intangible assets and resources such as intellectual capabilities/property, etc. An example of a tangible asset is enterprise information systems, the technologically-based systems that work to integrate and manage the information, processes, and other technological-based elements of an enterprise. Such systems deploy these assets throughout the enterprise via various tasks, activities, and functions that are operationalized through its business processes. Typically, these processes are automated and represented by various workflow systems designed such that the enterprise can provide a product and/or service for its customers, ensure cost effectiveness and efficiency of operations, etc (Caverlee et al. 2006).

Based on a preliminary synthesis of the literature, research, and our experience as engineers, our approach toward analyzing the enterprise took on a systems perspective; more specifically, a dynamically complex socio-technical SOS. However, unlike the nonlinear dynamical behavior of a physical system such as a command and control network system, an enterprise has a large human component from which system behavior emerges. Complex socio-technical problems such as this, almost by definition, are ill-structured and quite difficult to analyze. The enterprise system, like many dynamical physical systems, tends to operate away from equilibrium and is oftentimes inherently unstable. Cause and effect, input and output, tend to operate in a nonlinear way, thereby making enterprise performance extremely difficult to predict. Moreover, major alterations to the enterprise system can flow from apparently insignificant causes; at any one time, people of equal intelligence, skill, and dedication can produce quite unequal results as a result of small structural differences (Koch, 1998).

A dynamically complex socio-technical system is defined by Tyszer (1999) as a system consisting of a large number of entities such as humans, machines, computer systems, etc., interacting with each other in significant ways in order to accomplish a specific goal or set of goals. At least two levels of dynamic behavior of such a system, in our case an enterprise system, can be characterized: (1) by the behavior of individual "agents" within the enterprise system, and (2) the behavior that emerges as an artifact of the agent interactions with entities such as business units, etc. Axelrod (2000) notes that such systems challenge understanding and prediction due to both the large number and heterogeneity of its participants, and the intricate, complex, and dynamic manner in which they interact. Therefore, we assert that the enterprise is truly a system-of-systems. Specific characteristics of a SOS are discussed in section 2.6.2.

2.2.1 Enterprise Transformation

Enterprise transformation is introduced here as a 'first principle' since, in order to ultimately move toward the prediction of enterprise performance, the concept and theory of what happens when an enterprise undergoes transformation must be well understood. It suggests a progression of knowledge, information, and analysis from generating an understanding of enterprise performance at the tactical level. This theory is focused on cultivating a more vigorous understanding of enterprise performance as a foundation for future work on enterprise predictability and control. The theory of enterprise transformation will be discussed in more detail later in this section.

2.3 Enterprise Growth Dynamics

The following three sub-sections describe the constituent components of our analysis on enterprise growth dynamics; functions and uncertainties, underlying dynamics, and growth factor variables. The research protocol for our investigation of enterprise growth dynamics is depicted in Figure 2.

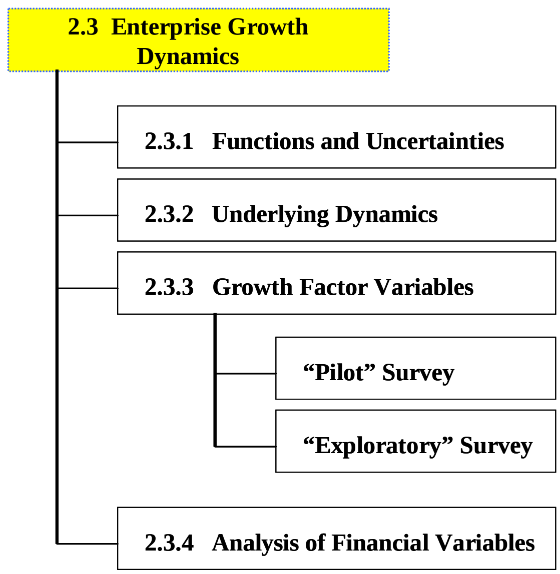


Figure 2: Enterprise Growth Dynamics Research Protocol

2.3.1 Enterprise Growth Characteristics: Functions and Uncertainties

Technical innovation is widely recognized to be a strong economic driver, but the history of enterprise formation around technical innovation is filled with enterprises that, despite early success and adequate funding, did not to live up to expectations and ultimately failed. A paradox emerges in that enterprise demise often cannot be attributed to a single point of failure, such as an intrinsic lack of product efficacy or marketplace relevance, since this is why the enterprise was formed and funded in the first place. Various studies have related organizational problems to stages of growth (Kazanjian, 1988; Åstebro, 2002; Block and MacMillan, 1985), but little is known about how entrepreneurs regard, from an operational perspective, the criticality of certain GFVs as a function of phase of growth. Consequently, we postulate that a foundational understanding of the operational dynamics typical of emerging growth technology enterprises would advance our ability to develop a more robust, general case model for larger more mature, technology-centric enterprises. (These types of companies from the aerospace and defense industry sector are discussed and analyzed in Chapters 6 and 8, respectively).

Those enterprises that are organized around technical and systems engineering innovation face growth-oriented challenges that must be well understood by management, communicated throughout the enterprise, and addressed in order for the enterprise to successfully transition from phase-to-phase in its lifecycle. The workflow from many seemingly disparate functional areas such as product development, marketing, etc., need to be coordinated and focused toward the achievement of enterprise-specific goals and milestones. That effort becomes more complex since the tasking level required of each functional area may vary at any point in time from routine to very knowledge intensive tasks, since humans are interacting with technology. A representation of what a technology-centric enterprise actually does is portrayed in Figure 3.

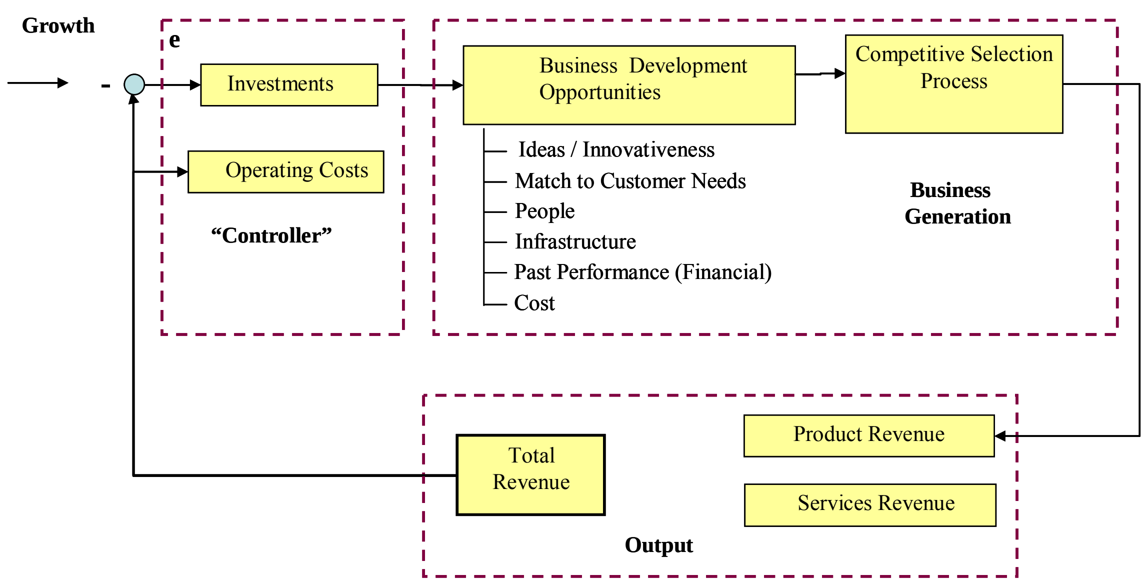


Figure 3: Control Theoretic Representation of a High Technology Enterprise
(Adapted from McMichael, 2005)

Phases of Growth / Framework

The ability of an enterprise to respond to a dynamic environment is tantamount to successful growth and sustained value creation over the longer-term. A first step is to ascertain and quantify what growth dynamics actually are, and how executives attempt to categorize and factor both endogenous and exogenous variability. The phase of growth framework was motivated and based, in part, on previous work conducted in the aeronautical systems laboratory at the Massachusetts Institute of Technology (Mykityshyn and Hansman, 1991). In that effort, systems and human engineering design issues associated with advanced avionics systems were explored. Pilot usage patterns concerning the information presented to them on paper Instrument Approach Plates (IAPs), the relative importance of that information, and the point in time they needed it to successfully complete the tasks at hand were investigated. To facilitate the analysis, it seemed logical to separate the conduct of a flight into various phases in order to fully understand the dynamics of information management and to test for the effects on pilot performance when using this information. Based on empirical pilot performance data, a feature was designed to allow pilots to selectively de-clutter the electronic display. This enabled pilots to see only that information that they felt was necessary to successfully complete the tasks required of that phase of flight.

Mykityshyn (2003, 2004) hypothesized that a similar approach could be applied to the emergent growth trajectory of a high-technology venture. The framework depicted in Table 1 is focused on specific functions associated with each phase-of-growth. Functions faced by executives are also referred to as 'uncertainties' simply because there exists a level of uncertainty in the ability of executives to successfully surmount each challenge. Consequently, we refer to them as "functions / uncertainties".

The idea is relatively straightforward: if executives could "selectively de-clutter" day-to-day activities to focus only on those functions and GFVs that had the greatest impact on performance, the likelihood that the enterprise would progress to the next phase should be increased. It is worth noting that, ten years later, Collins (2001) applied this concept when describing leaders: *"…The good-to-great leaders were able to strip away so much noise and clutter and just focus on the few things that would have the greatest impact…"*

An enterprise growth trajectory is separated into four phases: (1) conceptual design and innovation, (2) development, (3) expansion and commercialization, and (4) business maturity. Functions / uncertainties are grouped into two dimensions, strategy and operations. By so doing, we are able to understanding interactions within the enterprise in a more comprehensive, integrative fashion (Gruber 2002). The focus of the strategic dimension is the development of suitable strategies to position the enterprise relative to its competition; enterprise operations are all about the timely execution of tasks and strategies. The representative phases of growth and their functions were identified based on informal discussions with entrepreneurs, the authors experiences as entrepreneurs and venture capitalists, and a review of the extant entrepreneurship literature.

In Phase I, 'conceptual design and innovation', a core function is the creation of the firm's vision, underlying value structure, and market-facing value proposition. In Phase II, 'development', the enterprise's construct is planned to a much more rigorous level of detail. Core functions in the development phase are to, (1), ensure that the product concept is under control so that product development can be scheduled and accurately budgeted for, and, (2), establish the market for the product. This is the period of time during which needed improvements are made and the product is tested and proven to be commercially producible. Also, the team confirms that the product will perform as specified by constructing and testing engineering prototypes or pilot processes, resulting in a tested and proven product.

Phase III, 'expansion and commercialization', focuses on how best to strategically position the product within the market to develop a competitive advantage. If the product proves to be technically feasible and has achieved market acceptance, this is usually the demarcation point for further growth and expansion. Phase IV, 'business maturity', describes the period of time during which the enterprise typically secures its market position, reaches cash flow break even or profitability from business operations and, from a product perspective, explores diversification to pursue various markets. An overview of some core strategic and operational functions, respectfully, are depicted in Table 1.

Table 1: Phase of Growth Framework with Core Functions

	Phase I	Phase II	Phase III	Phase IV
	Conceptual Design and Innovation	*Development*	*Expansion and Commercialization*	*Business Maturity*
Strategic Dimension				
Corporate/ Executive Management	• Create vision, mission, and value structure • Define early organization	• Develop corporate strategy • Formulate strong management team	• Expand board with outside / unbiased directors • Review management skills and experience	• Review long term strategy • Obtain / develop tools and systems
Operational Dimension				
Operations	• Define facilities requirements • Define capital expenditure requirements	• Beta test / customer acceptance • Develop hiring plan, basic R &D	• Review / meet staff needs • Expanded customer base • Review / revise facilities and infrastructure needs	• Obtain / develop operational tools / systems • Review cost structure
Accounting and Finance	• Identify start-up costs • Identify capital requirements	• Obtain required funding / capitalization • Implement / monitor budget	• Develop or expand accounting systems / infrastructure for expansion • Analyze BE requirements	• Review / implement expense management
Sales and Marketing	• Initial market sizing • Competitive analysis	• Establish market for the product and begin sales process • Develop sales and marketing strategies	• Refine pricing strategy • Expand infrastructure • Refine product and company image	• Analyze / expand into new markets • Review / analyze product ROI
Technology / Products and Services	• Technical feasibility assessed • IP protection	• Develop architecture. • Develop prototype	• Refine / standardize development process • Expand product(s) life cycle	• Implement new functionality as required by market

The following are noted from Table 1:

1. Phenomena of Interest: The only phenomena of interest here are those functions / uncertainties faced by entrepreneurs, an understanding of which may help to predict the evolution of the enterprise. The cognition of both investors and managers might relate to their abilities to perceive enterprise states, infer underlying mechanisms, reach understanding of emerging phenomena, and make appropriate decisions. While these cognitive phenomena might influence the enterprise, this is quite different from predicting the evolution of the enterprise. This constitutes a different class of phenomena that are not investigated here. Again, it is noted that functions faced by executives are also referred to as 'uncertainties' simply because there exists a level of uncertainty in the ability of executive management to successfully surmount each challenge. Consequently, one might also regard the phase of growth framework as a generic uncertainty profile for an emerging growth enterprise;
2. Stratification of Functions: Conceptually, the notion of stratifying functions into those that are strategic versus operational in nature was a catalyst for the later creation of separate layers in our ESA to accommodate each of strategic and operational processes, respectively (see Chapter 4)

2.3.2 Enterprise Growth Characteristics: Underlying Dynamics

The next step in our investigation of enterprise growth characteristics is to examine the dynamics of the representative functions / uncertainties encapsulated in Table 2. Since the ability of an enterprise to dynamically respond to a changing environment is tantamount to successful growth over the longer term, we seek to understand and quantify what growth dynamics actually are.

State / Phase Transition Framework

The state / phase transition framework represents an effort to capture the essence of what's actually happening in each phase of growth. To illustrate the concept, the underlying dynamics and nonlinearities associated with the functions / uncertainties in the strategic dimension of the phase of growth framework for each phase are evaluated in Table 2.

Take for example the Phase I function / uncertainty, "create vision, mission, and value structure". Dynamically, the completion of this function is slow; through discussions and debate, the founders typically cultivate a common understanding of all three. The nonlinearity is elastic since, as more people join and the business evolves, the firm needs to adapt and change so as to maintain its culture, orientation, and business focus.

Table 2: State / Phase Transition Framework

	Phase I	**Phase II**	**Phase III**	**Phase IV**
	Conceptual Design and Innovation	*Development*	*Expansion and Commercialization*	*Business Maturity*
Function / Uncertainty	• Create vision, mission, and value structure • Define early organization	• Develop corporate strategy • Formulate strong executive management team	• Expand board with outside / unbiased directors • Review management skills and experience	• Review long term strategy • Obtain / develop management systems
Dynamics of Each Function (Slow, fast, time-varient)	• Slow • Fast	• Slow • Time-varient	• Slow/time-varient • Slow/time-varient	• Slow/time-varient • Slow/time-varient
Nonlinearity Characterization (Elastic, inelastic)	• Elastic • Elastic	• Elastic • Elastic	• Elastic • Elastic	• Elastic • Elastic

This type of an analysis may aide investors and entrepreneurs in determining whether or not the enterprise is ready to transition to the next phase of growth. It may also help to predict the outcome of such a transition or transformation.

2.3.3 Enterprise Growth Characteristics: An Analysis of GFVs

Thus far, our analysis considers the growth trajectory and dynamics of mostly earlier stage enterprises. However, prior to our preliminary foray to enterprise performance prediction, variables associated with an enterprise SOS are identified, categorized, and evaluated per phase of growth. It was hypothesized that enterprise state and its performance while in that state is not one-dimensional and can therefore not be described or defined simply by financial statements or financial variables. Figure 4 depicts a non-inclusive list of variability inherent in enterprise operations.

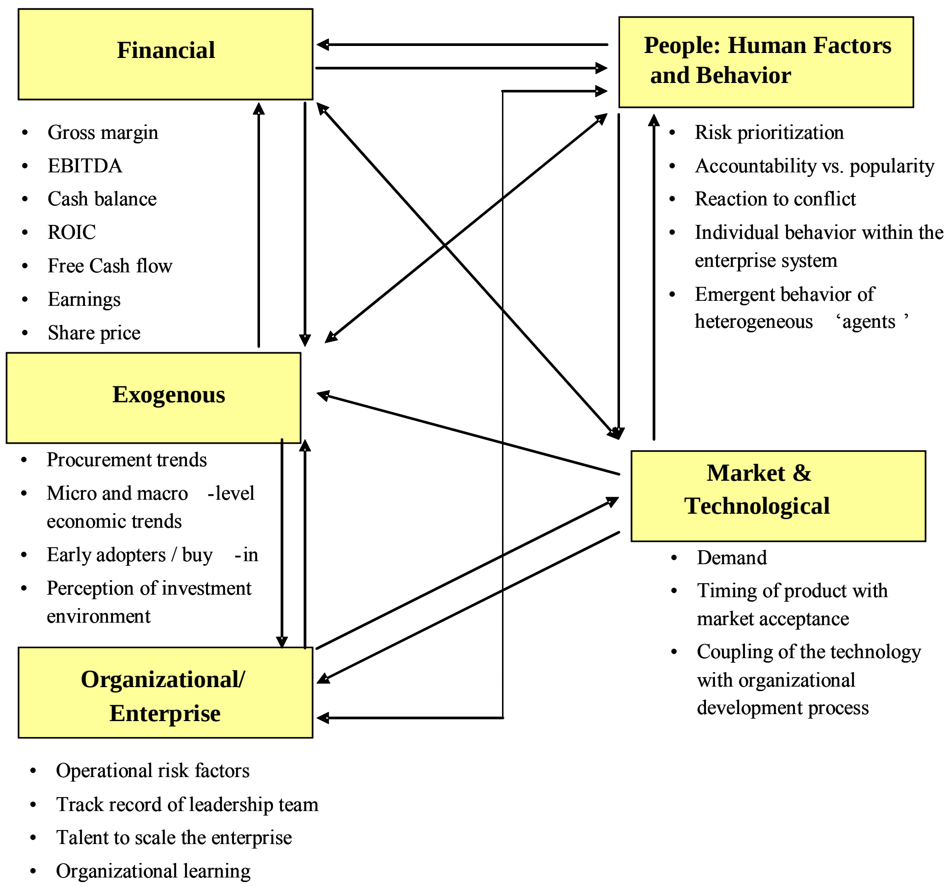


Figure 4: Representative Enterprise Variable Categorization

While not depicted here, (see Appendix A), one hundred nineteen (119) variables associated with enterprise growth are identified based on: (1) informal discussions with entrepreneurs, (2) our collective experience as entrepreneurs and venture capitalists and,

(3) a review of the extant entrepreneurship literature. In order to fully investigate these variables and how they impact enterprise growth, two surveys are conducted (see Appendix B)

The initial, or "pilot" survey, was distributed via mail to ten executive-level entrepreneurs from high technology venture enterprises They were asked to rank the criticality of the 119 GFVs as they pertain to the successful completion of phase of growth-specific tasks / milestones. It should be noted that while the tasks changed as a function of phase, the variables remained the same. A large number of GFVs were presented so as not to bias or constrain the entrepreneur's view about the scope of variables that might bear directly on maintaining an optimal growth trajectory. The primary purpose of the "pilot" survey is threefold:

1. To further check the validity of the phase of growth matrix;
2. Reduce the aggregate number of GFVs to the most relevant needed to complete the phase-of-growth-specific tasks / milestones;
3. Inform the development of our web-based study on GFVs

When ranking the criticality of GFVs per phase-of-growth, entrepreneur choices were weighted using a 5 point Likert scale with 1 being critical, and 5 extraneous. In the pilot survey, entrepreneur's were asked to rank the GFVs as either critical or extraneous; based on the data collected and ubsequent post-survey discussions with the survey respondents, the number of GFVs was reduced from 119 to 24 (see Appendix B, Part I). .

The web-based "exploratory survey" is built on the results attained from our pilot survey. Forty-nine (49) executive-level entrepreneurs responded to the survey. It can be seen from the results (Appendix B, Part II), that preferences for certain GFV's clearly change as a function of phase of growth. This is especially true when the ranking of GFV from Phase I is compared to the GFV ranking for Phase III and, similarly, when the GFV ranking from Phase II is compared to the GFV ranking for Phase III. This indicates a clear separation between Phases I and III, and II and III. This is true to a lesser degree for Phases I and II. The similar rankings for the top five GFV's for Phases I and II may indicate that at the very nascent stages of growth, entrepreneurs are of the opinion that a similar skill set is required in order to complete critical milestones. But what happens when the enterprise becomes more mature?

2.3.4 Analysis of Financial Variables

The previous analyses consider enterprise growth in a phased manner, whereby the likelihood of growth from its nascent phase is increased by focusing on the completion of certain strategic and operational functions. We next turn our attention toward the prediction of performance once the enterprise has reached phase four in its growth trajectory. How might overall performance be predicted?

When contemplating whether or not it is even feasible to try to predict future performance, a logical place to start is an analysis of an enterprise's historical financial performance. Even though financial data is a 'lagging' indicator; i.e., a reflection of past performance, every enterprise, public or private, documents its financial performance on a regular basis. By Securities and Exchange Commission (SEC) mandate, public enterprises are required to publish their financial results both a quarterly and annually. Since private enterprises are not required to follow SEC reporting guidelines, only data from public companies is readily available.

Our starting point for cultivating a more vigorous understanding of enterprise performance begins with an investigation of purely financial variables and how they either do or do not impact Return on Invested Capital (ROIC). For the data collection and subsequent analyses, ROIC is used as a proxy for enterprise performance.

We postulated that some key financial metrics might be used as a predictor of enterprise performance. First, working with analysts from several large investment banking firms who specialize in the aerospace and defense sector, a list of ten financial variables were generated:

- Revenue growth
- Bookings or backlog; absolute and growth; funded versus unfunded
- Book-to-bill ratio
- Margins, absolute / trend line; operating inc., pretax, net

- Working capital turns, particularly inventory and percentage of completion progress
- A/R
- Cash balance
- Cash flow
- Cost performance particularly on fixed price contracts
- ROIC

Next, data were collected for a group of small to medium-sized publicly-held firms in aerospace and defense sector. Initially, a database of over 300 companies who compete in the DoD satellite communications sector was compiled. The application of several 'filters' (see Appendix C) were applied in order to reduce that number from 300 to 50. Multiple regression and other standard statistical analyses were then performed on the data. Enterprise performance was used as the dependent variable; ROIC was used as a proxy for enterprise performance.

Results of the analysis (see Appendix C) show that EBITDA and cash flow are the only two significant predictors of ROIC, with cash flow having a negative impact on ROIC. Although ROIC can be used to some extent with the regression model, it was shown that the enterprise performance can not solely be predicted using financial measures; financial variables alone are insufficient to project or predict the future state of an enterprise. But why is it the case?

In terms of historical financial performance, financial metrics that can be linked to value creation such as ROIC are more meaningful than traditional accounting metrics such as earnings per share. However, every historical financial measure has two fundamental but salient flaws:

1. Historical financials are subjective since executives must make judgments about when to record both revenues and costs;
2. They cannot capture, nor do they reflect, the trade-offs that are constantly made by executives between achieving short-term financial objectives and

investing forward and building infrastructure and other capabilities for longer-term value creation and enterprise performance.

Recognition of these flaws was a fundamental motivation for the development of the Balanced Scorecard (BSC), (Kaplan and Norton, 1996.) The BSC is a strategic approach and performance management system that enables enterprises to translate its vision and strategy into actions working from 4 perspectives: (1) financial, (2) customer, (3) business processes, and (4) learning and growth. In theory, this approach facilitates monitoring of present performance and attempts to capture information about how well the enterprise is positioned to perform in the future. Perhaps most importantly, executives must not only have a theoretical understanding of value creation, but also be able to create tangible links between their strategies and value creation (Koller, et al., 2005). This means, for example, focusing less on recent (past) financial performance and more on what they are doing to create a "healthy" enterprise capable of creating value over the longer-term.

However, to do that, we assert that executives need a thorough grounding in the linkages / interplay between various elements of the enterprise, specifically its: (1) strategic and operational processes, (2), information technology, (3) information systems that support business processes, and (4) structure in the context of its enterprise architecture. Consequently, we argue that a more robust and balanced model of the enterprise is needed to both qualitatively and quantitatively evaluate these linkages. Theoretical concepts that underlie the formulation of such a model are explored in more detail in the section 2.4.

2.3.5 Summary and Next Steps

Regardless of enterprise size, a striking similarity exists in terms of failure rates. For discussion purposes, "failure" is defined as the net destruction of enterprise value. For earlier stage companies, a paradox emerges in that enterprise demise often cannot be attributed to a single point of failure such as an intrinsic lack of product efficacy or marketplace relevance since this is why the enterprise was formed and funded in the first place. Similarly, larger, more established companies, particularly Lead Systems

Integrators (LSIs) in the aerospace and defense industry, have not been able to create shareholder value; i.e., the creation of ROIC and economic profits, from mergers and acquisitions over the past fifteen years (Lewis and Bundy, 2007). Regardless of enterprise size or the size of an enterprise's chosen market, two common themes exist:

1. Variability in patterns of growth may exist depending on whether or not an enterprise is established or emerging;
2. The ability of both investors and managers to perceive enterprise states, infer underlying mechanisms, reach an understanding of emerging phenomena, and make appropriate decisions can have a substantial impact the enterprise.

2.4 Theoretical and Conceptual Foundations

2.4.1 Introduction

Complex systems research, and understanding / analyzing the performance of such systems are multi-disciplinary in nature. Consequently, the identification of disciplines and relevant studies within those disciplines is unwieldy and complicated. A high-level, holistic approach is taken as a first iteration to the literature review. Table 3 outlines some of the various theoretical domains of applicability and corresponding principles from which our investigation of enterprise performance is derived.

Table 3: Overview of Relevant Research Domains

Domain of Applicability	Applicable Principles / Parameters
Complexity	Game theory / chaos theory / chaotic dynamical systems
Systems Engineering	Various human machine systems models
Behavior / Psychology	Behavior/behavior modification
Investment Finance	Calculating ROIC / financial modeling / investment methodologies
Management	Management theory / lifecycle analysis / systems and strategic thinking
Engineering	First principles and commutable laws
Physics	Underlying precepts of quantum mechanics. Given multi-variable systems-of-systems, probabilistic versus deterministic view of performance outcomes
Optimization	As it pertains to the development of a performance prediction methodology
Control Theory	Open and closed loop systems correlated per stage; optimal control model
Modeling	Enterprise modeling and other software development tools
Business Process Engineering	Causality What causes what, and why (not influence diagramming)

2.4.2 Methodological Flow of the Literature Review

Given the breadth and depth of the literature base encompassed by the eleven domains of applicability articulated in Table 3, the domains are consolidated into three 'disciplines' in order to simplify our synthesis of the literature: enterprise studies, systems engineering, and IT /IS. For each discipline, both relevant sub-fields (level II) and fundamental precepts (level III) are described. The research methodology is depicted in Figure 5.

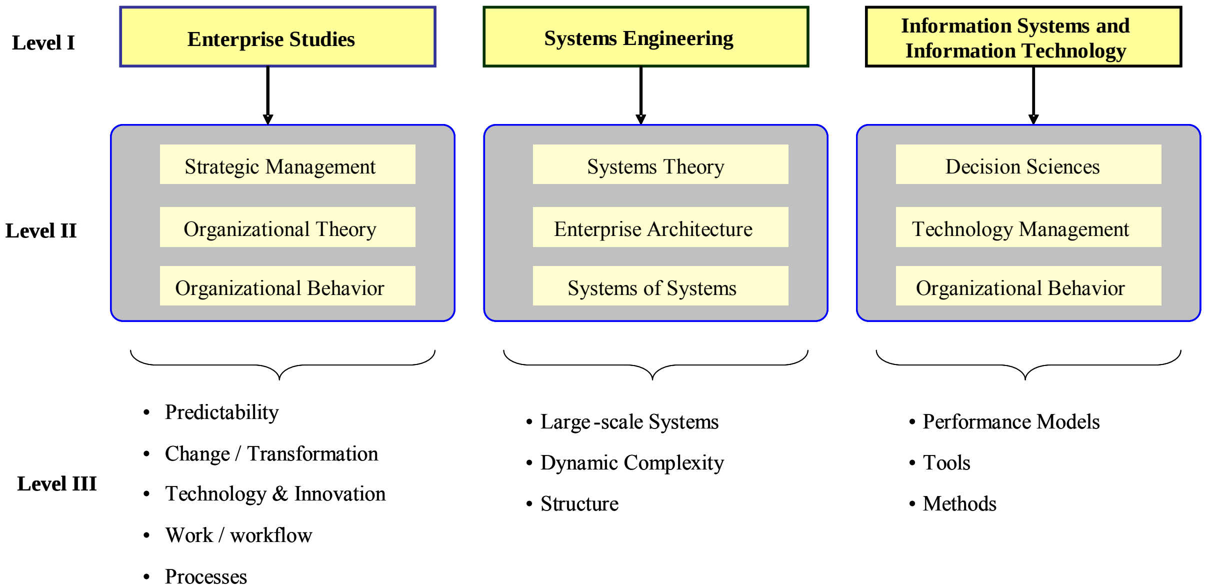


Figure 5: Theoretical Domains / Phenomena of Interest

Figure 5 is not meant to describe a fully comprehensive review of the relevant and complimentary research domains, nor does it capture the overlap between domains. Rather, this particular stratification accentuates how the lines of distinction between traditional disciplines might be artificially induced so as to facilitate the study and / or measurement of particular phenomena. It should be noted that, while some of the phenomena are addressed across multiple disciplines, some phenomenological concepts that pertain specifically to our analysis of the enterprise as complex SOS were also explored and are depicted in Figure 6.

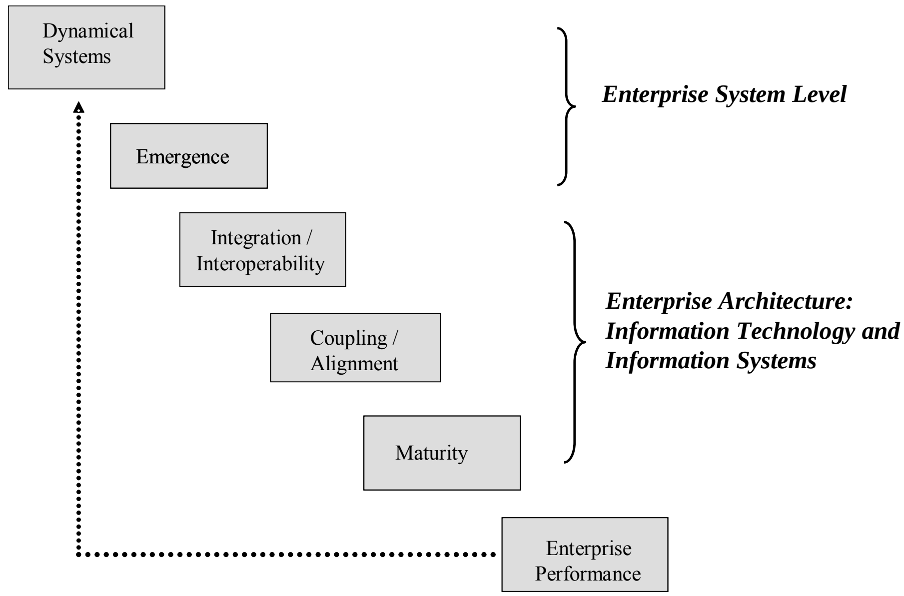


Figure 6: Enterprise Studies: Phenomenological Concepts Explored

In order to further simplify the classification of the relevant literature, each of the three disciplines was ascribed to a category as depicted in Table 4.

Table 4: Research Discipline Categories

Category	Research Discipline
I.	Enterprise Studies
II.	Systems Engineering
III.	Information Systems and Information Technology

There exists a large and growing literature base of research across the numerous research disciplines that is not confined exclusively to the academic literature and refereed journals. Consequently, a thorough literature search was conducted, primarily via online databases such as ABI/INFORM, Academic Search Elite, ACM Digital Library, IEEE Xplore, and Science Direct. Most of our research was adequately informed by these databases which employed multiple descriptors depending on the database and the type of information sought from the database. However, a critical part of the research protocol that provided a rich data set was garnered via our participation in industry as consultants and financiers.

2.4.3 Classification by Research Category

Table 5, Table 6, and Table 7 depict the relevant journals that were reviewed per each discipline: enterprise studies, systems engineering, and information technology / information systems, respectively.

Table 5: Research Synthesis Enterprise Systems Journals

Category	Journal	Years
I.	Academy of Management Journal	1996-2004
	Academy of Management Review	1995-2005
	Harvard Business Review	1999-2006
	Journal of Business Research	1998-2002
	Journal of Business Strategy	1995-2002
	Journal of Business Venturing	1995-2002
	Journal of Management	1998-2005
	Journal of Private Equity Capital	2000-2003
	Organization Science	1998-2005
	Strategic Management Journal	1998-2004

Table 6: Research Synthesis Systems Engineering Journals

Category	Journal	Years
II.	Journal of the International Council on Systems Engineering	1999-2005
	IEEE Transactions on Systems, Man and Cybernetics – Part A: Systems and Humans	1998-2005
	Engineering Management	1987-2003
	Expert Systems – The Journal of Knowledge Engineering	1995-2000
	Complex Systems	1985-2001
	International Journal of Systems Science	1992-2004
	Enterprise Information Systems	1987-2006

Table 7: Research Synthesis: IT / IS Journals

Category	Information Technology and Information Systems	Years
III.	Academy of Management Journal	1996-2004
	Business Intelligence Review	2001-2005
	Communications of the ACM	2001-2005
	Communications of the AIS	2001-2005
	Decision Support Systems	1996-2005
	Electronic Journal of IS Evaluation	2001-2003
	Information and Management	1985-2006
	Information Systems Journal	1987-2002
	Information Systems Management	1990-2005
	Information Systems Research	1995-2005
	Journal of Information Systems	1998-2002
	Journal of Information Technology	2001-2005
	Journal of IT Theory and Application	2001-2004
	Journal of Management Information Systems (MIS)	1993-2005
	Journal of Strategic IS	1990-1998
	MIS Quarterly	1985-2005
	Organizational Science	1990-2002

2.5 Category I: Enterprise Studies

Our review of the literature vis a vis enterprise studies focused on the following four aspects: (1) Enterprise as a system theory, (2) Theory of enterprise transformation, (3) Organizational structure and impacts on enterprise performance, and (4) Competitive business strategy.

2.5.1 Enterprise as a System Theory

In this dissertation, the enterprise is treated as a system that is comprised of various resources including technical, human, and financial, among others (Rouse, 2006a). The high rates of change characteristic of today's business environment mandate that organizations possess the ability to respond to environmental dynamics in order to capitalize on both opportunities and challenges. Those enterprises that are flexible, adaptable, and understand the underlying dynamics of not only how they can change but are apt to change, usually continue to grow into high performance organizations. Conversely, those enterprises that are less agile and knowledgeable about change tend to be less sustainable over the longer term and may ultimately experience failure of some sort. Consequently, a principal function for executive management is to design and lead the enterprise through a myriad of strategic and operational challenges ranging from transition issues related to phase of growth dynamics to enterprise transformation, defined as a fundamental change in the manner in which the enterprise conducts its business.

A distinction is made between simple and complex systems. Simple systems tend to be categorized by a small number of components and regular interactions between them. Conversely, complex systems are characterized by a larger number of components and more complicated interrelationships Maier and Richtin, 2000). Complexity implies that the system consists of parts that interact in ways that can heavily influence the probabilities of events that occur later in the lifecycle of the enterprise. Resulting system properties, or emergent properties, are those that the individual parts of the system do not have (Axelrod, 2000). Rouse (2003) notes that enterprise complexity is typically due to nonlinearities and discontinuities that exist among a large number of interacting elements. Further, the enterprise is an example of a socio-technical system (Shah and Pritchett 2005). Wooldridge (2000) describes a socio-technical system as one that links humans with hardware or tools so as to perform tasks that people want done. Socio-technical or human activity systems generally fall into the category of complex systems, while designed systems are usually considered not to be complex (Maier, 1998).

As discussed earlier in Section 1.1.2, a technology-centric enterprise is an example of a complex, adaptive socio-technical system SOS. Socio-technical business systems, like many dynamical physical systems, tend to operate away from equilibrium and can be inherently unstable. Major alterations in a business system can flow from apparently insignificant causes. At any one time, people of equal intelligence, skill, and dedication can produce quite unequal results, as a result of small structural differences.

More precisely, in the enterprise SOS, there are many interacting processes. Invariably, in such a system, cause and effect, and inputs and outputs tend to operate in a nonlinear manner. Consequently, thinking through the implications of growth and hence change, are not trivial. The high technology enterprise is comprised of people (the social system) who are using tools, techniques, technology, and knowledge (the technical system) in order to produce, in this case, a technology-based product. It is composed of a number of different entities such as management and employees who perform varied and distinct functions within the enterprise, a governing body (Board of Directors), and technical devices. The entire system needs to 'scale' with the business environment in order to maintain a satisfactory growth trajectory.

2.5.2 Theory of Enterprise Transformation

Given the current environment of rapidly changing markets and technologies, today's business executives are driven by both endogenous and exogenous pressures to achieve and sustain competitive marketplace positioning and advantage. As was described earlier in this section, many variables affect how decision makers understand, identify, and focus on the completion of functions and tasks that most impact sustained enterprise growth. These and other challenges may be surmounted via process improvements and/or other changes.

Of equal importance for executives is understanding when change needs to extend from small-scale, incremental change, to more significant, enterprise-wide transformation that might include executive leadership, and organizational / enterprise structure. Rouse's theoretical foundation accommodates this type of enterprise-wide change. He describes enterprise transformation as a: "fundamental change that substantially alters an organization's relationships with one or more key constituencies, e.g., customers, employees, suppliers, and investors." The theory of enterprise transformation asserts that transformation is motivated and driven by 'value deficiencies' that result in essentially new work processes that are an artifact of management's ability to make decisions, among other considerations (Rouse, 2006a).

Having created the context for enterprise transformation, Rouse then develops a three-dimensional framework to further illustrate the nature of enterprise transformation that is depicted in Figure 7.

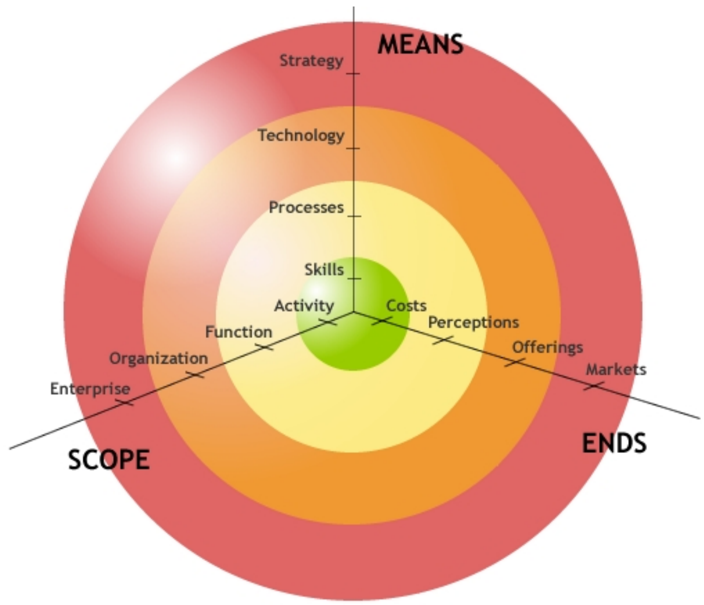


Figure 7: Framework of Enterprise Transformation
(Adapted from Rouse, 2005)

The framework entails three primary dimensions: (1) Scope, (2) Means, and (3) Ends. The scope of transformation can range from work activities to full-scale transformation of the entire enterprise. The means to successfully effectuate transformation may entail just about any factor ranging from how the enterprise structures and deploys its IT infrastructure, to how it aligns its business processes in order to satisfy stakeholder objectives. The ends, or some desired end-state, are numerous and varied. Some desired end-state objectives might include new product or service offerings, a reduction in operating margins, etc. It should be noted that the enterprise's risk profile and associated transformation costs increase as a function of the distance moved away from the center of the framework.

The theory of enterprise transformation relates quite well to the issue of enterprise performance prediction as it is a fills a critical theoretical gap in the continuum of enterprise growth from a fledgling start-up to a mature enterprise. Compared to the management of mature enterprises, transformation of the enterprise in the early phases of growth presents a unique challenge to the founding entrepreneurs. In addition to building the enterprise day-to-day, they must, in parallel, focus on building a long-term sustainable enterprise. As the growth continues, decision makers find it necessary to enhance the value creation capabilities of the enterprise, thereby making an understanding of its processes, culture, and technological systems critical. Also, as the phase-of-growth framework and subsequent analyses conducted in Section 2.3 show, proper identification of functions / uncertainties, and GFVs necessary to surmount concomitant challenges, is both a strategic and operational necessity.

Herein lies the value of the theory for our research: it provides the theoretical foundation from which to cultivate an understanding of what value deficiencies drive those critical functions / uncertainties, and what new or redesigned work processes emerge may from them.

2.5.3 Organizational Structure: Impacts on Enterprise Performance

Clearly, the issue of organizational structure and how it may influence or even shape enterprise performance is a focal point of our research. The question of how the amount of organizational structure may shape performance in dynamic market environments has been well studied in both the organizational theory and strategy literature Thematically, the fundamental relationship often highlighted in research that explores this question in that of "too much" versus "too little" structure (Davis et al, 2007). Fundamentally, we take a different tact, whereby enterprise system maturity is used as a proxy to describe the extent to which multiple system dimensions, taken individually or in the aggregate, are used to evaluate the impact of structure on performance.

Given the vast number of studies from multiple domains that investigate organizational structure versus performance, the scope of the research synthesis is limited here to those domains that are most directly applicable to our research method. They include complexity theory (section 2.6.3), competitive business strategy, typologies of organizational strategy (section 2.5.4), and various organizational studies.

As context, Davis et al (2007) describe multiple types of organizational structures, each of which have varying amounts of structure ranging from low to high. One such hierarchy is depicted in Figure 8. Using a system-of-systems analogy, 'loose coupling' equates to moderate or a medium level of structure.

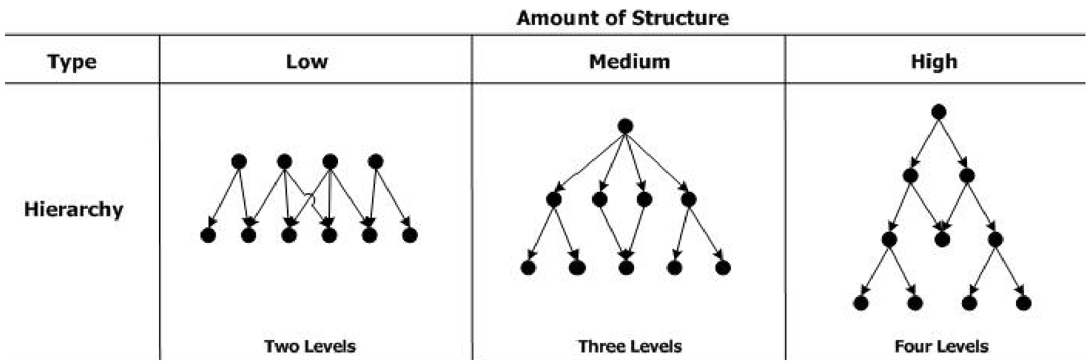


Figure 8: Various Levels of Organizational Structure
(Adapted from Davis et al, 2007)

One dilemma for executives whose enterprises compete in dynamic competitive environments is how to choose the 'right' structure; that is, one that affords flexibility, adaptability, and efficiency of operations in order to respond to vicissitudes in the marketplace. A brief synopsis of various authors and their research on structure is presented in Table 8.

Table 8: Sampling of Research Studies on Organizational Structure

(Adapted from Davis, et al, 2007)

Author (s)	Aspect of Structure Investigated
March (1991)	Exploration versus exploitation
Hansen (1999)	Search versus lock-in
Brown and Eisenhardt (1998)	Structure versus Chaos
Bradach (1997)	Uniformity versus adaptability
Mintzberg (1979)	Emergent versus deliberate
Gibson and Birkinshaw (2005)	Alignment and adaptability
Rivkin and Siggelkow	Interaction among elements of a system

It is interesting to note from the research synthesis that the predominant method appears be a singular focus on one particular trade-off that is made vis a vis structure; only a handful of studies considered the interaction among elements of a structure (enterprise). Consequently, the outcome of some of these studies is readily apparent and intuitive. For example, Okhuysen and Eisenhardt (2005) find that, in dynamic environments, it is "effective to increase the amount of structure when there is little or even none; to engender efficiency, decrease the amount of structure when it is extensive"

By contrast, ours is a different approach. First, we develop a novel ESA from which we focus on and identify several system dimensions. Further, we not only investigate the interaction among these ESA dimensions, but their impact, both individually and collectively on enterprise performance. One of the key differentiators is that we characterize and analyze enterprise performance in the context of a SOS rather than a monolithic system (Sage and Lynch, 1998). A SOS approach such as ours is particularly useful for dynamic environments where the focal phenomena are non-linear.

2.5.4 Competitive Business Strategy

In general, business strategy represents the outcome of decisions made by executives in order to guide the enterprise with respect to its competitive environment, structure (enterprise architecture), information technology-based systems, and processes (strategic and operational). Strategy is all about gaining and sustaining competitive advantage.

The strategic layer process: “Developing Enterprise Strategy”, is treated in detail in Chapter 3, but is important to introduce it here because: it is a critical determinant for: (1) how information technology and information systems are structured and deployed throughout the enterprise and, (2) how such systems either are or are not aligned. Given the potential impact of such systems on enterprise performance, an understanding of how they interact with other enterprise dimensions, and the extent to which they can be aligned with enterprise strategy, is of critical importance to executives. While several typologies of business strategy exist (Bergeron and Croteau, 2001) the characterization of strategy by Miles and Snow (1978) is the most frequently cited from 1989-2000.

In the context of our research it is particularly relevant since they describe multiple types of competitive strategies: prospector, analyzer, defender, and reactor. A principle strength of this typology is the simultaneous consideration of the structure and processes necessary for the realization of a given type of business strategy (Bergeron and Croteau, 2001). As such, their typology reflects a complex view of processes and various other attributes such as products, markets, and management characteristics. As such, it fits nicely with our characterization of the enterprise as a dynamically complex SOS, whereby the type of strategic positioning adopted by the enterprise is reflective of how it views its competitive environment. By applying this to the context of ESA maturity and enterprise performance, it is palpable to see the specific impacts of organizational strategy on how information technology-based systems are structured and deployed which, in turn, affects enterprise performance.

2.6 Category II: Systems Engineering

Systems engineering is an interdisciplinary approach and means to enable the realization of successful systems (INCOSE, 2007). Further, it is concerned with the architecting, design, and integration of elements that, taken together, comprise the system. From a business perspective, it focuses on required functionality early in the development cycle such as requirements documentation, design synthesis, and system validation, among others.

Systems engineering activities are very much aligned with our exploratory, theory-building research approach in order to validate our initial theories of enterprise performance predictability. These activities involve the technologies (IT and IS), processes, and systems management approaches needed in order to:

- Define Systems: identification of user requirements and technological specifications;
- Develop Systems: conceptual architectures, tradeoff of design concepts, configuration management during system development, integration of new systems with legacy systems, and integrated product and process development;
- Deploy Systems: operational test and evaluation, maintenance, and process reengineering, if necessary.

Modern technology-based systems include both products and services. They are often very knowledge intensive, and are found in both the public and private sectors. The discipline of systems engineering emphasizes strategic and program management of products and services. It also emphasizes the information and knowledge base for knowledge principles, knowledge practices, and knowledge perspectives for the engineering of systems.

2.6.1 Enterprise Architecture

Rouse (2007a) led a National Science Foundation (NSF) initiative on "Complex Engineered, Organizational, and Natural Systems" that was designed to bring together "thought leaders" from various communities in order to formulate an agenda for complex systems research. One outcome of the workshop was the cultivation of overarching, fundamental research questions. It is interesting to note that four of the five research questions generated by the workshop participants focused on architectures.

As a precursor to a more in-dept analysis of architectures (see Chapter 4), it is relevant and useful here to address the underlying precepts of the term "architecture". Even though a wide dispersion of opinion exists regarding a precise definition of architecture (Sage and Lynch, 1998, Levis, 1999), consensus on the construct of an architecture is a necessary first step toward establishing a common foundation for designing, developing, deploying, operating, and controlling complex systems (Rouse, 2007a). The general idea behind architecture is to represent and/or model, in the abstract, not only an orderly arrangement of system elements, but their interactions and relationships. It should be noted that architectures are contrasted here with the means used to create them, architecture frameworks, and the activity of creating them, architecting (Nightingale and Rhodes; 2004; Rouse, 2007a).

Finally, architecture is a foundational component for our research so as to cultivate a more robust understanding of complex systems such as an enterprise; i.e., how they grow, the nonlinear dynamics that underlie growth, functions / uncertainties faced by executives, and GFVs that most directly impact growth. This is at the core of our research efforts as described in Section 2.3.

2.6.2 System-of-Systems

In order to arrive at a comprehension of what a complex system is, we first identify its constituent components in order to understand how they interact. As previously stated, the behavior of a complex system may result in emergent phenomena that can not be predicted by its subsystems. This is often true of systems whose sub-systems have a degree of autonomy and their own objectives. Such systems are often referred to as "System-of-Systems" (Shaw and Pritchett, 2005; Sage and Cuppan, 2001).

Basically, three types of sub-systems need to be architected and integrated in an enterprise SOS: (1) organizational and human elements, (2) process elements, and (3) product elements. A system is referred to as a true SOS, as distinguished from a large-scale and complex monolithic system, when the following criteria / conditions are satisfied (Sage, 1992; Sage and Cuppan, 2001):

- The component systems achieve purposes by themselves, and continue to operate in this manner even though they may be detached from other system components;
- The system components are managed in large part for their own purposes rather than the purposes of the whole, yet, they function to also resolve purposes of the

whole that are generally not achievable by individual systems acting independently;

- Development is evolutionary in the sense that functions and purposes are added, removed, and modified with experience of the system;
- Emergent behavior

A more complete treatment of system complexity / complexity theory is discussed in the next section.

2.6.3 System Complexity / Complexity Theory

In socio-technical systems such as an enterprise SOS, we are interested in emergent phenomena. “Emergent” is defined here as a system property in which systems behaviors at a higher level of abstraction are induced or caused by behaviors at a lower level of abstraction which could not be predicted at that lower level (Shaw and Pritchett, 2005). This is often true for complex systems such as system-of-systems whereby unintended consequences can result, but only due in part to emergent phenomena (Rouse, 2007a). Issues affecting systems complexity is depicted in Figure 9.

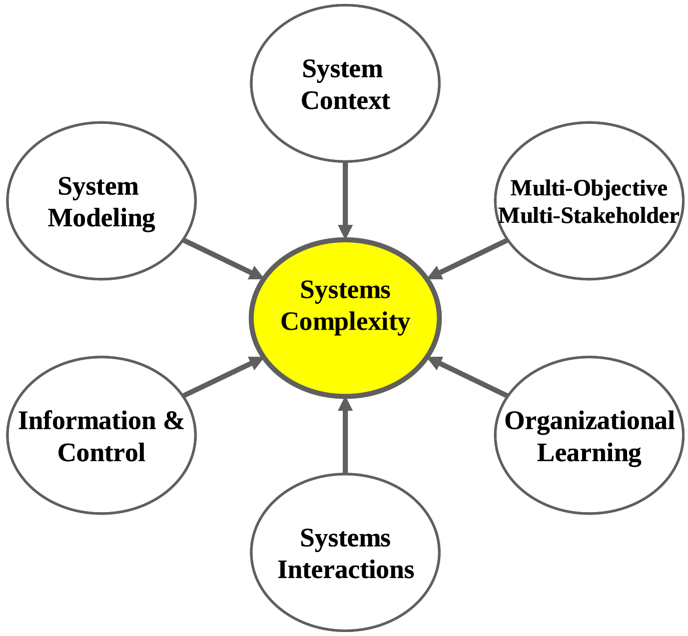


Figure 9: Issues Affecting the Complexity of Systems
(Adapted from Rouse, 2007a)

Several interpretations and viewpoints of both complexity theory and related complexity sciences are described in the extant literature (Davis, et al, 2007). Some research refers to complexity theory in broad terms as part of the larger body of complexity sciences that includes, for example, general study of nonlinearities such as tipping points, cusps, and cascades, loss of control, and chaos. In contrast, we take a narrower view that follows closely with the conceptions of Gell-Mann (1994) and Kauffman (1993). Specifically, the "complexity" in complexity theory refers to the complicated and often surprising behavior that emerges from loosely coupled 'agents'; i.e., people, processes, systems, etc., that operate within the context of simple rules (Gell-Mann 1994).

Much like the two prevailing views that exist of enterprise architecture (see Chapter 4), synthesis and distillation of the complexity literature reveals at least two prevailing views. The first view of complexity (Eisenhardt and Bhatia, 2002, Meyer, 2004), refers to outcomes of complex adaptive systems. Others such as Simon (1962), adopt a contrasting view in that complexity is focused on the complexity of the system and not its outcomes. Several outcomes emanated from Rouse's NSF initiative on complex engineered, organizational, and natural systems that not only support both views articulated above, but offer amplifying thoughts and trade-offs that are suggestive of alternative views of complexity:

1. Complexity is related to the context of the system definition, design, development, and operations;
2. Human and social behaviors and their interactions are critically important to cultivating an understanding of the nature of complexity;
3. Fundamental limits may exist to understanding, representing, and controlling complex systems

How does complexity theory apply to enterprise performance prediction? The answer is simple: it is a foundational, “first principle” theory for the study of dynamically complex enterprise systems for the following reasons. First, it is a relatively abstract and somewhat fungible theory that can be applied to various domains, with the basic theory remaining the same across each domain. As such, complexity theory fills a void by proposing a specific problem structure and the theoretical logic necessary such that it can be operationalized in many situations. Given the interdisciplinary nature of our research, the key is that we can apply complexity theory to fit our model of an enterprise system architecture (Chapter 4).

Second, our ESA fits the criteria of a SOA as outlined earlier; i.e., it has partially unique and loosely coupled agents, and successful adaptation is a necessary condition for the prediction of emergent growth and, ultimately, performance prediction. Much of complexity theory focuses on explaining how complex adaptive systems cope with both endogenous and exogenous change; we operationalize this principle as a central construct for describing interactions between multiple dimensions of our ESA. Some examples include human interaction with information technology-based systems and the interaction between strategic and operational processes.

Consequently, complexity theory provides a framework and theoretical basis to acquire a better understanding of how and, to a certain degree why, emergent behavior has a direct and consequential effect on performance. Complexity theory is further operationalized as we analyze the interactions between the four dimensions of our ESA in general, and their relative maturities and individual and collective impact on overall enterprise performance, in particular.

One key insight is the somewhat counter-intuitive observation that systems composed of simple parameters may result in emergent behavior that is complicated and high-performing in dynamic environments (Davis et, al., 2007, Langton, 1992, Kauffman, 1993). Through the use of structure, and a focus on variables that most impact growth and performance, complex adaptive systems enable better efficiencies and are better positioned for better performance (Mykityshyn, 2004, Gell-Mann, 1994).

Finally, from the literature synthesis, it is interesting to compare some fundamental precepts from complexity theory to corresponding principles as synthesized from the management theory literature. These are depicted in Table 9.

Table 9: Complexity Theory vs. Management Theory

Basic Principles from Complexity Theory	Corresponding principles from Management Theory
Change and transformation are inherent quality of dynamic systems. The goal of management is to increase learning and self-organizing in continuously changing contexts.	Organizations exist in equilibrium, therefore change is a non-normal process. The goal of management is to increase stability through planning, organizing and controlling behavior.
Organizational behavior is inherently nonlinear, and results may be non-proportional to corresponding actions. New models and methods are needed to understand change.	Organizational behavior is essentially linear and predictable, and results are proportional to causes. Thus, linear regression models explain most of the variance of organizational change.
Inputs do not "cause" outputs. The elements of a system are interdependent and mutually causal.	System components are independent, and can be analyzed by separating them from the rest of the system was well as from their outcomes.
An organization is defined according to its underlying order and principles. These give rise to surface-level organizing structures including design, strategy, leadership, controls, and culture.	An organization can be completely defined in terms of its design, strategy, leadership, controls and culture.
Change should be encouraged through embracing tension, increasing information flow, and pushing authority downwards.	Change should be controlled by minimizing uncertainty and tension, limiting information and centralizing decision making.
Long-term organizational success is based on optimizing resource flow and continuous learning. A manager's emphasis is on supporting structures that accomplish these goals.	Organizational success is based on maximized resource utilization, to maximizing profit and increasing shareholder wealth. A manager's emphasis is on efficiency and effectiveness, and avoiding both transformation and "chaos."

2.6.4 Cognitive Models: Building Environmental Context

While not a primary phenomena of interest in our research effort, it is useful to introduce the concept of decision-making, certain characteristics that describe it, and cognitive elements that affect executive decision making since it has an obvious and direct impact on enterprise performance.

The nature of how decisions are made, and their subsequent impact on performance, has been the focus of empirical studies by cognitive engineers, psychologists, and researchers from other disciplines (Garcia, 2006). Bainbridge (1997) stipulates that there are two types of cognitive goals: (1) those that are concerned with the development of a person's understanding of the situation and, (2) those that constitute their plan of what to do about it. In general, human behavior and cognition can be modeled through a variety of approaches and technologies. Some of them are focused on the individual components of human performance, while others focus on the integration of components at the architectural level. The various ways in which human models can be used in the evaluation of an enterprise do not inherently favor either component or integrative approaches (Zacharakis and Meyer 2000). Some models include complete formulations or families of them, and attempt to describe, predict, or prescribe aspects of human competence or performance. Modeling techniques that include computation, mathematical, or methodological formulations have been used to evaluate human competence/performance. Still other cognitive models have been applied to system design, operation, or problem evaluation. The following characteristics pertain to most types of executive decision-making situations:

- Information: Most decisions are made in the absence of exhaustively complete information. This is true given the number and scope of decisions that are made on a regular basis, and wide range of uncertainties that are inherent to such decisions in the context of a dynamically complex SOS such as an enterprise. In order to compensate, some executives may develop a "structure of inference" which describes the situation as they can best understand it (Bainbridge, 1997).
- Multiple Processes: Usually, executives are expected to be aware of one or more situations that are, in and of themselves, dynamically complex with

varying timescales for completion. For example, both the design process and engineering plan for the development of a new product are complex systems in and of themselves that evolve and change as a function of time, perhaps not with similar timescles. Consequently, the actions taken by the manager responsible for the achievement of milestones needed to finish the product on time and under budget need to have the right size and scope.

- Multiple-Task Hierarchy /Complexity: At any point in an enterprise's lifecycle, multiple tasks happen contemporaneously, many of which are dynamically complex. While not all are time-critical, executives need to allocate sufficient processing between several task responsibilities. However, due to the nature of business dynamics, it is not generally possible to complete required tasking in a sequential manner, nor is it possible to anticipate a priori all possible situations that may arise;
- Decision Making Rationality: It is well recognized in the literature that decision makers are not perfectly rational, but tend to be "boundedly rational" (Newell and Simon, 1972; Simon, 1955). This is especially true for executives, since it is difficult to fully evaluate all information, even in the absence of decision-making bias (Fiske and Taylor, 1991). Biases not only inhibit the decision process, but they also likely impede the executive's ability to accurately report on her/his decision process. For instance, the availability bias (Tversky and Khaneman, 1974) encourages decision makers to recall information from memory that is salient, versus recalling information used to make typical decisions (Dawes, 1988; Dawes, Faust and Meehl, 1989).
- Decision Uncertainty: Clearly, in the absence of complete information, all executive decisions involve a degree of uncertainty. Keeney and Raiffa's (1993) Multi-Criteria Decision Analysis (MCDA) provides a robust theoretical approach to complex decision making under uncertain conditions. Specifically, their approach enables decision-makers to dissect the problem into what is known versus what is unknown by differentiating between preferences, information, and alternatives.

Decision making can have a direct impact on enterprise performance, especially complex decisions such as enterprise strategy, deployment and structure of information technology-based systems, the type of enterprise architecture to adopt, etc.

2.7 Category III: Information Technology / Information Systems

In the broadest sense, information technology refers to both the hardware and software that are used to store, retrieve, and manipulate information. In short, information technology deals with the use of computers and computer software to convert, protect, process, transmit and retrieve information, securely. Installed on servers are elements such as database and web serving software that are connected to each other and to users via a network infrastructure. Typically, users accessing these servers have their own hardware, operating system, and software tools. IT plays a significant strategic role within organizations (Henderson and Vekatraman, 1999). Its operationalization via information systems is a critical component of an enterprise system-of systems, and can support or even shape business strategy.

Consequently, information technology-based information systems are a focal point of our research methodology for two reasons: (1) Taken together, IT and IS provide the primary means to facilitate interoperability between an enterprise's organizational and human elements, its processes and product elements, and (2), IT and IS constitute two of the four dimensions used to evaluate the maturity of our ESA. A thorough discussion about IT and IS that support enterprise processes is presented in Chapter 4; a discussion of previous research models and the topic of maturity is discussed in detail in Chapter 5.

2.8 Research Implications

An extensive literature and research review is fundamentally important, not only to extend theory and its concomitant empirical testing, but for creating an appropriate foundation for the suggestion of novel approaches that can impact or influence practice. The theoretical background and research synthesis presented in this chapter was intended to be a thorough overview of various research streams that have some contributory effect on the enterprise performance research domain. As markets exhibit increased levels of dynamism and complexity, executives face increased pressure from stakeholders to create value. As such, the study of enterprise performance is an important research issue to academics, which is reflected by the studies that have been conducted from a wide range of disciplines. However, the extent to which academic research can influence practice; specifically, enterprise performance and related issues, depends to some degree upon how well multi-disciplinary theories and approaches can be synthesized into tangible implications for executive decision makers.

2.9 Conclusion

Understanding how to enhance enterprise performance and ultimately predict it, is a highly complex and multi-faceted issue. As the various dimensions of an enterprise SOS evolve over time as they tend to do, a solid understanding of how business processes, IT, IS, and enterprise architecture is increasingly more important to executives.

The synthesis of the enterprise studies, systems engineering, and information technology / information systems literature is revealing. Several implications are concluded based on the findings from the literature analysis and review of extant theories. First, we show that a multidisciplinary approach to the investigation of enterprise performance prediction is well suited so as to have meaningful implications for practitioners. For example, enterprise studies from organizational theory, strategic management, and various other research streams that address the notion of 'right-sizing' enterprise organizational structure to "optimize" performance, should do so in the context of a dynamically complex enterprise SOS. In other words, a uni-dimensional focus on enterprise performance significantly limits the utility of any such approach. Second, by incorporating a multi-disciplinary approach, an opportunity exists to integrate and synthesize various theories, approaches, and methodologies into a holistic model such as our ESA from which a more specific, novel approach to enterprise performance prediction can be developed.

CHAPTER 3:
ENTERPRISE PROCESSES

3.1 Introduction

The primary focus of this Chapter is to introduce strategic enterprise processes as separate and distinct from operational enterprise processes. Initially, we build on the concepts presented in Chapter 2 whereby four dimensions of an enterprise system are introduced. Our research considers the lifecycle of an enterprise as a continuum from development through maturity, so our initial research efforts were primarily focused on early stage enterprises. The purpose of those data collection efforts and subsequent analyses was to arrive at an integrated understanding of the growth characteristics of emerging enterprises. As was previously discussed, the theory of enterprise transformation provides a basis from which an understanding of fundamental enterprise change can be derived.

As a central element of the theory, the focus of the first part of this chapter is work and workflow that underlies an enterprise's business processes. Several perspectives on the nature of work, workflow, and work processes are discussed. Some modeling frameworks for workflow management are also briefly discussed. How enterprise processes can be accommodated in the context of an enterprise structure, and how they can best be supported by information technology-based systems is the focus of the following Chapter.

The reader is referred to the Information, Knowledge, Systems, and Management special issue on work, workflow, and information systems (2007) for a complete treatment on work processes, work, and workflow. A primary motivation for the issue was a belief that the success of enterprise change relates directly to changes in work processes (Rouse and Sage, 2007; Mykityshyn and Rouse, 2007). While work and work processes can be studied from a variety of perspectives, we limit the scope of our investigation to include a high-level treatment of executive work, work processes, and enterprise information systems that model and manage them.

3.1.1 Work and Workflow

Work is described and discussed in the context of executive work. The executives of an enterprise are typically referred to as its senior leadership team. Typically, the core team is comprised of the Chief Executive Officer (CEO), Chief Technology Officer (CTO), Chief Financial Officer (CFO), Chief Operating Officer (COO). (Note: Many enterprises would include marketing, sales and human resource executives as part of the senior leadership team). Even though, by definition, the CEO has formal authority over the entire organization, all executives need to work together in order to lead and manage the enterprise. Descriptors of some of the things that executives actually do are presented in Figure 10.

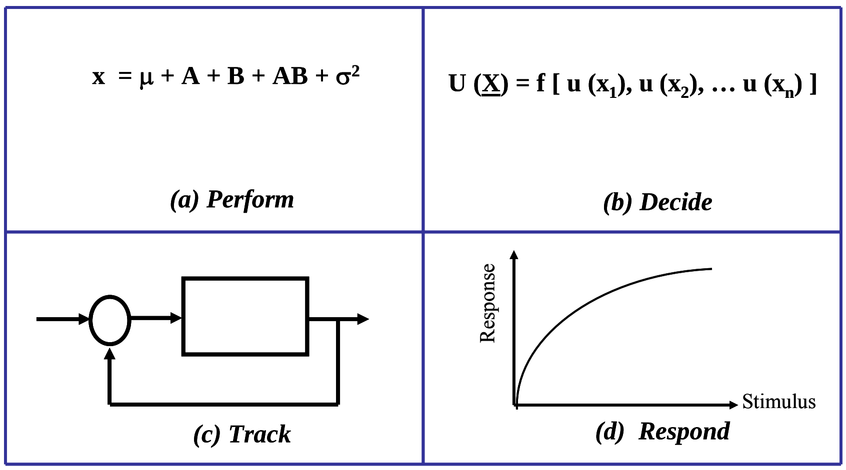


Figure 10: Models of What Executives Do
(Adapted from Rouse, 2004)

Thematically, the development and implementation of an enterprise's strategic plan is used to illustrate both the nature of enterprise workflow and different work systems that accommodate that workflow. Underlying the development of a strategic plan is strategic thinking. This involves understanding marketplace dynamics and opportunities, and an objective assessment of enterprise strengths and weaknesses in the face of these trends and opportunities (Rouse, 1996; Kaplan and Norton, 1995). Strategic planning is a 'tool' that executives use to help the enterprise do a better job; to focus its energy, to ensure that members of the organization are working toward the same goals, to assess and adjust the organization's direction in response to a changing environment. In short, strategic planning is a disciplined effort to produce fundamental decisions and actions that shape and guide what an organization is, what it does, and why it does it, with a focus on the future.

"Workflow" connotes a technical context used to describe how executives or "agents" both connect to and interact with an enterprise's information technology-based systems. Executive workflow is considered as part of a representative strategic planning process from the task /activity level to the enterprise work level, and is depicted in Figure 11.

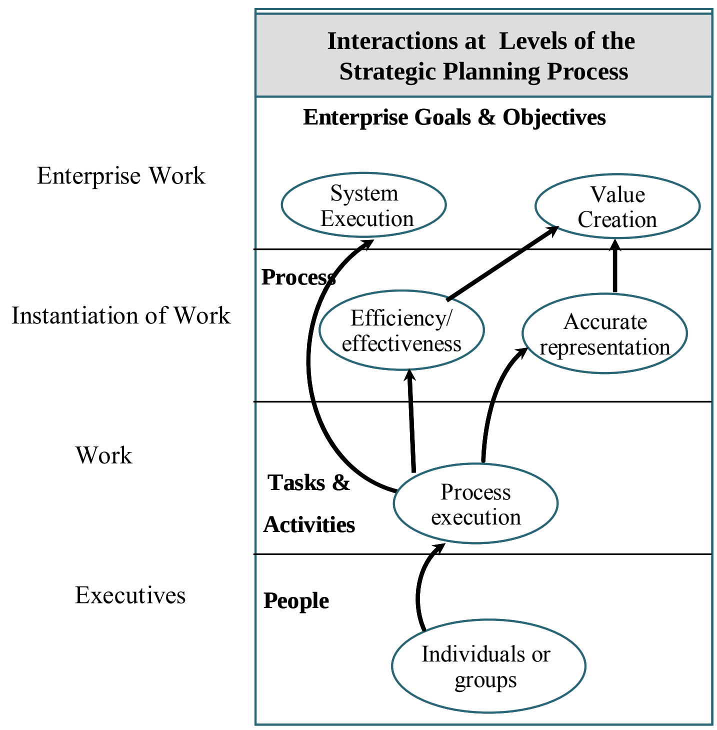


Figure 11: Representative Enterprise Workflow

3.1.2 Work Systems

Many people factor into both creating and implementing an enterprise's strategic plan. Input variables are typically provided by individuals whose spheres of influence include business development, sales, engineering, marketing and communication, product operations, finance, and possibly others. Figure 12 presents separate work systems for two reasons: (1) in a larger enterprise, those who are responsible for implementing strategy may be different from those who formulated it and, (2), the development of an effective strategic plan is only "half the battle." Getting it implemented is the other half; that is, completing the action steps to accomplish the strategies and objectives within the plan. (Note: Even though the work systems are depicted in Figure 12 as 'separate' systems, a feedback loop that exists between them is not depicted).

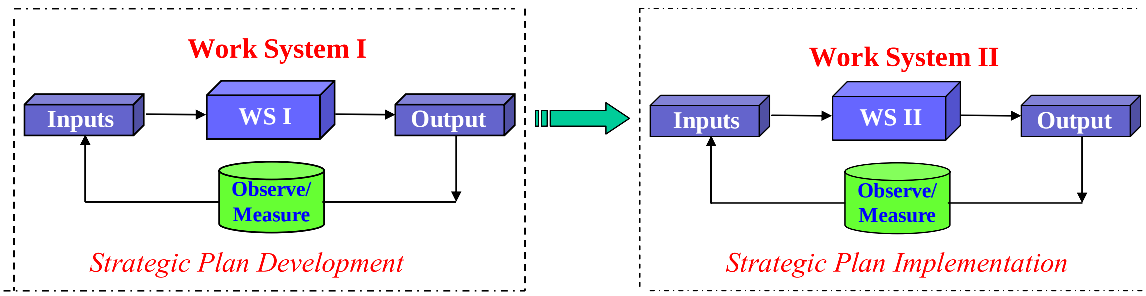


Figure 12: Representative Work Systems

The first 'system' depicts a representative strategic planning process undertaken by an enterprise. This process, when thoughtfully conducted, requires multiple inputs and decisions from multiple people. Having participated in numerous strategic planning processes, they are quite interesting in that emergent phenomena resulting from the process itself can exhibit properties that are decoupled from the properties of its sub-systems and are often counterintuitive.

Holistically, the strategic planning process as a 'system' can be thought of as a microcosm of how an enterprise system operates. The 'system' can be viewed from the perspective of how the tasks are performed, and how the processes are actually executed. In Figure 13, both work systems are portrayed using a systems engineering view (Adamsen, 2000). The work/workflow that underlies both the planning and implementation phases of the strategic planning process is included. Note that the output of this process generates variables by which enterprise performance is measured

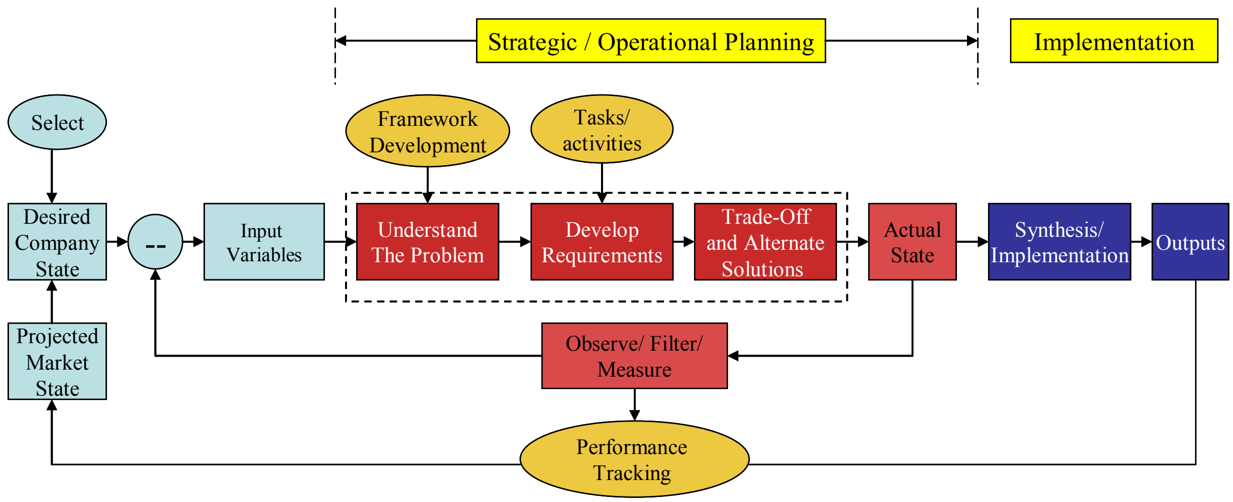


Figure 13: Systems Engineering Perspective of Strategic Planning

Prior to a discussion of business processes that represent the embodiment of those tasks and activities described by the strategic planning system portrayed in Figure 14, we briefly touch on how, from an information systems perspective, work can be modeled and managed.

3.1.3 Modeling Frameworks and Workflow Management

An enterprise continually faces fundamental change as it progresses along its growth continuum from development to maturity. Transformation-induced change may also affect corresponding business processes, so it is important for enterprise information technology-based systems to support these changes with minimal disruption to enterprise operations. An example of one such system is a workflow management system. It is a generic information system that supports modeling, execution, management, and monitoring of workflows. Such a system operates on a workflow specification, a description of the business processes in the organization that should be supported. A workflow management system can be compared to a database management system; it is a generic system that operates based on a definition of enterprise processes. As such, workflow modeling is the task of creating workflow specifications that may change based on an enterprise's activities or growth.

Caverlee, et al., (2007) examine selected workflow techniques that have been created in order to deal with these changes. They describe workflow management as the core component for implementing and executing the processes and tasks defined by business process management. They focus on transformation-related techniques such as workflow patterns and workflow patters. Others (Orin and Haller, 2005) survey formal modeling frameworks and approaches for workflow management that include Petri nets, temporal logic, and transaction logic. McGinnis (2006) describes enterprise modeling as a possible enabler of enterprise transformation.

3.2 Enterprise Business Processes

The remainder of this Chapter focuses on enterprise business processes. An enterprise's business processes are an amalgam of its internal and external assets. If an enterprise's activities describe how tasks are performed, and tasks describe how processes are executed, then processes enable an enterprise to create value (Rouse and Sage, 2007b). How these processes fit, structurally, within the context of an enterprise architecture, is addressed in Chapter 4.

3.2.1 Strategic Processes

A distinction is first made between the fundamental issues addressed by strategic and operational processes, respectively. It should be noted that, while both are business processes and both involve executives, the primary difference between them is the issues addressed by each. At the strategic layer (the concept of a 'layer' is described in more detail in Chapter 4), the issues are about intent, communication of that intent to stakeholders, the creation of enterprise goals and objectives, strategy development, etc. At the operational layer, it's all about plans, tactics, and execution.

Those processes that are contained in the strategic layer are referred to as "strategic processes". The strategic layer determines and governs the means embodied in the operational layer; as such, 'requirements' flow down from the strategic layer to the operational layer. Consequently, strategic processes can be thought of as those processes that constitute the top layer of a business process architecture, described in more detail in Chapter 4.

Those processes that are contained in the operational layer are referred to as "business processes". They are the operationalized means to achieving stated enterprise goals and objectives, referred to here collectively as the 'results'. The flow of information from strategic to operational processes, and the fundamental issues addressed by each are depicted in Figure 14.

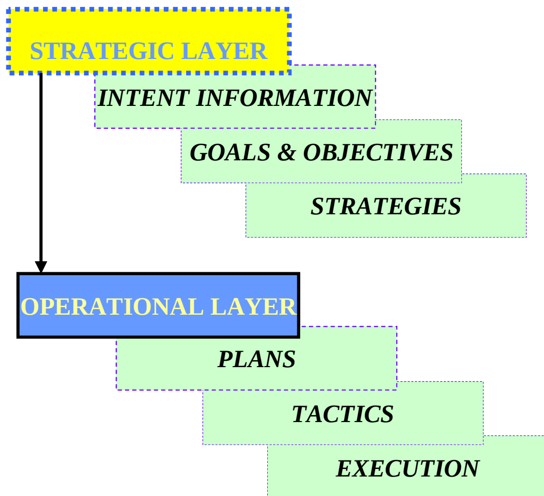


Figure 14: Stratification of Strategic and Operational Processes

Strategic processes are distinctly different from traditional business processes. The amalgam of the processes described in Table 9 enable the CEO and his or her leadership team to:

- Attain a holistic perspective of the enterprise in the context of its marketplace environment;
- Set the vision and strategic direction of the enterprise,
- Specify how the vision is to be achieved; in military parlance, this is referred to as the Concept of Operations, or "CONOPS"
- Establish the goals and objectives necessary to achieve the vision and strategic direction of the enterprise;
- Monitor performance and effect business outcomes

Table 10: Representative Strategic Processes

Strategic Layer Process	Process Attribute (s)
Situation Assessment	The executive team gathers data and information from multiple sources to acquire a holistic perspective of the enterprise and the world. Its strategic view is derived, in large part, from drivers external to the enterprise
Vision, Mission, & Strategy Development	The executive team sets and/or refines the vision of the enterprise and develops the overall direction and strategy.
Strategic Decision Making	The executive team makes decisions that affect the direction of the enterprise, not tactical, day-to-day operational decisions
Communication of Intent	The executive communicates the following: • Vision: How the vision is to be achieved • Mission: How the mission is to be carried out; i.e., the "concept of operations" • Doctrine: How the enterprise is to conduct itself, to be monitored by its Board of Directors
Recruiting and Retention	The executive team recruits and retains key managers and employees necessary to accomplish stated business goals and objectives
Designing Incentives & Rewards	The process of incentivizing and rewarding executives and employees for achieving key business goals and objectives.

Strategic layer processes are "externally-driven and internally enabled". They include those processes that are strategic decision-making/leadership centric, and are at a higher level of abstraction than operational layer processes since enterprise goals and objectives are an artifact of the vision created by the CEO and the strategic direction developed by the CEO and the executive team. Simply stated, operational layer processes exist to implement the strategy.

Strategic layer processes share the following characteristics:

- Strategic-Centric: Certain processes are purely strategic in nature, as is depicted in Table 9. It should be noted that the other strategic processes include an element of strategy and strategic thinking. Each is an integral part of recruiting, retention, and the development of an effective enterprise-wide incentive and reward system;
- Complex Phenomena: The behavior that emerges at the enterprise level caused by human behavior at different levels of abstraction; i.e., the process, systems,

and technical layers, respectively, may affect system performance in ways that are quite difficult to quantify. In particular, understanding emergent behavior is extremely difficult due to the large number and heterogeneity of the enterprise's participants who interact in intricate ways that continually shape the enterprise;

- Judgment: Leadership decisions are typically made based on judgments of and reactions to the current and emerging state of the environment exogenous to the enterprise. Judgment is also dependent upon the ability of the executive team to acquire a base knowledge of the marketplace, industry, and most importantly, the business;
- Uncertainty: Processes that are strategic-centric tend to be the least structured and may require more creativity and imagination since they are "big picture"-oriented, longer-term, and far reaching. Consequently, they are inherently more uncertain in terms of outcome. This includes things that the executive team does not know enough about, may not fully understand, or may not even know exist.

The strategic layer process, "Strategy Development", and its representative attributes is depicted in Figure 15.

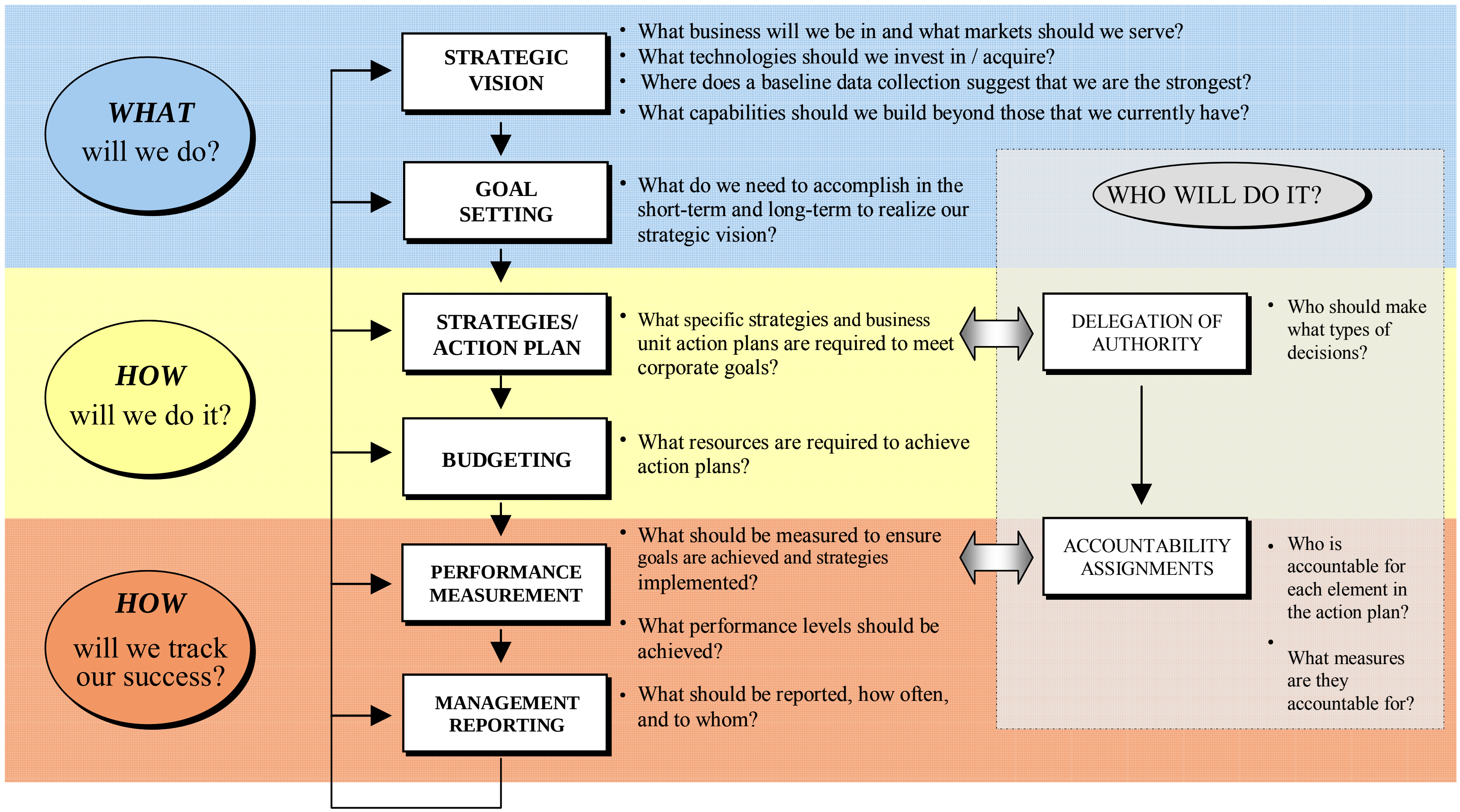


Figure 15: Enterprise Processes

3.2.2 Idealized Capabilities of the Strategic Layer

Ideally, the strategic layer should move the enterprise toward some future state of performance predictability versus trying to extrapolate (future) enterprise stases from "lagging" indicators such as financial variables and from other transactional data that is at the core of the operational process layer. To this end, the orientation of the strategic layer might be thought of as more of a strategic pull than an operational push, and geared toward a 'projective' BSC (Kaplan & Norton, 1996) versus the current approach where executives merely assess the enterprise's situation..

While it may be possible to relate strategic process-related workflow to current information technology-based systems and other technical artifacts, it does not appear that such systems currently provide an integrated, interoperable solution – especially between the operational layer and the strategic layer. Of course, an interesting situation is when the aspirations of the enterprise are not reachable with existing operational processes. Consequently, new processes are needed, perhaps achievable via enterprise transformation or acquisition of another enterprise (Rouse, 2006a).

3.2.3 Strategic Versus Operational Processes

Essentially, a business process is a set of tasks and activities intended to achieve a stated business objective created at the strategy layer. Functionally, it is a collection of related activities that work in concert to create something of value to the enterprise, its stake holders, and/or its customers. In the aggregate, the goal of such processes include, but is not limited to the improvement of efficiency of its operations, improving quality, reducing costs, and reducing the time it takes to get its products to the marketplace.

It should be noted here that, at the enterprise systems level, work is not necessarily represented by individual tasks, jobs, or activities. Enterprise work/workflow is embodied in the processes that are performed at the highest levels of abstraction; the strategic and operational layers, respectively. Making changes in the enterprise at this level equates directly to making changes in purpose, objectives, and function. Thus, work at the enterprise level involves the enterprise's goals, objectives and challenges. Consequently, work at the enterprise level is rather different from work at the individual task, activity, or job level. Vicente (1999), Rasmussen and Pejtersen (1994), and others examine various approaches to work domain analysis, activity analysis, and work organization, while rouse (2006a) provides a more complete treatment of enterprise organization, while Rouse (2006a) provides a more complete treatment of enterprise work/workflow in the context of the enterprise as a system.

Table 11 provides a generic description of some critical operational layer processes.

Table 11: Representative Operational Layer Business Processes

Operational Layer Process	Process Attribute (s)
Project and Program Management	Monitor and Control: Project data, evaluate projects, and design-to-cost engineering in order to optimize product costs
Supply Chain Management	Planning and Execution: Capabilities to manage enterprise operations. Typically includes visibility and collaboration. The desired result is improvements through cost reductions, service-level increases, and productivity gains ultimately leading to stronger profit margins
Finance / Financial Management	Accounting, financial, and management reporting. Usually includes internal controls and documentation of all financial processes and transactions for governance and compliance issues
Customer Service/ Quality Assessment	Monitor financial trends, costs, and revenues per customer, as well as service contracts and operations. Customer and warranty analytics are normally part of the assessment
Enterprise Doctrine	While doctrine that establishes enterprise policy is crafted at the strategic layer, refinements to guidelines and policies are continually evaluated and refined
Enterprise Concept of Operations (“CONOPS”)	Mission intent is established at the strategic layer which drives the generation of alternative plans at the operational layer

Business processes contained within the operational layer are at a lower level of abstraction than processes that are contained within the strategic layer since the day-to-day work they embody executes the vision, direction, goals and objectives, and other requirements provided by the executive leadership at the strategy level. As was previously stated, business processes exist to implement and execute the plans that reflect the vision, goals, and strategies of the CEO and executive team. In contrast to strategic processes, operational layer business processes share two salient characteristics:

- Tactics & Operations Focused: Business processes are designed to be linear in both function and outcomes;
- Transactional Data: Because they are focused on day-to-day activities, business processes typically do not deal with nonlinear, complex phenomena that are characteristic of strategic processes. Consolidation of processes at warehouses and/or distribution facilities, converting manual processes to online processes, and reducing order cycle times illustrate the concept of the linear orientation of business processes. (Note: It seems to me that the "nonlinearity of strategic processes is due, in part, to their external orientation over which management has much less control, and certainly less ability to fully observe.)

It should also be noted that while the strategic and operational layers are separate and distinct, there is a degree of commonality between them vis a vis their respective processes; for example, the development of an enterprise could be considered to be a business process. Also, both strategic and operational layer processes involve similar elements such as executives, decision making, tasks, activities, etc. However, operational layer processes are focused on day-to-day tactical and operational issues that help the enterprise achieve its stated business objectives. Conversely, strategic layer processes are considered as those activities performed by the executive team, but are enterprise leadership-focused and deal with issues related to strategy.

For illustrative purposes, Table 12 depicts decision making as both a strategic layer process and an operational layer process. Note the difference in the impact to the enterprise when decision making is performed in the context of each process. It should also be noted that the operational layer processes "support" strategic layer processes.

Table 12: Decision Making as Both a Strategic Layer Process and Operational Layer Process

	Strategic Layer Process	Operational Layer Process
Decision Focus	Leadership focused; enterprise architecture / organizational construct-related issues	Operational processes, tasks, activities, work, workflows, and various measures
Decision Impact	Longer-term; “big picture’	Immediate; short-term; short-range
Level Impacted	Enterprise	All levels necessary but primarily rank-and-file employees
Decision Direction	Top-down	Bottom-up
Drivers	Both external and internal (strategic), e.g., market position	Operational concerns; precision, cost, speed of delivery (product/service)

This comparison also serves to illustrate the difficulties in developing a technical representation for strategic layer versus operational layer processes. Several information systems are capable of capturing transactional data such as product throughput as a function of time which is common to most business processes. However, it is much more difficult for a software engineer to inform and specify a model that captures the work practices behind developing an organizational construct or vision for the enterprise.

3.2.4 Summary

This chapter considers enterprise work and workflow and presents a high-level view of information technology-based systems designed to support them. The instantiation of work and workflow -- enterprise business processes -- are stratified into strategic and operational processes layers. A primary motivation for so doing is to facilitate a better understand of the unique attributes of such processes. The focus of the following Chapter is to investigate several artifacts, both architecturally and technically, to support them.

CHAPTER 4:
STRUCTURES AND SUPPORT FOR ENTERPRISE PROCESSES

4.1 Introduction

This Chapter is focuses on an analysis of several artifacts, both architecturally and technically, that provide structure, context, and support for the strategic and operational processes described in Chapter 3. The extent to which information technology and information systems support enterprise processes is investigated both quantitatively and qualitatively in Chapter 8, based on a conceptual model that is introduced in Chapter 5.

Section 4.2 introduces our ESA in detail. The ESA is then used as the basis from which to highlight the relationship between, and general interactions of each layer. Since the phenomena of interest are the two business process layers, strategic and operational, other aspects of the ESA are not discussed in detail.

Sections 4.3 – 4.5 provide a synthesis and analysis of architecture frameworks from various domains in order to gain insights and test the potential viability and applicability of a notional strategic layer. Two categories of architecture frameworks, Application-Class, and Enterprise-Class, are introduced (Greefhorst et al., 2006). Each is reviewed and assessed in terms of its capability to explicitly and/or indirectly support a strategic layer, as defined by our ESA. Further, it we seek to understanding if other architecture frameworks can provide insights into how strategic and operational processes, collectively the core of our ESA, might be better designed for increased interoperability, function, and communication.

Since the workflow required to implement the processes contained within a strategic layer of our ESA is largely dependent upon the capabilities of executives-in-the-loop, we also investigate human behavior and performance frameworks in the context of operating a dynamically complex enterprise SOS. We refer to such frameworks as "architectures" of human behavior and performance. Finally, Section 4.6 presents an analysis of information technology and information systems that were designed to support both strategic and operational processes

4.1.1 Background

Enterprises operating in today's global economy are faced with unprecedented competitive and regulatory pressures, along with heightened levels of business uncertainty. Executives need to balance capabilities, manage risks, and act in order to achieve desired business end-states. Like their military counterparts, business executives strive to achieve “decision superiority”; i.e., to make decisions better and faster, thereby enabling their enterprise to act/react with more agility, and/or impair the ability of a competitor to react as effectively as they can. Enterprise agility is a consequence of agile decision making (Rouse, 2007c).

Increasingly, these types of decisions have become data-driven as many enterprises are choosing to compete on analytics at the operational level (Davenport, 2006). Even though an abundance of technological artifacts and IT-based systems exist whose primary function is to capture, process, and present transactional data in support of day-to-day operations, it is unclear as to whether or not operational layer, process-related data, has sufficient utility at a strategic layer of abstraction (see Chapter 3 for a clear distinction between strategic layer processes and operational layer processes was established in Chapter 3)..

Important as strategic, executive-level decisions are, their futurity cannot be adequately assessed without a thorough understanding of the process-oriented infrastructure that facilitates them. Consequently, a primary focus of this Chapter is to test the viability and applicability of a notional strategic layer that is separate and distinct from an operational layer that is found in a traditional business architecture framework.

4.1.2 Lexicon of Enterprise Characteristics

Prior to investigating an enterprise system architecture framework, and for clarity and consistency, it is useful at this point to define some terms that will be used throughout this chapter in the context of an enterprise.

- System: In general, a system can be defined as a collection of mutually dependent entities whose initiatives, activities, and actions form a dynamic process toward the accomplishment of some purpose (Tyszer, 1999). A system is considered to be a large-scale system when it involves interactions with several diverse sectors including technological, economic, social, and cultural, among others (Sage, 1981). The enterprise, therefore, is a ubiquitous system; a goal-directed and focused organization of various activities, processes, and resources, usually of significant complication, strategic and operational scope, and risk (Rouse, 2005a);

- Complexity: A more complete treatment of system complexity and complexity theory is presented in section 2.6.3. To recapitulate, simply stated, complexity deals with systems that are composed of many interacting entities, or agents. Complexity implies that a system, in general, consists of parts that interact in ways that can heavily influence the probabilities of events that occur at some future point. This is typically due to nonlinearities and discontinuities that exist among a large number of interacting elements (Axelrod and Cohen, 2000).

Consequently, a complex enterprise system exhibits the following characteristics:

- The system consists of many elements that are interconnected in a complicated manner, often involving different time scales;
- The enterprise is a system-of-systems, with component systems that may have their own objectives and priorities;
- A complex system exhibits a hierarchy of structures (Ye, Lai, Farley, 2003). In the context of our ESA, such a hierarchy consists of four "layers"; strategic, operational, systems, and technical, respectively.

As was discussed in Chapter 2, an enterprise is dynamically complex due to both endogenous and exogenous variables. Such dynamics include a constantly changing marketplace, changing strategies of competitors, a customer / business base that constantly changes in response to their respective markets, finances, decision making regarding products and services, partners and suppliers, the changing nature and state of technology, etc.

- Nonlinearity: A nonlinear system is one whose behavior is not simply the sum of its parts or their multiples. From a systems perspective, this implies that a small perturbation may have a variety of effects: an apparently random effect (low correlation between cause and effect), a proportional effect, (a direct correlation between cause and effect), or no effect at all (a linear correlation between cause and effect). Conversely, cause is always directly proportional to effect in a linear system. Hence, the enterprise is, at the same time, a large scale system-of-systems that exhibits dynamic, nonlinear behavior;
- Prediction / Predictability: Since executives do not currently possess the ability to predict enterprise performance, goals such as revenue, profits, etc., are set. The executive team then determines how they believe the enterprise can achieve such a level of performance, and how to track progress toward its stated objectives. Currently, this is not a prediction or forecast, per se, but instead a "backcast" from desired end states to what the executive team believes are precursors to achieving these (desired) end states. (Note: While they cannot predict (accurately), they try to control the enterprise system, as does a pilot.)

4.1.3 Architecture Context

As an enterprise system grows in both scale and complexity, various factors may impede the ability of its executives to not only recognize the problems faced by the enterprise, but how to structure and solve them. Consequently, developing a fungible enterprise structure to better facilitate the conduct of its business in anticipation of such situations presents a challenge for the executive team.

Precision is attempted here in defining the terms 'architecture' and 'framework' in the context of an enterprise system prior to investigating the general characteristics of architecture frameworks. Rouse (2007) attempts such a distinction: "It is useful to contrast architectures with the means used to create them (i.e., architectural frameworks) and the activity of creating them (i.e., architecting)". In some respects, it is difficult to discern where architecture and architecting ends and engineering begins (Nightingale and Rhodes, 2004). Maier and Rechtin (2000), suggest an architecting-engineering continuum that is depicted in Table 13.

Table 13: Architecting Engineering Continuum

(Adapted from Maier and Rechtin, 2000)

Characteristic	Architecting	Architecting & Engineering	Engineering
Situation	Ill-structured	Constrained	Understood
Methods	Heuristics/synthesis	Combined synthesis/analysis	Equations & analysis
Interfaces	Focus on misfits	Critical	Completeness
System Integrity	Single mind	Clear objectives	Disciplined Methodology
Customer	Working for client	Working with client	Working for builder
Issues	Confidentiality	Conflict of interest	Profit vs. cost

For completeness, enterprise architecture is also defined in the context of our high-level ESA.

- Architecture: The abstraction used to accommodate various levels of system complexity is called "architecture". There is not a singular, commonly agreed-upon definition of "architecture" relating to enterprises or systems, and architectures differ in focus and level of detail. Nevertheless, in a broad sense, they are all similar (Rood, 1994). That is, the general idea is to represent and/or model, in the abstract, not only an orderly arrangement of system elements, but their interactions and relationships. Methodologically, each element of the system is less complicated than the aggregated system, which allows the architect to deal with increased levels of complexity (Kamogawa & Okada, 2004).
- Enterprise Architecture: The term "enterprise architecture", however, connotes different meanings. Some associate EA solely with the development and deployment of information technology-based systems; specifically, in this context, it refers to how information technology elements fit together to support a business architecture (Gottlieb, 2004). That is, most architecture frameworks that apply to the enterprise are IT-centric with the goal of creating technical

solutions; for researchers and practitioners who maintain this perspective, EA is very much an information technology concept. Others (Steen, 2004, Armour, 1999, Rood, 1994) adopt a broader interpretation of EA, whereby the enterprise is considered holistically, not just in terms of its information technology-related infrastructure. Taken in this context, EA is considered to be more of a conceptual framework that describes how the entire enterprise is constructed by defining its elements and the relationships between them. In other words, IT systems and other technical artifacts are treated as one of several elements of the enterprise.

- <u>Architecture Framework</u>: An architecture framework is not, in and of itself, an architecture. It is simply taken as a plan of how to organize and represent an enterprise architecture, which can be quite broad and may describe enterprises that are large and complex. In order to manage this complexity, some architecture frameworks establish a common approach for describing and representing an enterprise architecture (DoDAF VOL. 1, 2004). Others, such as the Zachman Framework (1987a), allow an enterprise architect to 'frame' the problem.
- <u>Model</u>: Simply, a model is taken to be a representation containing the essential structure of some object or event in the real world. In this context, models are employed as a way to investigate behavior or decisions in the model before attempting to change behavior or implement decisions in the enterprise itself, with no consequence other than the cost of creating and using the model (McGinnis, 2005).

For the purposes of this effort, the term architecture is taken in the context of an enterprise as a large-scale system-of-systems (if not defined earlier, it needs to be defined here), and possesses the following characteristics:

- View: The enterprise is viewed holistically; information systems and various technical artifacts are treated as layers of the architecture. As will be discussed in more detail, various enterprise system elements are grouped into layers;
- Composition: The architecture consists of various structures and processes; an architectural framework, then, is a representation of those structures and processes;
- Information: Certain information and/or data flows are contained within the various structures and processes;
- Construct: The architecture enables communications between and among various stakeholders, including the executive team, management, and employees

Figure 16 depicts the general characteristics of architecture frameworks.

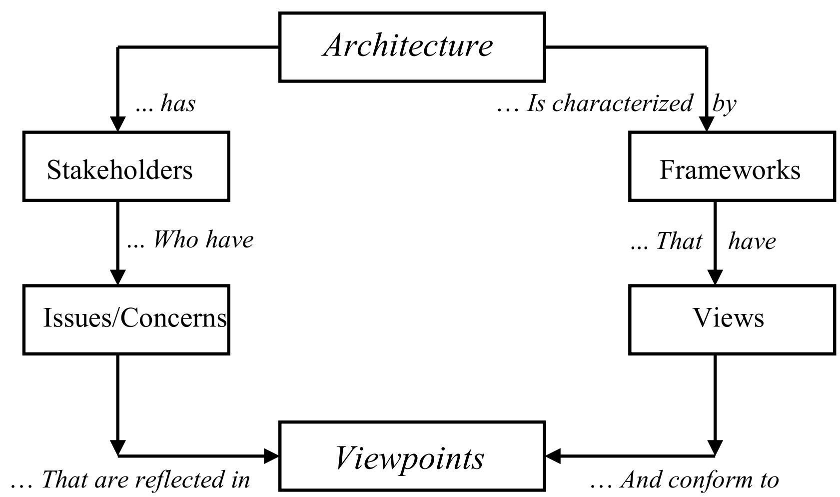


Figure 16: General Characteristics of Architecture Frameworks
(Adapted from Martin and Heidorm, 2002)

Figure 16 is somewhat self explanatory; as was previously discussed, architecture frameworks are the instantiation of the frameworks.). The frameworks themselves are driven by the concerns expressed by various stakeholders.

4.2 High-Level Enterprise System Architecture

Building on the concepts, theories, and analyses presented in Chapter 2, Chapter 3 focused on introducing strategic processes as separate and distinct from operational processes. In this section, our focus is on providing and investigating a structural 'platform' that can accommodate the unique attributes of both strategic and operational processes.

4.2.1 Conceptual Model of an Enterprise Architecture: The ESA

History has shown that there is no singular "right" model or organizational construct (Carley 2005, Mintzberg, 1983). The enterprise system has continued to evolve, having been shaped by a constantly changing economic environment as well as a myriad of technological change and other forces. Taken together, they have enabled the formation of new markets and products to serve those markets. The net result is that the enterprise system now operates within the context of a much more complex, highly-informed market system, thereby forcing to adapt much more quickly to remain competitive. This is true for both high growth market segments such as software and biotechnology, but also for slower growth markets such as manufacturing. Timely, accurate decision making in the context of its stated strategic objectives is a key enabler for such enterprise agility (Rouse, 2006c).

The purpose here is the development of a different high-level ESA rather than an exhaustive treatment of the enterprise as a system. Consequently, we:

- Introduce the enterprise as an integrated amalgam of sub-systems; that is, as a system-of-systems rather than a simple, linear aggregation of discrete processes, functions, tasks, and activities;
- Elucidate an ESA as a 'higher-order' form of a typical business architecture by virtue of the addition of a notional strategic layer that is separate and distinct from the operational process layer. As such, our ESA is the next instantiation of the phase-of-growth framework (see Chapter 2). Recall that in the framework, we introduce the notion of separate enterprise dimensions for strategy and operations, respectfully.

Our ESA can provide a means by which to investigate the impact of prospective decisions and behavior prior to implementation in the actual enterprise itself. Even though it is certainly possible to make poor design decisions using the framework, it provides a relatively risk-free way to experiment with different approaches or decisions (McGinnis, 2005). Finally, since all layers of our ESA are inter-related, it may help to highlight areas of greater risk and uncertainty pertaining to enterprise goals and objectives (Kikuchi & Perincherry, 2004).

Figure 17 presents our ESA. Its primary utility is to depict the relationship between, and general interactions of, each constituent element of the enterprise. The core of the ESA, its strategic and operational layers, respectively, is highlighted in the figure. Even though all four layers are process layers, the phenomena of interest for this Chapter are the strategic and operational layers, respectfully.

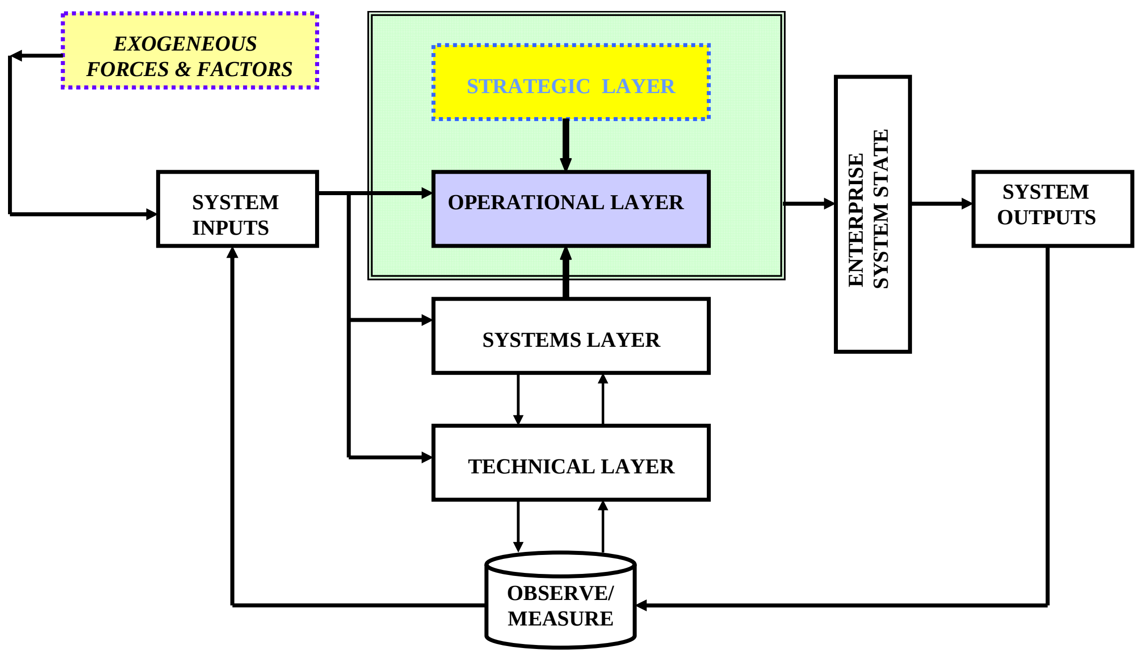


Figure 17: Enterprise System Architecture

The simplicity of the ESA belies the high level of dynamic complexity created by the processes contained within each layer, and the interactivity between layers; specifically, the strategic and operational layers. In addition to this interactivity, the strategic layer must also be ‘outward-facing’. This implies that its processes need to account for the exogenous environment that continually shape and affect the enterprise. The following should be noted from Figure 17.

- Requirements; i.e., strategic direction, business goals and objectives, etc., all flow down from the strategic layer directly to the operational layer;
- The operational layer and its associated tactics and operations, explicitly “support” the strategic layer and its associated processes. Essentially, the issues addressed by this layer and their associated processes execute the strategy of the enterprise;
- Located at levels of abstraction below the operational layer are the systems and technical layers, respectively. Collectively, these layers provide the underlying information technology-related infrastructure for the enterprise including security, data delivery architecture, etc.

As is the case with all complex systems, relationships exist within the enterprise system, and among its elements. System inputs include exogenous variables such as micro and macro-level economic conditions and regulatory influences such as those imposed by the SEC. They also include endogenous variables such as operational, finance, and people-related considerations. System inputs affect enterprise work/workflow, which are embodied by its business processes which, in turn, affect system state.

System outputs, such as various financial metrics and the quality and competitiveness of the enterprises’ products and/or services, are observed, measured, and fed back to the executive team and other management. Endogenous variables, to the extent that they are controllable as part of strategic and operational processes, are adjusted on a periodic basis. So, at the core of the enterprise are the interactions and dependencies between its stated goals and objectives and the processes that are established and implemented in order to achieve those objectives. Consequently, operational layer processes and their management are the instantiation of the tasks and activities necessary to achieve the desired end state of the enterprise.

4.2.2 Other Architecture Frameworks

It is important to consider how existing architecture frameworks may contribute to the representation of an additional layer that accommodates only strategic level processes of an enterprise system. This section reviews a range of alternative frameworks. Beyond the specific observations that follow, the reader should note that the concept of exploring these phenomena was inspired, for the most part, by previous studies of the disciplines and methods that have been successfully adopted for the creation, design, development and operation of complex human-machine systems such as airplanes, process plants, factories, and command and control systems.

This section investigates the structure, design, and function of architectural frameworks from various domains that include academia, and the public and private business sectors. Also of interest is the identification of characteristics from these frameworks that may be similar to those of our ESA. Characteristics that are of particular interest include the dynamic complexity germane to large-scale, distributed systems, interconnectivity between functional layers or views of the architecture, requirements that drive the creation and implementation of information/technical solutions to manage layer-specific processes, and human-in-the-loop behavior and associated dynamics.

It should be noted that we fully recognize that the other architecture frameworks herein reviewed may not be directly comparable to the ESA in terms of execution due to variability in application domains for the respective frameworks. It is also noted that some of these other frameworks may not have been defined with a strategic layer in mind. That said, there are five essential motivations for investigating their representations:

1. An understanding of the structure and function of other architecture frameworks might better inform enterprise system architecture. While the methodologies associated with this range of architecture frameworks may

not be entirely compatible, a new method may emerge for better supporting those executives responsible for leading and managing an enterprise system;

2. By examining the differences between strategic and operational layers, a methodology that will enable them to be more interoperable and functional may emerge;
3. The construct of other architecture frameworks might influence thinking and provide insights as to how strategic and operational processes, collectively the core of the enterprise system, might be better designed for enhanced enterprise performance;
4. Since today's business environment is characterized by a high degree of dynamic complexity, variability, and uncertainty, prediction of a future enterprise state is quite difficult. An investigation of alternative frameworks and the dynamics that they have been designed to accommodate may enable executives to better account for risk and uncertainty associated with enterprise system-specific dynamics;
5. Finally, these collective insights might be used to predict how the enterprise will respond to alternative future scenarios and alternative planned responses, thereby supporting better informed strategic decision making.

Architecture frameworks from two categories are investigated; application-class, and enterprise-class. These categories were investigated since the frameworks employed within them, though from different domains, are relevant to an enterprise system. Specifically, the focus is on the identification of issues related to a strategic layer of the ESA. In the following, architectural frameworks from each category are described in more detail.

4.3 Category 1: Application-Class Architecture Frameworks

As a baseline, these types of architecture frameworks, from both the public and private sectors, were reviewed because of their relevance to the systems / technical layer of the enterprise system. Category 1 frameworks are exclusively focused on the development of IT systems and, concomitantly, how such systems fit together to support a business architecture. Collectively, as a category, their view is that IT infrastructure constitutes the enterprise architecture in its entirety. Frameworks from three sectors of the economy were reviewed; DoD, Federal Government, and the private sector.

4.3.1 Department of Defense Architecture Framework (DoDAF)

Version 1.0 of the DoDAF is an evolution of the Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) architecture framework, and supercedes it (DoDAF Volume I, 2004). The DoDAF defines a common approach for describing, presenting, and comparing DoD enterprise architectures while facilitating the use of common principles, assumptions and terminology, regardless of what methodology was used to develop the architecture, and regardless of what kind of architecture it is. The overarching objective is to ensure that architecture descriptions can be compared and related across organizational boundaries, and to facilitate continuity / interoperability between and among various commands within the U.S. armed services, Joint, and multi-national forces. Consequently, it can improve the capabilities of DoD entities by enabling a quick synthesis of requirements with sound infrastructure investments.

Theoretically, such an architecture framework can lead to the rapid employment of improved operational capabilities. This architecture framework was developed to facilitate comparison of similar and dissimilar information system architectures that have tended to proliferate within the armed services (Air Force, Army, Marine Corps, Navy, etc.). While some existing architectures are complementary, some are competing systems. Having a common standard is essential as the DoD requires more interoperability among its systems. Increased operational efficiencies that can be derived from legacy architectures are critical as DoD must make difficult decisions to better leverage its resources.

What is perhaps the most interesting about this architecture framework is the manner in which it addresses the complexity of multiple existing (deployed) architectures with various data and/or information requirements and associated technical solutions intended to meet those requirements. All of this complexity has been compressed into three views; operational, systems and technical. The data model which articulates the linkages between the views is depicted in Figure 18. This is really the Joint Technical Architecture (DISA, 2002), which is imbedded into the DODAF. Note that, unlike an enterprise system with its hierarchical, layered approach to architecture development, the DoDAF is more heterarchical in construct since it is geared toward more operational/tactical issues.

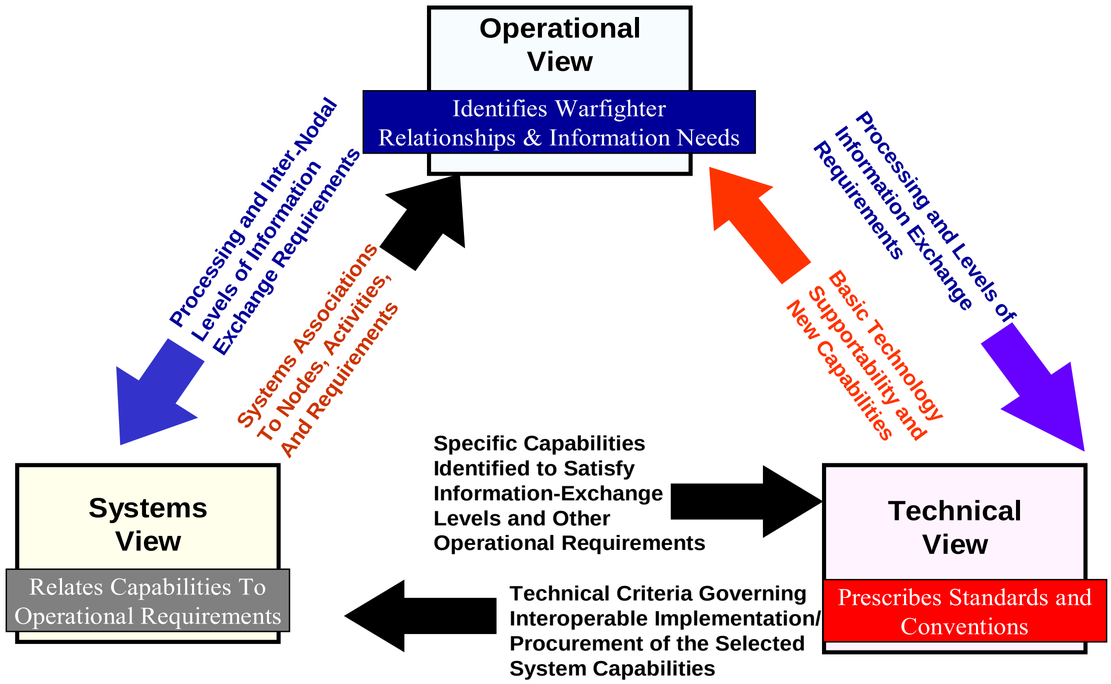


Figure 18: Fundamental Linkages Among the Views
(From DoDAF, Volume 1.0)

The analogy of the DoDAF to a commercial enterprise seeking to adapt its business processes and the technical systems that represent them is salient. Simply put, as the business grows, information and technical systems must evolve to keep pace. However, a disconnect occurs as the executive team chooses to grow its information systems. Most often, currently deployed 'legacy systems' are upgraded and patched together in a reactionary versus a proactive manner (Rigby and Bilodeau, 2005). Getting those pieces to seamlessly interact and evolve in a geographically disbursed business environment, and according to and in compliance with longer-range strategic business objectives, is quite challenging. Another prominent challenge in an enterprise system is focused on IT and IS. The issue focuses on adapting and / or creating information systems capable of explicitly supporting strategic layer processes and, at the same time, providing enhanced interoperability between the strategic and operational layers.

4.3.2 Federal Enterprise Architecture Framework

Following the industry trend of defining architectural frameworks to guide the development of large, complex systems and acquisition efforts, Congress passed the Clinger-Cohen Act in 1996 which requires each Federal Agency to have CIOs whose responsibilities include developing, maintaining, and facilitating integrated systems architectures. This framework was developed by the USA Chief Information Officers Council. The overarching objective is to improve interoperability within the U.S. government by creating one federal enterprise architecture, the goal of which is to integrate the separate architectures of the various federal agencies (OMB, 2002). As such, the framework attempts to define and align federal business functions and supporting information technology systems via a set of common reference models; business, service element, performance, data, and technical. Figure 19 depicts the current version of the FEAF.

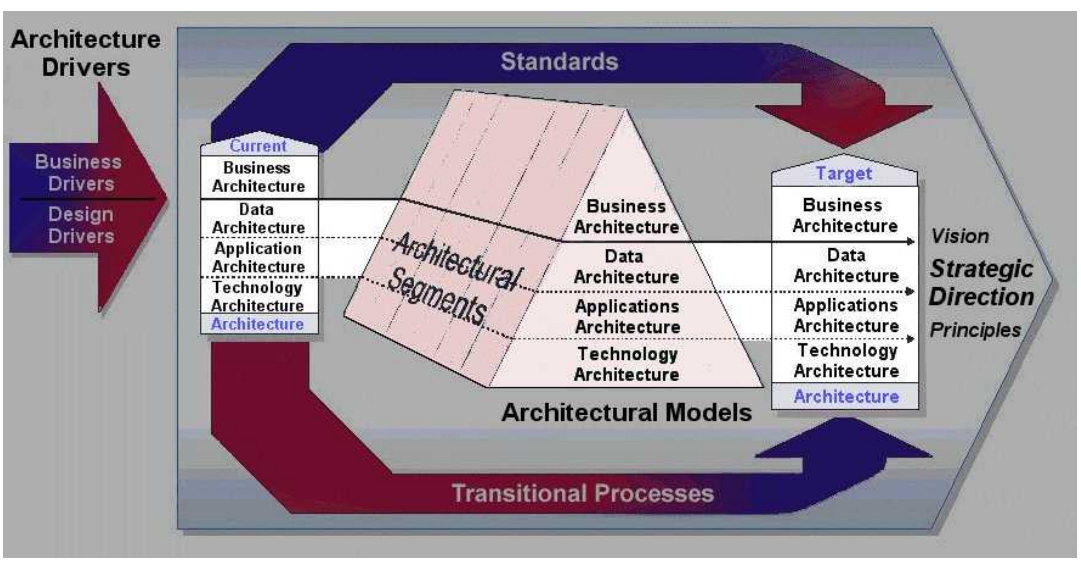


Figure 19: Current FEAF Architecture
(From the Federal Enterprise Architecture Framework, Version 1.1)

It should be noted that the FEAF is one of several federally sanctioned architecture frameworks, all of which involve similar constructs. One such example is the Treasury Enterprise Architecture Framework (TEAF), which is meant to guide the planning and development of enterprise architectures in all bureaus and offices of the Treasury Department. This framework was actually derived from an earlier Treasury model, the Treasury Information Systems Architecture Framework (TISAF), and the FEAF. Other examples of such frameworks include the DoDAF, and Enterprise Architecture Planning (EAP).

It is also interesting to note that the current version of the FEAF is actually an amalgam of the Zachman Framework (described later) and the EAP. While the intent of EAP is to define a process for enterprise architects that emphasizes interpersonal skills and techniques for organizing and directing enterprise architecture projects, its main application has been EAP for the development of business and industrial information systems.

4.3.3 Service Oriented Architectures

We now turn our attention to the private sector.

IBM's proprietary Service Oriented Architecture (SOA) is presented as an exemplar of private sector software development. It is not an architecture per se, as the name connotes, but rather a framework for the development, deployment and management of a loosely coupled business application infrastructure. Systems are considered to be loosely coupled if they are just connected and coexist in a larger system, and can merely exchange information with each other (Vernadat, 1996); the continuum of systems integration spans from uncoupled to tight integration into a single large-scale system (Levis, 2006). SOA's are focused at the operational layer and below.

Enterprises in every industry seek ways to respond ever more quickly and effectively to changing market conditions. To achieve this level of business flexibility, many enterprises are attempting to implement an SOA. One SOA construct, IBM's proprietary SOA, is presented as an exemplar of software development.

At a high level, an SOA provides the flexibility to treat elements of an operational layer and its underlying IT infrastructure as secure, standardized elements (services) that can be reused and combined to addres changing business goals / priorities. Figure 20 depicts IBM's version of an SOA.

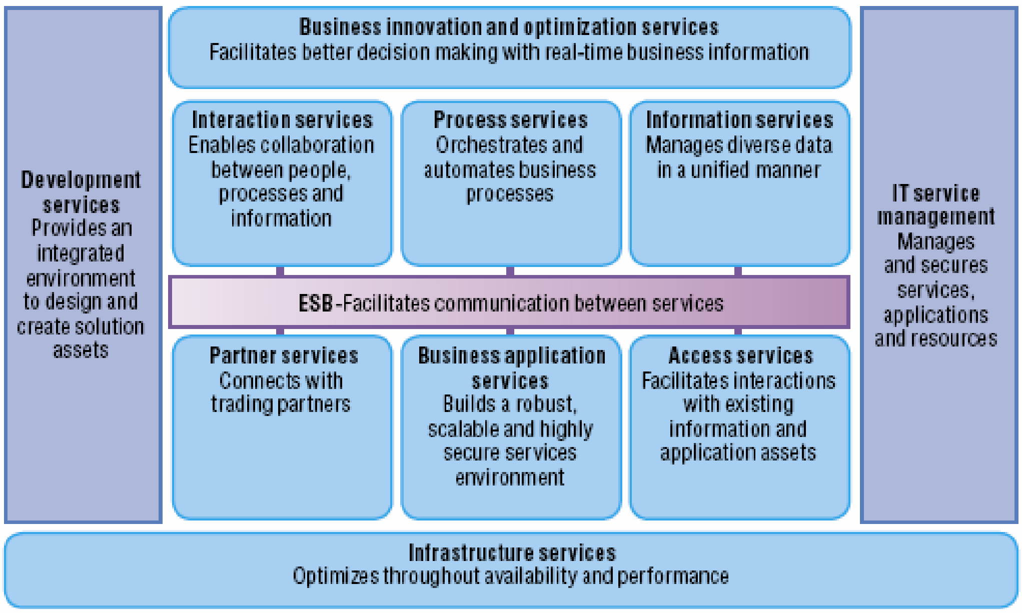


Figure 20: IBM's Version of an SOA
(IBM, 2005)

Much in the same vein as the problem that motivated the DoD's architecture framework; that is, making a large scale distributed system operate more efficiently, IBM's version of an SOA is focused not only at the operational layer, but extends down to the lower layers; the Enterprise Service Bus (ESB) and its definition is at the technical level, below the systems level. Ostensibly, this helps to extend applications and business processes, since they are the operationalized means to achieving stated enterprise goals and objectives on a day-to-day basis. Fundamentally, it addresses the problem of scalability in legacy system architectures that are not only complicated and discrete in functionality, but tend to be unable to keep pace with the need to respond quickly to new and changing business requirements.

Unlike other architecture frameworks whose orientation is (essentially) to help developers build better architectures from which more robust technical solutions can be developed, the IBM SOA adds an ESB layer to its business architecture. This is a flexible connectivity infrastructure for integrating applications and services, and enables an enterprise to decouple application logic from the external interfaces; essentially, it is the underlying layer for the SOA, making business processes and applications available as services, and increasing the reuse of those services across the enterprise.

Like other architectures that seek to assist developers build more robust enterprise software applications, IBM's SOA does not include a functional layer above the ESB. Its business optimization and innovation service "layer" acknowledges that it is difficult for executives to achieve enhanced performance if the current state of the enterprise is unknown and that, "too often", strategic decisions are based on historical data; i.e., lagging indicators such as financial data.

However, issues pertaining to SOA compliance from an architecture perspective exist; namely, that a clear definition of an ESB and its functionality has yet to emerge. This is especially critical given that multiple versions of an ESB currently exist. Further, none of the ESB versions can explicitly support a strategic layer, nor do they attempt to define what happens within a strategic layer.

4.3.4 Typical Business Architecture Framework

These types of frameworks address how the mission-critical functions of the enterprise are accomplished, and are almost exclusively designed to accommodate transactional data for day-to-day operations. As such, the framework is also focused at the operational layer and below. A typical architecture used to represent current performance 'dashboards' and 'scorecards' is used as a proxy for a business architecture and is represented in Figure 21. Note that this architecture stops well short of being able to address the issues that are handled by the notional strategic layer depicted earlier in our ESA.

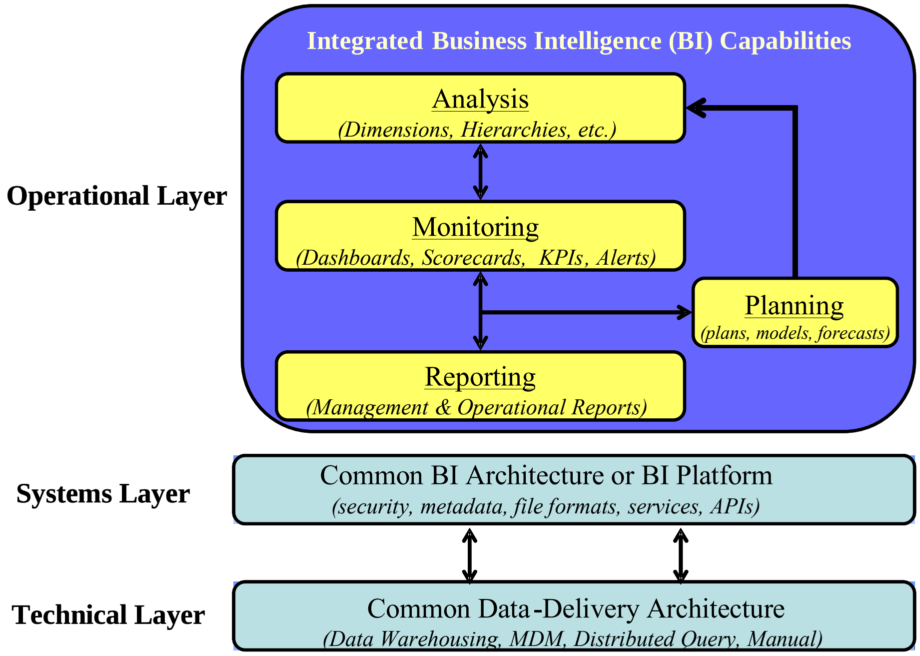


Figure 21: Typical Business Architecture
(Adapted from Eckerson, 2006)

According to Eckerson, several different processes occur within what we refer to as the operational layer of an enterprise framework; he refers to each of these processes as a "layer", such that four layers exist within the tactical and operational layer. The top monitoring layer uses dashboards, scorecards or alerts to notify users of material changes in the performance of processes and activities. The analysis layer allows users to drill down to explore a problem's root cause using multidimensional analysis. The reporting layer provides users with detailed operational data, while the planning layer lets managers use the output of their analyses to create plans (Eckerson, 2006).

4.3.5 Summary of Application-Class Architecture Frameworks: DoD, Federal Enterprise, IBM SOA & Business Architecture

The DoDAF defines a common approach for architecture representation; describing, presenting, and comparing DoD enterprise architectures while facilitating the use of common principles, assumptions and terminology. Similarly, the FEAF strives to improve interoperability within the U.S. government by creating one federal enterprise architecture, the goal of which is to integrate separate architectures from the various federal agencies. The SOA focuses on enabling people's actions and interactions, while the BA addresses mission-critical functions of the enterprise. Table 14 depicts a summary of the application-class frameworks.

Table 14: Summary of Application Class Architecture Frameworks

	DoD	Federal Enterprise	IBM SOA	Business Architecture
Description and Focus	• Ensure continuity/ interoperability between and among Commands, Armed Services, and Agencies	• Define and align federal business functions and supporting IT via a set of common models	• IBM's approach to Service-Oriented Architecture (SOA) is focused on how to enable people's actions and interaction	• Addresses how the mission-critical functions of the enterprise are accomplished
Function / Application	• Develop a common approach for architecture representation; ensure that architecture descriptions can be compared and related across organizational boundaries	• Improve effectiveness of IT spending to help yield substantial cost savings and improve service delivery for citizens	• The primary goal is "to align the business world with the world of information technology (IT) in a way that makes both more effective."	• Portrayal of how the enterprise actually accomplishes its mission rather than how it is organizationally structured to manage its mission
Architectural Views and/or Layers	• There are 3 major views; i.e., perspectives that combine to describe the architecture; operational, systems, and technical. There are also ~26 smaller views.	• Five: business reference model, service component reference model, performance reference model, date reference model, technical reference model	• The SOA was designed such that elements of business processes and underlying IT infrastructure can be treated as components (or services) that can be reused and combined.	• The predominance of these technical solutions have three layers; tactical/operational, systems, and technical. The tactical/ operational layer typically includes monitoring, analysis, reporting, and planning functions

Table 14: Summary of Application Class Architecture Frameworks (continued)

	DoD	Federal Enterprise	IBM SOA	Business Architecture
Noteworthy Components	• Each view has a number of key products to be developed • Fundamentally, this framework is itself a framework for building a an architecture framework for large-scale distributed systems	• This guide to help federal agencies develop and implement an enterprise architecture was the first of its kind.	• Within the SOA, applications, information and other IT assets are viewed as services or “building blocks”; each of these services can be mixed and matched to create new, flexible business processes	• These systems are almost exclusively designed to categorize transactional data to aide in day-to-day operations

4.4 Category 2: Enterprise-Class Architecture Frameworks

These architecture frameworks represent another view of enterprise architecture. In this view, which provides a holistic perspective of the enterprise, the orientation is to assist software engineers in formulating a common approach for architecture development. Consequently, information technology-related systems are treated as but one element of the enterprise. The Open System Interconnection (OSI) reference model is considered a Category 2 architecture framework because of its orientation around interconnection and interoperability, a critical function to be accomplished between the business and strategic layers of an enterprise system.

4.4.1 Open System Interconnection Model

The OSI reference model framework is a layered abstract description for communications and computer network protocol design, which has important implications for business function continuity and interoperability. Much in the same way as our ESA divides enterprise processes and functions into layers, the OSI reference model divides the functions of a protocol into a series of layers. The OSI reference model describes how information from a software application in one computer moves through a network medium to a software application in another computer. The OSI reference model is a conceptual model composed of seven layers, each specifying particular network functions. It is now considered the primary architectural model for inter-computer communications.

The OSI model divides the tasks involved with moving information between networked computers into seven smaller, more manageable task groups. A task or group of tasks is then assigned to each of the seven OSI layers. Each layer is reasonably self-contained so that the tasks assigned to each layer can be implemented independently. This enables the solutions offered by one layer to be updated without adversely affecting the other layers (IOS, 1984) Figure 22 details the seven layers of the OSI reference model.

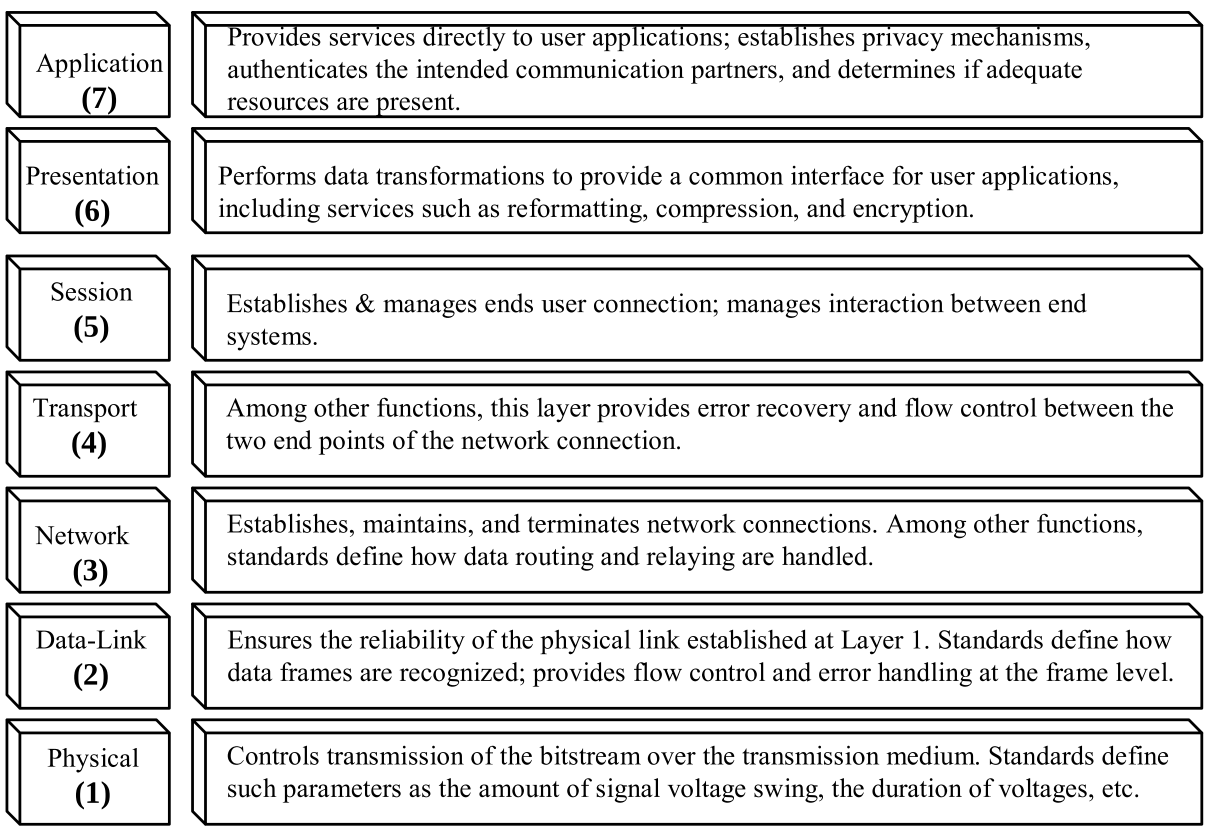


Figure 22: Operations System Interconnection (OSI) Reference Model
(From the International Organization for Standardization [OSI], 1984)

The seven layers of the OSI reference model are divided into two categories, upper layers and lower layers. The upper layers of the OSI model deal with application issues and are generally implemented only in software. The highest layer, the application layer, is closest to the end user. Both users and application layer processes interact with software applications that contain a communications component. The term upper layer is sometimes used to refer to any layer above another layer in the OSI model. The lower layers of the OSI model handle data transport issues. The physical layer and the data link layer are implemented in hardware and software. The lowest layer, the physical layer, is closest to the physical network medium (the network cabling, for example) and is responsible for actually placing information on the medium.

4.4.2 Zachman Framework

The Zachman Framework is based on principles of classical architecture that establish a common vocabulary and set of perspectives for describing complex enterprise systems (Schekerman, 2003). It is an approach for documenting and/or developing an enterprise-wide information systems architecture. As such, it allows an architect to 'frame' the problem to be solved via the use of a holistic model of an enterprise's information infrastructure from various perspectives.

The Zachman framework is perhaps the most widely cited of the enterprise architecture frameworks because of its broad applicability to both interpretations of EA. While this framework was originally designed to guide the creation of IT systems and solutions, it has rather easily and successfully been adapted for true enterprise architecture applications.

Zachman (1987a) proposed a simple matrix as a framework for planning information systems architecture. The matrix puts on one axis the "things of interest" - things that must be considered or created to manage information (data, function, network, people, time, and motivation). On the other axis, it shows the perspectives that need to be considered for each of those things; enterprise, information system, technology, and non-contextual. Each perspective contains a complete view of the business and must therefore cover various focus areas, each of which answers a basic question: what = data; how = function; where = network; who = people; when = time and why = rationale. When mapped against each other, the perspectives and the focus areas form a matrix that is the Zachman Framework (Zachman, 1997b). These categories became the row and column headings of Zachman's Framework, depicted in Table 15.

Table 15: The Zackman Framework

(Adopted from Zackman, 1987a)

	Data (What)	Function (How)	Network (Where)	People (Who)	Time (When)	Motivation (Why)
Objectives / Scope						
Model of the Business						
Model of the Information Systems						
Technology Model						
Detailed Representation						
Function System						

As the matrix intersections, the particular forms that the elements of interest take vary from one perspective to the next. For example, the information systems perspective is interested in entities, attributes, and relationships, but the technology perspective is concerned with the tables, columns, and constraints that support those information system constructs within a relational database. In fact, in many cases, there is a process by which the constructs from one perspective are transformed into necessary supporting constructs of the next perspective. Each transformation moves the architect closer to the final, working information system. The manner in which the framework has evolved has made it increasingly more relevant to the notion of a strategic layer for an ESA. Researchers and practitioners have realized that limiting the use of the framework to the information systems of an enterprise was not justified, given the background and thinking that led to its creation. This is true because the framework not only recognizes the different representation layers, but addresses different points of design such as data, function, network, people, time, and motivation with respect to the different layers.

Finally, the Zachman Framework is not an architecture and was never proposed as such. It can be thought of as a multidimensional visual checklist (Gottlieb, 2004). The artifacts that instantiate the cells of the framework for a given architecture are indeed architectures or subsets of an architecture, depending on one's point of view. The framework itself does not impose architectural rigor, although following its constructs might reduce the probability of mishaps in designing an architecture using the framework.

4.4.3 Summary of Enterprise-Class Architecture Frameworks: OSI Reference Model, Zachman Framework

Note that both architecture frameworks entail a structured, layered approach with a focus on interoperability and communication between layers. Table 16 provides a summary of the OSI model and the Zachman Framework.

Table 16: Summary of Enterprise Class Architecture Frameworks

	Operation System Interconnection Reference Model (OSI)	Zachman Framework (ZF)
Description and Focus	• The OSI Model is a layered abstract description for communications and computer network protocol design	• Based on practices in traditional architecture and engineering; an approach for documenting and/or developing an enterprise-wide information systems architecture
Function / Application	• Each layer has the property that it only uses the functions of the layer below, and only exports functionality to the layer above. Together, the layers define the requirements for communications between two computers.	• Provides a basic structure for creating & maintaining architectural representations of an organization. Essentially, this framework can be thought of as a more of a classification scheme for design artifacts rather than a rigorous method for designing purely IT systems.
Architectural Views and/or Layers	• Seven; application, presentation, session, transport, network, data link, physical.	• 2-D matrix of views representing the architecture. Rows represent the views of different types of stakeholders; the columns represent different aspects or views of an architecture
Noteworthy Elements	• Its main feature is in the interface between layers which dictates the specifications on how one layer interacts with another. This means that a layer written by one manufacturer can operate with a layer from another	• The primary strength of the ZF is that it explicitly shows that there are many views that need to be addressed by an enterprise architect. • A related strength is that the ZF explicitly communicates that there are several stakeholders in an enterprise architecture, not just the enterprise architects and developers

4.5 "Architectures" of Human Behavior and Performance

Since a strategic layer, by definition, requires extensive executive-in-the-loop involvement, it is useful to consider models of both human behavior and performance to generate insights as to how they may impact the execution of strategic layer processes. While neither the SRK taxonomy or the OCM, discussed below, is considered to be an "architecture" in the usual sense, both serve to address salient, 'human-operator' issues in the context of a large-scale, dynamically complex system such as an enterprise.

When investigating enterprise performance, we are interested in 'emergent' phenomena; emergent being defined as a system property in which behaviors at a higher layer are caused by behaviors at a lower layer which could not be predicted or made sense of at that layer (Shah & Pritchett, 2005). Since enterprise performance is in turn affected by the performance -- and behavior -- that emerges based on the interaction of executives, management, and employees, it seemed logical to note "architectures" of human behavior and performance. As such, the SRK taxonomy, and the OCM are introduced and briefly discussed.

4.5.1 Human Behavior: Skills, Rules, Knowledge Taxonomy

The overarching context for the SRK taxonomy is rooted in the types of competencies that executives need in order to effectively implement executive layer processes. Given that the processes to be executed at the strategic level are known, as are the executives responsible for their execution, the final piece is to determine the constraints that may be imposed on the skills, rules, and knowledge of the individual executives (Vicente, 1999).

The SRK taxonomy defines three types of behavior or psychological processes present in operator information processing (Rasmussen, 1990; Vicente, 1999). The taxonomy's construct is such that it provides for a set of basic distinctions, not a model of psychological processes, with each level in the taxonomy corresponding to a category of human performance.

- Skills: A skill-based behavior represents a type of behavior that requires very little or no conscious control to perform. Performance consists of highly integrated patterns of behavior (Rasmussen, 1990). Some skill-based behaviors require little effort for control which frees up cognitive resources for other tasks.

- Rules: According to Rasmussen (1988), a rule-based behavior is characterized by the use of rules and procedures to select a course of action in a familiar work situation. An example is an aircraft emergency. Pilots have highly proceduralized instructions in the event of an engine fire, for example. Consequently, when such a situation is detected, the pilot can perform the necessary steps to ensure the safety of the aircraft, without having to know specific details about the engine's situation.
- Knowledge: In this mode of behavior, cognitive workload is typically greater than when using skill or rule based behaviors, especially when the situation is unexpected. In such situations, as is commonplace in today's business environment, a higher level of reasoning and induction is required in order to derive a solution based on analysis of the current state of the enterprise system.

4.5.2 Optimal Control Model

The Optimal Control Model (OCM) has been used to describe 'optimal' human-in-the loop performance in a human-machine system. It provides a means by which to quantitatively model the response characteristics of a human operator in a manned-vehicle system. The model's output can be used to predict human control characteristics in reasonably complex, linearized manual control tasks.

It should be noted that a driving force behind the cultivation of the SRK taxonomy is to facilitate the development of models of human performance. Because the OCM specifically attempts to address human performance in the context of operating a dynamically complex system, it was not discussed along with the other architecture frameworks.

Perhaps the most interesting aspect of the OCM is the elements of the overall model; i.e., filtering, etc., as well as the model's ability to predict performance. Essentially, the model tells the designer the kinds of things needed to be accomplished in order to help the human-operator control his or her system.

The OCM is especially relevant since the workflow required to implement the processes contained within a strategic layer is largely dependent upon the capabilities of executives in the loop. Consequently, a closer investigation of the OCM may provide significant insights into human performance at the strategy layer of an ESA. The OCM is fundamentally a stochastic, linear multivariable-control system designed to quantitatively model the response characteristics of a human operator in a wide range of aviation-related human tracking tasks (Kleinman, Baron & Levision, 1971).

Figure 23 diagrams the general structure of a human-in-the-loop system, with an OCM modeling the pilot-operator.

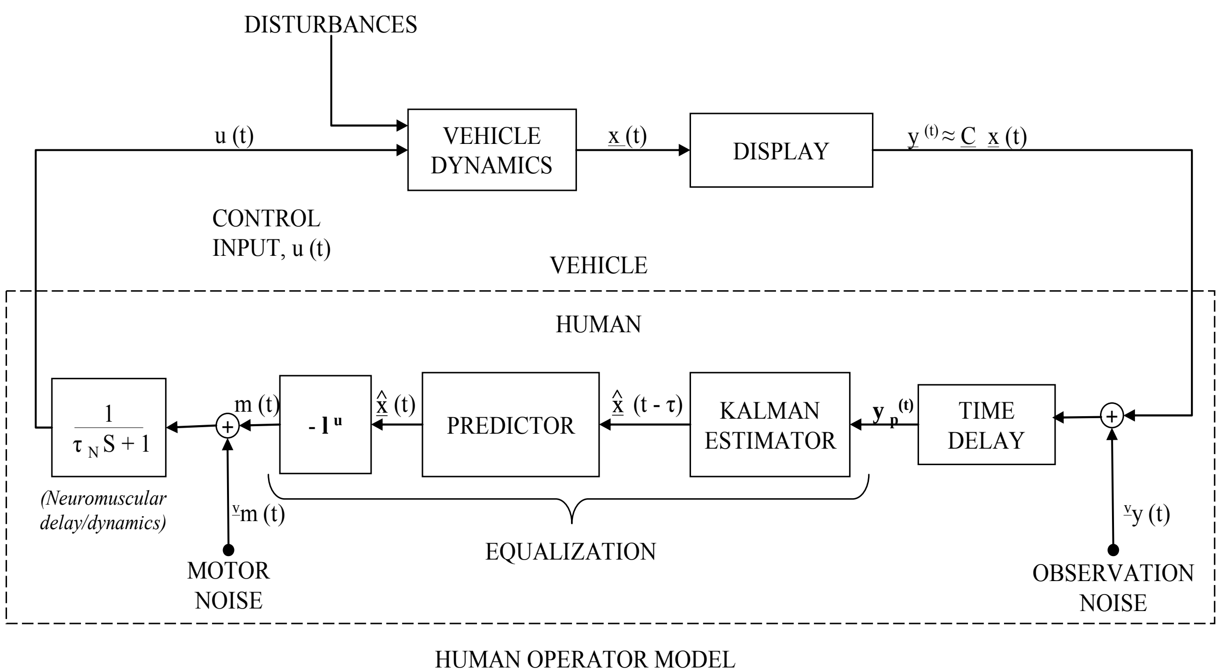


Figure 23: Control Theoretic Model of Human Performance
(Kleinman, Baron, Levison 1971)

The model assumes that the human operator acts optimally in the execution of a tracking task. While so doing, it is also assumed that the pilot-operator acts as if he or she possesses complete or near complete knowledge of dynamics of the system being controlled. Most importantly, it assumes that the human knows the boundary conditions of how he or she will respond; i.e., the statistical properties of his own randomness

(Kleinman, et. al. 1971). While it may be difficult to prove conclusively that these conditions have been satisfied, it is logical to assume that an expert pilot-operator (or executive) will develop an awareness of his own limitations and the dynamics of the controlled system with practice and experience. It should be noted that although we expect that executives face such changing conditions, especially externally, they cannot know the dynamics as well as pilots.

For example, this is precisely the reason that investors desire to provide investment capital to a proven executive or executive team. Logically, those who have demonstrated the ability to translate both applied domain knowledge and knowledge about themselves, their team, and the marketplace within which they choose to compete, are more likely to generate a higher return on invested capital. It should be noted that the implementation of strategic layer processes is likely to involve highly nonlinear phenomena; the OCM, for simplicity, tends to linearize around nominal operating conditions. Mathematically, the control characteristics of the pilot-operator are largely determined by the solution of a well-defined optimal linear regulator problem with a time delay and observation noise (Kleinman, et. al, 1971). One would expect that executives might be more successful if the task was to optimize around nominal operating conditions, which may be the case in highly-regulated industries. (It is left to future research to apply this framework in the context of such industry sectors.)

In Table 17, each element of the OCM is described first as it applies to human vehicle-system, and then its implication of a strategic layer in the context of an enterprise system. Based on the analysis presented in Table 17, a graphical depiction of an OCM-centric view of the enterprise system is depicted in Figure 24.

Table 17: OCM Elements Applied in an Aircraft versus Enterprise System

Optimal Control Model Element	Human-Vehicle (Aircraft) System Application	Application to and Implications for a Strategic Layer
Time Delay	• Is a lumped representation of time delays associated with visual and neuromotor pathways. Assumes that the pilot perceives a noisy and delayed version of the displayed variables	• Most often, executives do not possess a real-time assessment of the state of the enterprise, and may be unable to derive the information necessary to assist in implementing strategic processes
Kalman Estimator	• Computes an optimal estimate of the state of the vehicle, which is a delayed estimate since the (noisy) display to the pilot is delayed	• Data provided from multiple sources needs to be filtered in a timely manner so as to provide executives with information about enterprise status; typically delayed and incomplete
Predictor	• For the reasons listed above, a predictor element is needed to project the state of the system, in part to compensate for the time delay	• Currently, executives do not have access to a mechanism/ methodology in order to extrapolate forward to predict performance. Typically, this is done using “lagging” indicators such as financial variables
Disturbances	• The OCM does not try to predict either the magnitude or size of exogenous disturbances	• To some varying degree, the executive team formulates business strategy based on exogenous forces that shape its ‘world view’. The executive attempts to predict both size and magnitude of the perturbations
Dynamics	• Vehicle; multiple degrees of freedom, random atmospheric perturbations, etc.	• Enterprise; multiple locations, people, business units , competitors, etc.
Display (s)	• Electronic Flight Information System (EFIS), airspeed indicator, etc.	• Various IT system configurations; performance dashboard, “management flight simulator”, etc.
Observation Noise / Motor noise	• Human sensing mechanisms require a finite time to execute their physical processes, thereby introducing a time delay and added noise	• Perception/subjective interpretation of a strategic process combined with internal politics and agendas introduce time delays and noisy perceptions
Neuromuscular Dynamics	• A element of the OCM which represents these dynamics converts commanded control into actual control	• The implementation of strategic layer process entails multiple nested loop dynamics that delay responsiveness. Corporate culture effects is one example

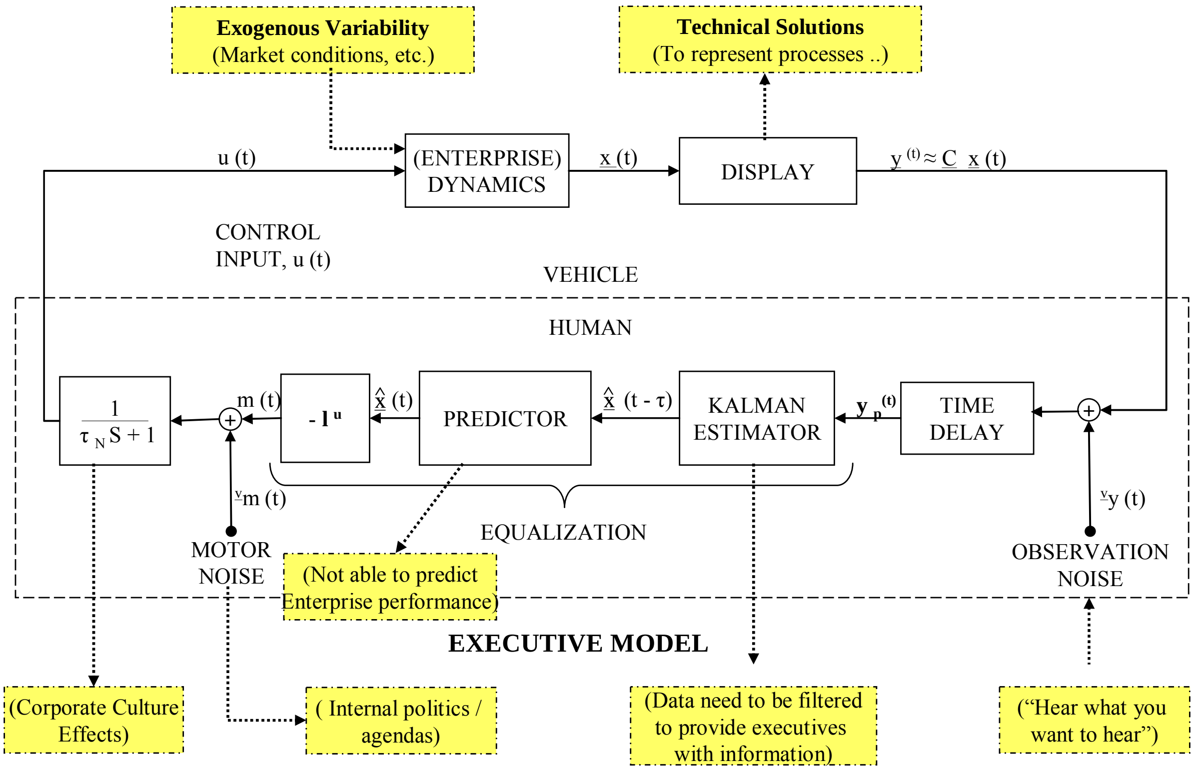


Figure 24: Enterprise System Focused Control Theoretic Model of Executive Performance

4.5.3 Analysis and Summary of Architecture Frameworks

Based on a system-of-systems view of the enterprise, our high-level ESA is introduced and discussed. The uniqueness of the architecture is the addition of a strategic (process) layer that is separate and distinct from an operational (process) layer found in a traditional business architecture framework.

Six architecture frameworks within two categories were identified; Application-Class, and Enterprise-Class. When investigating performance in a large-scale system such as an enterprise, we are interested in 'emergent' phenomena; emergent being defined as a system property in which behaviors at a higher layer are caused by behaviors at a lower layer which could not be predicted or made sense of at that layer (Shah & Pritchett, 2005). Since enterprise performance is in turn affected by the performance -- and behavior -- that emerges based on the interaction of executives, management, and employees, it seemed logical to briefly address "architectures" of human behavior and performance. As such, the SRK taxonomy, and the OCM were introduced and briefly discussed.

Each framework was investigated in the context of applicability to a notional strategic layer of an enterprise system. Based on this analysis, the following general and specific observations are noted:

General Observations

1. <u>Strategic Layer Processes Are Different From Operational Layer Processes</u>: The characteristics of strategic processes as introduced in the strategic layer are vastly different than the characteristics of operational processes. Strategic processes are those that are leadership focused and strategy-centric. They are far-reaching and are completely reliant upon strategic-in-the-loop judgment based on acquired awareness about the state of the environment exogenous to the enterprise. Since the enterprise operates in a dynamic environment, it must continually evolve and adapt to change. Consequently, strategic layer decisions often involve nonlinear phenomena and involve interactive compilation of information (not data).
2. <u>Strategic Layer Processes Require Different Technical Support</u>. Given the fundamental difference in orientation between the strategic and operational layers, the strategic layer requires a level of technical system support that may not be available with current IT systems. Such systems need to accommodate a major objective of the strategic layer which is to move the enterprise toward performance predictability versus the current mode of operation which tends to rely on extrapolating future enterprise states from "lagging" indicators such as financial variables and other transactional data collection that are at the core of the operational layer.

Specific Observations

The following observations refer to Table 17 which depicts the applicability of various architecture frameworks to typical elements contained within the layers of our high-level ESA.

1. Application Class Architecture Frameworks Dislocate the Straegic Layer:
    - Multiple categories of architecture frameworks have been created based on interpretations and /or competing views of the term ‘Enterprise Architecture’. The first category, application-class architecture frameworks, maintains a purely IT-centric view of the enterprise. Consequently, the IT systems created by software engineers that are based on application-class architecture frameworks support the lower levels of abstraction of an enterprise system; specifically, the operational layer and below.
    - It is not clear that such systems, as they currently exist, are either indirectly capable of supporting a strategic layer, or have any applicability to the execution of its processes. Further, these systems are designed to capture transaction-related data that is oriented to deliver specific answers to particular questions about various aspects of day-to-day enterprise operations. This approach does not appear to be supportive of executives who require a more holistic view of the entire enterprise.
2. Enterprise-Class Frameworks May be Extensible to a Strategic Layer:
    - Enterprise-class architecture frameworks, on the other hand, espouse a design methodology that considers the enterprise in the aggregate. The Zachman Framework has been extended to focus on the enterprise as a system-of-systems, whereby systems and technical layer solutions are considered as elements of an enterprise system. As such, it can be thought of as a generic classification schema rather than outlining a more rigorous method for IT system design. The principles of this framework are relevant to the strategic layer, as the view of the enterprise as seen through the eyes of the executive needs to be enabled and/or facilitated by systems and technology, not driven by them.
    - While the strategic layer is at higher level of abstraction and its processes are largely separate and distinct from the operational

layer, there needs to be a high level of interoperability between the two layers. This does not currently appear to be the case. Since requirements flow from the strategic layer to the operational layer whose processes and associated workflow execute day-to-day operations, the underlying precepts of the OSI reference model are very relevant to a strategic layer from the perspective of interoperability and communication.

3. <u>Understanding Executive-in-the-Loop Dynamics is Critical to Strategic Layer Execution:</u>
    - The implications of both the OCM and the SRK taxonomy to a strategic layer are palpable. Specifically, almost all the OCM elements outlined in Table 18 are applicable to an executive-operator of a dynamically complex system such as an enterprise. Most notably lacking from a strategic layer perspective is that of a 'predictor' function; currently, executives do not have robust mechanisms / methodologies to enable them to extrapolate forward and infer future enterprise state.
    - A second order effect of not having information-based systems that can adequately support a strategic layer is time delay, a phenomenon well accounted for in the OCM. As implied for a strategic layer, executives most often do not possess a real-time assessment of enterprise system state; therefore inputs as presented/displayed by current information systems are 'noisy' and lagging since, for the most part, they are based on 'lagging' data. There is also the "neuromotor lag" of execution throughout complex enterprise processes and systems.

Table 18: Framework Applicability to Layers for an Enterprise System

		Application Class Architecture Frameworks				Enterprise-Class Architecture Frameworks	
		DoD	**Federal Enterprise**	**IBM SOA**	**Business Architecture**	**OSI**	**Zachman Framework**
Generalized Layer	• Typical information elements contained within each layer	○	○	○	○	◉	◉
Strategic	• Situation assessment • Communication • Intent formation	◉	◉	◉	●	●	◉
Operational	• Monitoring • Reporting • Analysis • Planning	◉	●	●	●	◉	●
Systems	• Information security • Sub-system interaction • Various file formats • Application Programming Interfaces (APIs)	◉	●	●	●	◉	●

Key

● Supports Explicitly

◉ Supports Indirectly And/Or May Be Applicable

○ Does Not Support

4.6 Supporting Enterprise Processes: Information Systems/Information Technology

IT and IS are used in virtually all aspect of an enterprise. As the enterprise evolves from its nascent stages into business maturity, IT and its associated systems can either be a cross-cutting enabler or inhibitor of transformation of various kinds. We use the term cross-cutting in reference to the various layer of our ESA, and the respective processes that are contained in the strategic and operational layers, respectfully. The first part of this chapter focused on extending the analyses that were conducted in Chapters 2 and 3, respectfully. Given the plethora of information technology-based systems that exist today, it is beyond the scope of this dissertation to provide an exhaustive review and summary of all such systems. Rather, this section highlights a sampling of IT and IS used through out an enterprise system, and their utility in support of strategic and operational layer processes.

4.6.1 Background

The notion that better informed decision-makers make better decisions gave rise to emergence of decision support systems as a focused topic of corporate research and development efforts (McGinnis, 2005). It also spawned an entire market oriented around workflow-based automation systems. Products such as executive information systems, executive dashboards, management flight simulators, and business intelligence software have all been designed to provide executives with access to real-time financial and operational data to guide them in the decision-making process. Again, these mainly embody a linear view of the enterprise and tend to be more operational than strategic.

The ultra-competitive nature of today's business environment is driving companies to optimize the processes that affect their financial and operational performance. As a result, many enterprises seek to apply performance-driven management techniques to streamline day-to-day business operations and hopefully facilitate better operational/tactical decisions that drive continual, incremental, improvement (McCune, 2005). This has given rise to an abundance of systems and tools such as Business Performance Management (BPM), and Corporate Performance Management (CPM) among many others.

Table 19 provides a selected set of information systems and stratifies them into enterprise methods, tools, and models. A sampling of these is profiled in the context of supporting enterprise processes.

Table 19: A Sampling of Business Process Representation Methods and Tools

System Type	Information System Representation
Enterprise Methods	• Total Quality Management • Lean Transformation • Six Sigma • Business Process Reengineering (BPR) • Business Performance Management (BPM) • Corporate Performance Management (CPM) • Enterprise Application Integration (EAI) • Enterprise Modeling (EM)
Enterprise Tools	• Enterprise Resource Planning (ERP) • Customer Relationship Mgmt. (CRM) • Supply Chain Management (SCM) • Sales Force Automation (SFA) • Enterprise Application Integration (EAI) • Enterprise Decision Management (EDM)
Enterprise Models	• Petri Nets • Finite state automata • Graphical models and Bayesian networks • Agent-based models and simulation • Organizational Simulation

Various methods and tools are required to formulate a model of the enterprise such that more rigorous techniques can be applied to better understand, design, and manage the enterprise as a complex system (Rouse, 2006b). They are also needed to assist executive-level decision makers to make transformation-oriented decisions. But, a salient question to be postulated, based on the findings of Rigby and Bilodeau (2005), is how well the availability of such tools correlates with enterprise performance.

4.6.2 Systems Categorization

Information used for executive decision-making is heterogeneous, often laced with uncertainties, typically aggregated from multiple sources, and frequently quite complex.

The decision process itself consists of a large number of components, tasks, and associated sub-tasks that interact in varying and dynamic ways, each of which require different types of processing. This leads to complex behavior that is oftentimes difficult to quantify, understand, and manage, let alone predict. Somehow, the executive must sift through the "noise" that is an artifact of the process in order to make important decisions over a wide range of both strategic and tactical issues that face the enterprise.

In Figure 25, systems such as those profiled in Table 19 have been classified into a notional "intelligence hierarchy". The idea is that the more focused and grounded in context the Enterprise Information Technology (EIT) system / tool is, the higher it is on the hierarchy and, in theory, the greater its utility in helping management make sense of vast quantities of data it collects. It should be noted that this hierarchy has salient relations to the SRK taxonomy, which provides the basis for it.

At the top of the hierarchy is Enterprise System Simulation (ESS), also known as organizational simulation. While it is widely accepted that modeling and simulation of possible organizational structures and relationships are needed, organizational simulation is still in the nascent stages. In organizing and editing "Organizational Simulation", Rouse and Boff (2005), review and extend the present state of knowledge of various methods and tools for organizational simulation to become more widely disseminated.

Next in the hierarchy are EIT systems/tools that exhibit a "predictive" intelligence capability. That is, the tool may be capable of inferring meaningful relationships across many different functional business levels by simultaneously analyzing and comparing patterns within and between datasets. In theory, these "predictive" insights could be significantly more precise than today's systems in providing more value-add when compared to those EIT systems / tools that are lower on the hierarchy. However, they still fall well short of being able to predict emergent behavior at the enterprise level and hence, enterprise performance.

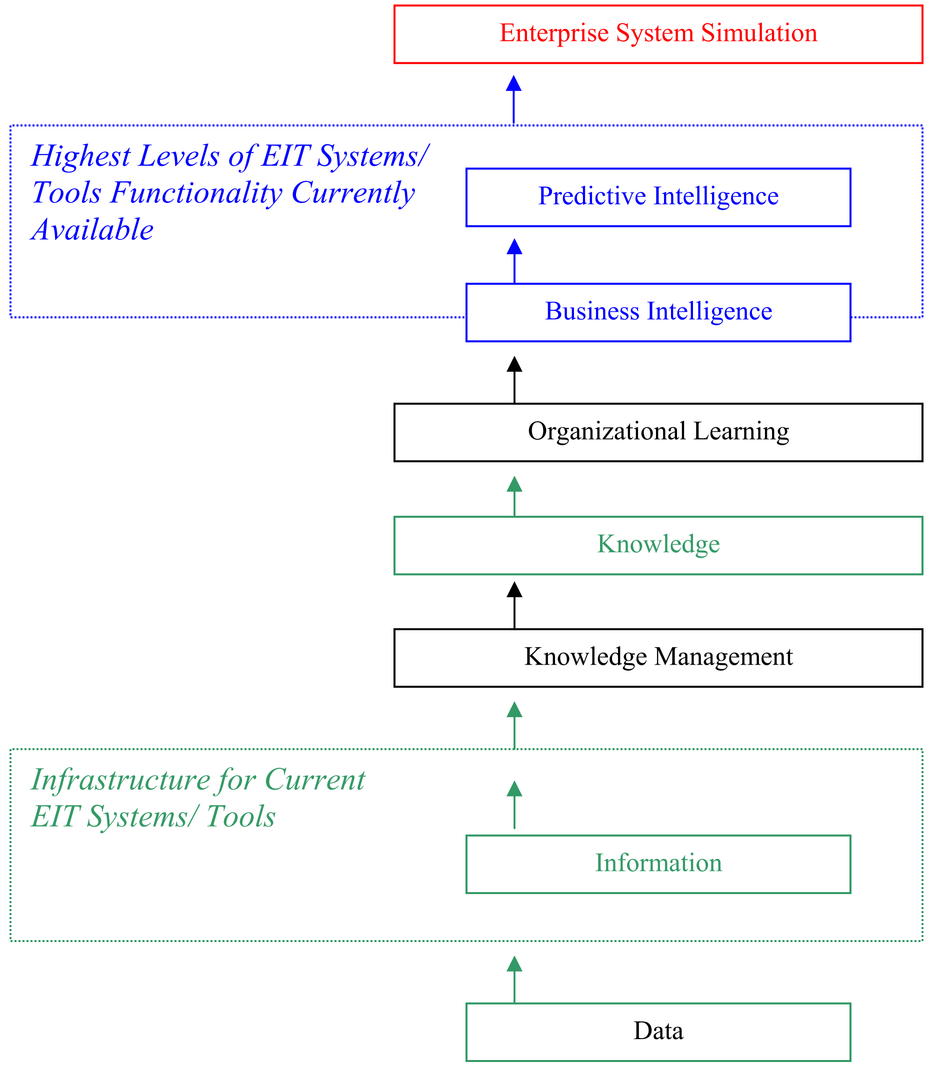


Figure 25: Notional Intelligence Hierarchy for Current IT and IS

The hierarchy begins simply with data, which, in and of themselves and to the executive, may be meaningless points in space and time, void of any context. The key concept as it pertains to data is that it is out of context; consequently, it is without a meaningful relation to anything else. In an enterprise context, data simply represents facts or values of attributes, and relations between data and other relations have the capacity to provide information. Information, however, has a tendency to be relatively static in time and, in and of itself, tends not to be conclusive relative to predicting future behavior of the enterprise.

Progressing up the hierarchy, patterns of relations of data and information, and other patterns tend to evolve. As they do, the capacity to represent knowledge is created.

For the representation to be of any utility it must be understood, and when understood the representation is information or knowledge (Belinger, 2004). The management of this knowledge has spawned a slew of 'knowledge management' systems/tools (Alavi, 1999). However, we believe that knowledge management per se should be viewed simply as one of many cooperating means toward the end, the development of a predictive intelligence tool, not the end itself. At the knowledge management level of the hierarchy, generating insights for management is important only to the extent that it enhances an organization's ability and capacity to deal with various situations in order to effectively envision and create their future.

Currently, no singular EIT system or tool exists that can provide executives with a predictive intelligence capability (Rigby and Bilodeau, 2005). Some "business intelligence" (BI) tools include but are not limited to various data mining techniques, system dynamics, management "flight simulations", executive information systems and associated management tools, and "executive dashboards". Finally, at the top of the hierarchy are those EIT systems / tools that may have the capability to provide management with a predictive "intelligence" capability, if and only if, they are used in conjunction with other tools such as simulation.

4.6.3 Sampling of Information Software and Systems

In today's ever-changing, competitive business environment, more and more executives are turning to executive support systems and business intelligence technology to help them gain a competitive advantage. Because older management / measurement systems were designed for a more stable business environment, executives today need new methods and systems capable of providing them with the right actionable information to help them make business decisions. While there are many types of systems and software on the market to handle business processes, most do not support executive processes. The general function of each system is as follows:

1. Enterprise Modeling (EM): These tools are normally used to model business processes, not executive processes. Enterprise models capture the

fundamental business processes, the external entities (customers, suppliers, partners, or competitors), and the major workflows between them.

2. Enterprise Resource Planning (ERP): This software attempts to integrate all departments and functions across an enterprise onto a single computer system that can serve all those departments' particular needs. Like EM, ERP systems capture transaction-related data that is oriented to deliver specific answers to specific questions about various aspects of day-to-day enterprise operations. It is designed to control many business activities like sales, delivery billing, inventory management, etc. ERP software was not designed to support high level, executive processes.
3. Enterprise Decision Management (EDM): These solutions are more frequently applied to operational rather than strategic decisions. EDM uses business rules management and predictive analytics to automate core day-to-day decisions, often in real time. EDM is designed for product line managers, customer service managers, etc. to help guide them in making more precise, consistent and agile operational decisions.
4. Business Intelligence/Decision Support Systems (BI/DSS): Business Intelligence software and Decision Support Systems mainly help managers with operational, day-to-day decision making. They gather, analyze, and transform raw financial data into usable information.
5. Enterprise Information Systems (EIS): While these systems do provide executives with fast and easy access to data regarding the company's products, customers, services and resources, the information provided tends to give the executive a linear view of the organization. The data presented is more operational than strategic in nature.
6. Management Flight Simulators: Management Flight Simulators allow managers to test business strategies and experiment with alternative decisions in a simulated business environment. For example, a simulation model could represent how the acquisition and management of resources at a company determine sales and profitability. As with the case of EIS and

BI software, Management Flight Simulators tend to simulate operational rather than strategic decisions.

Table 20 provides a definition of each system, along with its general focus, application area (s), enabling technologies, and sample software.

Table 20: Overview of Several Classes of Enterprise Information Systems

	EM	ERP	EDM
Definition	• Enterprise Modeling (EM) is the process of improving the enterprise performance through the creation of enterprise models to include the modeling of both business processes and IT.	• Enterprise Resource Planning (ERP) is a business management system that integrates all departments of a business (i.e. planning, manufacturing, sales, and marketing) onto a single computer system that can serve all those departments' needs.	• Enterprise Decision Management (EDM) refers to the application of rule-based systems – sometimes in conjunction with analytical models – to automate and improve high volume operational decisions across the organization
Function	• Can help facilitate better understanding of the business processes of the extended enterprise and the relationships that extend beyond the enterprise boundaries.	• Integrates and automates many of the business practices associated with the operations or production and distribution aspects of a company engaged in manufacturing products or services	• Automates operational decisions (in real time or batch) as a closed-loop process. Limits or removes the need for human intervention in the decision-making process
Focus / Intended to support	• Supports process, data flow and work flow modeling to serve the needs of both business and technology analysts. Enterprise • Modeling provides a mechanism for capturing key business knowledge while increasing collaboration, improving productivity and quality, and guiding the application development process.	• ERP systems typically handle the manufacturing, logistics, distribution, inventory, shipping, http://en.wikipedia.org/wiki/Invoiceinvoicing, and accounting for a company.	• High-volume operational decisions whose criteria are typically subject to frequent changes and/or are complex (i.e. loan approval, insurance underwriting, and multi-channel personalization)
Typical Application Areas	• Can be used for process improvement, Six Sigma, quality initiatives, strategic planning, process documentation, enterprise architecture and UML Modeling.	• Enterprise Resource Planning or ERP software can aid in the control of many business activities, like sales, delivery, billing, production, inventory management, quality management, and human resources management.	• Finance, supply chain, sales and marketing, compliance, fraud prevention, manufacturing
Enabling Technologies	• Uses an integrated set of intelligent tools and methodologies. Also can include data collection and exchange capabilities, as well as simulation and analytics.	• ERP software attempts to integrate all departments and functions across a company onto a single computer system that can serve all those departments' particular needs.	• Rule-based systems sometimes in conjunction with predictive analytic models; supplemented by data warehousing, business intelligence and data mining

Table 20: Overview of Several Classes of Enterprise Information Systems (continued)

	BI / DSS	EIS	Management Flight Simulators
Definition	• Operational Business Intelligence (BI) generally refers to the process of gathering, analyzing, and transforming raw financial and operational data into useable information. • Decision Support Systems (DSS) are computerized information systems that support decision making activities.	• Kaniclides and Kimble define Enterprise Information Systems (EIS) as "computerized systems designed to be operated directly by senior executive managers without the need for intermediaries. They aim to provide fast and easy access to information from a variety of sources, both internal and external to the organization. They are easily customizable and can be tailored to the needs and preferences of the individual executive using it."	• Management Flight Simulators are system dynamic models that try to create a virtual world where executives can "safely test hunches, run scenarios, and preview the impact of big and small decisions – all without major investments, public embarrassments, and competitive backfires."
Function	• Real-time automated event monitoring and alerting; primarily supports human decision-making and some closed-loop processes	• EIS systems gather data from internal and external systems into s a standard format. The data is then presented, usually using a dashboard through a corporate Intranet or the Internet.	• Management Flight Simulators allow managers to test business strategies and experiment with alternative decisions in a simulated business environment before committing resources
Focus / Intended to support	• Assists executives and line managers with operation, day-to-day decision making with alerts to key events	• EIS systems manage data to give executives a complete view of products, customers, services and resources.	• Intended to support executives and managers to allow them to safely test the impact of big and small decisions.
Application Areas	• Executive dashboards: provide at-a-glance analyses • Supply Chain: order/delivery status, customer order tracking • Customer Service: contact center operating status, capacity planning	• Gathers and translate data you're your marketing, operations, and financial systems and databases into standard, compatible formats and presents the information in a dashboard environment.	• Used for strategic planning and decision-making.
Enabling Technologies	• Event notification, database triggers, and broadcast servers in support of data warehouses, BI query, OLAP, and reporting and embedded analytics	• The emphasis of EIS is on graphical displays and easy-to-use user interfaces. They offer strong reporting and drill-down capabilities.	• Features can include dynamic functions, arrays, sensitivity analysis, data handling, optimization and application interfaces.

4.6.4 Current Systems Support for Strategic and Operational Processes

The information systems profiled in the previous section were analyzed to determine whether or not they are capable of support both strategic and operational layer processes. A brief description of each is provided, the mapping of the capability of these systems to support strategic and operational processes, respectively, is presented in Table 21.

Table 21: Processes as Supported by Information Systems

Strategic Process	Process Attribute (s)	EM	ERP	EDM	BI/ DSS	EIS	MFS
Situation Assessment	The CEO gathers data and information from multiple sources to acquire a holistic perspective of the enterprise				X	X	
Setting Vision, Strategy, Strategic Direction	Based on this perspective, the CEO sets/ refines the vision of the enterprise; strategic direction is an artifact of his vision						
Strategic Decision Making	Decisions that affect the direction of the enterprise, not tactical, day-to-day operational decisions	X					X
Recruiting	This process entails the retention and/or recruiting of key managers and employees necessary to accomplish stated business goals and objectives						
Retention Incentive/Reward System	The process of rewarding executives and employees for achieving key business goals and objectives. Typically in the form of cash bonus and/or the granting of stock options.						
Operational Process	**Software-Based Process Attribute (s)**	**EM**	**ERP**	**EDM**	**BI/DSS**	**EIS**	**MFS**
Project And Program Management	Monitor and control project data, evaluate projects, and design-to-cost engineering in order to optimize product costs	X	X		X		X
Supply Chain Management	Planning and execution capabilities to manage enterprise operations. Desired result is improvements through cost reductions, service-level increases, and productivity gains	X	X	X	X	X	X
Finance / Financial Management	Accounting, financial, and management reporting. Usually includes internal controls and documentation of all financial processes and transactions	X	X	X	X	X	X
Customer Service/ Quality Assessment	Monitor financial trends, costs, revenues, contracts and operations per customer	X	X	X	X	X	X

As is already deducible in Table 21, it appears that systems are seldom capable of reaching beyond the operational layer into the strategic layer.

4.6.5 Summary of Information Technology and Information Systems

Section 4.6 we highlight a sampling of IT and IS used by an enterprise and describe the extent to which these systems may have utility in supporting both strategic and operational layer processes. It is shown that current enterprise information systems appear to have more utility for operational versus strategic layer processes. This analysis highlights a gap between those information elements that are capable of being represented, versus what needs to be represented, in order to facilitate the execution of strategic layer processes. The ultimate validation of the requirements for such systems emanates from executives whose mandate it is to lead and manage the enterprise.

The next four Chapters of the dissertation are briefly described. Chapter 5 introduces a novel conceptual model that extends our ESA. Chapter 6 addresses transformation in the context of the aerospace and defense industry. Building on the theoretical and practical support provided in Chapters 2-4, we argue that the dimensions of this transformation should mirror the dimensions of our ESA that was introduced in Chapter 4. Chapter 7 describes the research design and methodology we used to empirically validate the aforementioned ESA dimensions. Chapter 8 presents a discussion of the results obtained from a series of focused interviews and a web-based expert survey instrument that was conducted with executives from the aerospace and defense industry to:

- Comment on the notion of a strategic layer;
- Comment on what happens (strategic processes) within such a strategic layer;
- Provide specific input as to what information / knowledge they feel is needed to support strategic layer processes;
- Articulate where they now get data and information upon which their decisions are based.

The notion of how strategic layer processes, supported by information technology-based systems may move the enterprise toward projecting its future end state at a specific point in time is explored in great detail. The current approach of trying to extrapolate (future) enterprise states from "lagging" indicators such as financial variables, and from transaction-based data at the core of the business process layer was shown not to be viable (see Chapter 2).

Rather, information systems that provide the executives with the capability to predict its future state rather that just assess its current state should lead to a better understanding of the underlying dynamic characteristics of an enterprise. This in turn, should provide a more robust understanding at multiple levels of abstraction that can lead to better executive decision-making capability. Taken in the aggregate, better strategic decision making and execution of strategic layer processes may improve enterprise performance, as well as reduce enterprise failure rates.

CHAPTER 5:
CONCEPTUAL FRAMEWORK AND HYPOTHESES

5.1 Introduction

This Chapter builds upon the ESA that was presented earlier in Chapter 4. The conceptual framework presented in section 5.2 extends the ESA by adding dimensionality to the architecture. Each of these four broad dimensions are discussed in more detail: (1) enterprise processes, (2) technology-based support of enterprise processes and enterprise architecture [denoted information systems], (3) technology structure and deployment [denoted information technology], and (4) enterprise architecture. Finally, in a new approach, the four dimensions of our ESA are considered collectively to produce an overarching dimension for analysis, ESA maturity.

5.1.1 The Concept of Maturity

Nolan (1973, 1979) made one of the first attempts to characterize IT in the context of enterprise adoption. His "stages of EDP growth" model describes an evolutionary adoption process that could be used by executives to identify and plan various stages of IT systems growth as a function of time. Of primary importance in this model was its attempt to explain the fundamental relationship between a stage of growth, and its preceding and successive stages. However, as with most research efforts that are at the vanguard, some questioned the model's empirical validity (King and Kraemer, 1984).

The most notable contribution of the model relative to our research was the concept of an enterprise's "maturity". Nolan confined his definition of maturity to the evolution of computer-based information systems, regarding maturity as simply "the ultimate stage

65

of computing growth in an enterprise". Consequently, Nolan's definition of IS maturity refers to a state whereby computer-based information systems are fully integrated, and information resources are fully developed.

5.1.2 Maturity Models

The concept of maturity models is not novel to either the academic or practitioner communities. Currently existing maturity models can be broadly classified by the following focus areas: (1) assessing an enterprise's software development process and competence, (2) assessing an enterprise's range of engineering processes and, (3) assessing architectural and related process improvements that are feasible based on the architecture. The phase-of-growth framework (see Chapter 2) is also reviewed in this context.

In this section, we briefly highlight and summarize the key aspects of existing maturity models / frameworks as they apply to our research. The broad foundation derived from this review was instrumental in coalescing our thinking about how to develop and refine our conceptual framework for an analysis of ESA maturity.

Capability Maturity Models (CMM)

The primary, holistic instantiation of Nolan's theory was in encapsulated in the notion of architecture maturity, which was first introduced by IBM (IBM, 1987). In the early nineties, it was extended and elaborated in terms of Capability Maturity Models (CMM). CMMs represent a formalism to gain control over and improve IT-related process, as well as to assess an enterprise's software development competence (Paul, et at, 1995). Much in the same manner that Nolan's model has been widely cited as providing the theoretical foundation for the characterization of IS maturity, CMM is used here as the theoretical foundation for the characterization of ESA maturity.

Broadly, CMMs refer to a process improvement approach that can be used to assess an enterprise on one of five process maturity levels. It was derived from the capability maturity matrix, which was an approach to improve manufacturing processes towards "zero defects". The working assumption was that the net business value would be greater if the number of defects were reduced. The Software CMM by the Software Engineering Institute (SEI) at Carnegie Mellon University is perhaps the best known of the CMMs. Their framework measures eighteen key processes for software engineering that entails requirements management, quality assurance, etc., and presents a five-stage approach for improvement as a function of time.

The newest instantiation of the CMM, CMM Integrated (CMMI) is a process improvement framework used by enterprises to improve their ability to build and maintain quality engineering products and services. The framework defines a set of objective standards for assessing an organization's full range of engineering processes. It is also a set of best practices that addresses productivity, performance, costs and integration of traditionally separate organizational functions. The highest level achieved by the model, level 5, connotes that the enterprise is deemed a high performance, 'learning enterprise'.

However, problems exist with CMMs (Cross, 2006). First, some organizations, particularly those in the aerospace and defense industry, regard the CMM process as an end state and create huge bureaucracies in order to manage the processes which, in turn, stifles creativity and innovation. Second, since a CMM rating may be tied to winning contract awards from the federal government, attainment of the rating itself may supplant an enterprises' commitment to process improvements over the longer turn.

National Association of State Chief Information Officers (NASCIO)

The NASCIO Enterprise Architecture Maturity Model provides a path for architectural and procedural improvements within an enterprise and across agency boundaries. At a high level, the components of the model include architecture governance, business architecture, and technology architecture. They are mapped across five stages of maturity that closely conform to SEI's CMM.

Extended Enterprise Architecture Maturity Model (E2AMM)

This model attempts to prescribe a path for architectural and process improvements. The E2AMM extends the CMM in that, at its fullest maturity, enterprise architecture becomes an extended-enterprise concept. In its ultimate stage of maturity, the infrastructure allows for information flow from enterprise to enterprise (Schekkerman, 2004). In a similar manner, but focused predominantly on Enterprise Resource Planning (ERP) systems, Holland and Light (2001) proposed a staged maturity model that contemplates three stages of maturity, and is based on five theoretical constructs. The purpose of the model was to provide a road map for understanding the evolution of ERP systems in enterprises. Once again, the model closely parallels the CMM.

Phase-of-Growth Model

Our phase of growth model is another form of maturity model. It provides for an integrated understanding of how emerging enterprises either transform into high performance organizations or fail. The model explores some of the elemental functions that need to be completed in order to evolve the enterprise, as well as the characterization of those functions in terms of their uncertainty, dynamics, and nonlinearities. In its final phase of growth, the enterprise attains business maturity.

5.1.3 The Need For Enterprise Maturity Assessment

As was identified in Chapter 4, information technology-based systems are used in virtually all aspects of an enterprise. As the enterprise evolves as a mature business, they have the potential to become a cross-cutting enabler, or inhibitor, of transformation of various kinds. Consequently, the implementation plan for such systems is often a critical element of an enterprise's overall strategy. Of primary importance, however, is how an enterprise's chosen information systems interact with, are coupled to, and support its enterprise processes.

In order to minimize associated risks and maximize potential benefit of such interactions, an assessment of overall ESA maturity would assist the enterprise in understanding the following:

- Structure and Deployment of its Information Systems:
  - Identify deficiencies in how system properties / maturities are related;
  - Improve integration and interoperability;
  - Speed the implementation of new systems via "spiral development", based on having technologies / systems, and associated skills and learning in place

- Efficiency:
  - Lowers support and cost as the number of deployed systems are reduced;
  - Reduces complexity as it reduces the total number of components and; processes, thereby improving control
- Enterprise Performance:
  - Understand how the maturity level of each dimension of the ESA (described later in Section 5.2); i.e., process, IS, IT, and enterprise architecture, contribute to and impact enterprise performance;
  - Understand how, taken collectively, the maturity of these dimensions might be used as a predictor of future performance

5.2 Conceptual Framework

As was previously mentioned, the concept of maturity has been addressed in both the academic and business press literature. While various models have attempted to measure such things as software development competence, engineering processes, and IT maturity, such analyses have been conducted discretely and in isolation from one another. The concept of maturity of an entire enterprise system, in the context of our ESA, has not been addressed in either the academic and business press literature. We propose that, in a general sense, such a concept can be used as a predictor of enterprise performance. In a later chapter, we report a test of this hypothesis.

We also assert that, in attempting to assess the maturity of an entire enterprise system, several dimensions of the system must be considered contemporaneously. Figure 26 portrays each of the four dimensions: enterprise processes, information technology, information systems, and enterprise architecture.

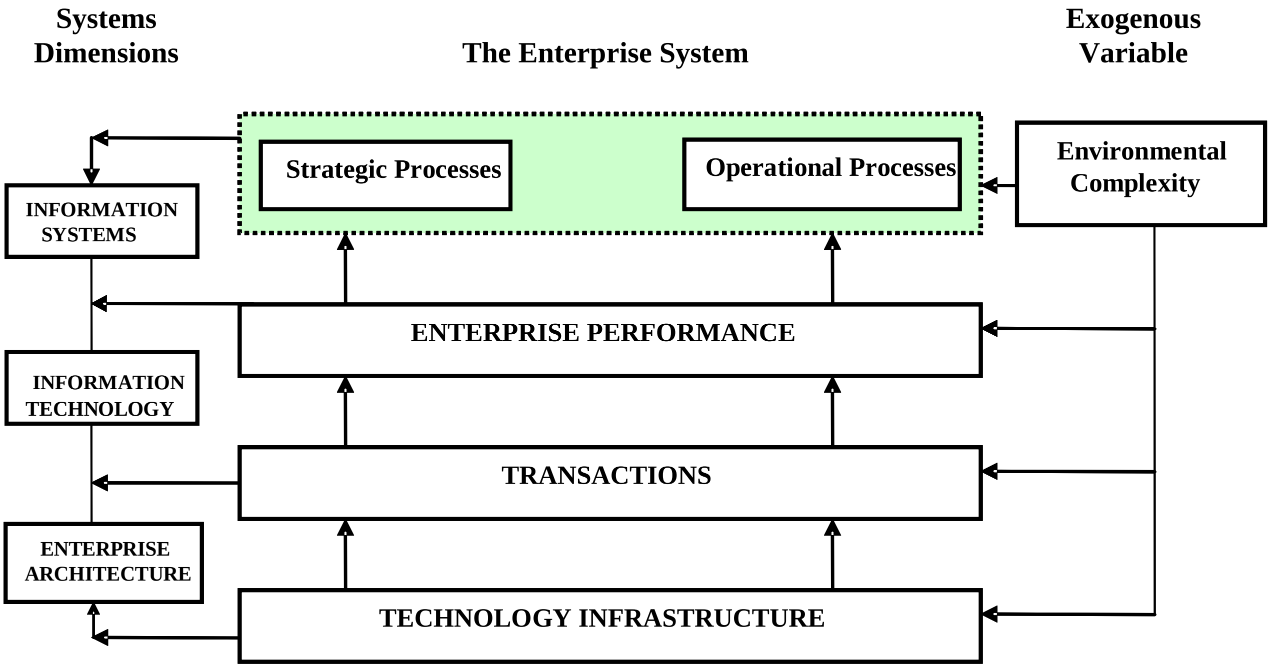


Figure 26: Conceptual Framework and ESA Dimensions

The conceptual framework and subsequent analysis is based on a broader architectural view of an enterprise as a system-of-systems. The framework was designed to be broad in scope in order to both reflect the scale and complexity of an enterprise system, and provide a general understanding of existing relationships at the macro, enterprise level. The chosen method of analyzing each dimension of the ESA (see Chapter 8) was intended to provide high level guidance rather than a detailed assessment of process, IT, and IS characteristics. This limits our methodological approach from providing design level guidance. However, the research was undertaken with the intent of conducting a macro-level analysis that investigates relationships in and among complex, amorphous, "messy" variables such as information technology, information system, and enterprise processes, respectively. It was reasoned that such an approach may provide the appropriate context and groundwork for future work; specifically, a more in-depth analysis of discrete sub-components of each relationship hypothesized in the model. The following questions emanate from the framework depicted in Figure 26.

In the context of an ESA, what is the relationship between strategic processes and operational processes?

- Can the relationship between strategic / operational processes be linked to enterprise performance?
- What is the link between enterprise system architecture and information systems?
- How is enterprise performance affected by the interaction between the maturity of its information systems, and the maturity of its IT infrastructure?
- What, if any, is the correlation between enterprise system architecture maturity and enterprise performance?

5.3 ESA Dimensions and Proposed Relationships

Building on and extending the literature reviewed in Chapter 3, theoretical and practical support for each of the four ESA dimensions is provided in the following sections.

5.3.1 Enterprise Processes

As described earlier in Chapter 3, business processes involve tasks and activities intended to achieve a stated business objective. Functionally, they represent a collection of related activities that work in concert to create something of value to the enterprise, its customers, and its stake holders in general. In the aggregate, the goal of such processes include, but is not limited to the improvement of efficiency of its operations, improving quality, reducing costs, and reducing the time it takes to get its products to the marketplace. One way to think about processes is that strategic processes make sure one does the right things; operational processes focus on doing those things correctly.

Proposed Relationships:

Of particular interest to us is the relative maturity level of processes, both strategic and operational, within an enterprise system. It is argued that process maturity exists when a palpable difference between strategic and operational processes is recognized in and among enterprise executives. The other components that constitute process maturity are depicted in Table 22.

Table 22: Measures of Process Maturity

	Enterprise Processes (Measurement of Process Maturity)
H1(a)	Strategic layer processes and operational layer processes are different.
H1(b)	Strategic and operational processes that are tightly coupled will have a positive relationship with enterprise performance.
H1(c)	The use of capability / process maturity models will not have a positive relationship with enterprise performance.
H1(d)	The use of capability / process maturity models will not have a positive relationship with the use of mechanisms to link business operations to strategy.
H1(e)	The level of process maturity will be greater among high performing enterprises than among low performing enterprises.

5.3.2 Information Technology and Information Systems

Prior to describing research efforts into the dimensions of information technology and information systems, some differences between the two are important to note. Information systems are taken as a particular type/class of work systems that use information technology to perform a variety of functions; store, capture, transmit, retrieve, or display information in support of other work systems. Categories of such systems as they pertain to specific functional areas of an enterprise include product design systems such as Computer Aided Design (CAD), supply chain management systems, and various manufacturing, sales, and marketing systems. Information technology is taken as the 'backbone' such systems, being comprised of devices, physical objects, and software involved in the processing of information. We do not infer information technology to involve an enterprise's information technology department or people who work in that department.

The wide proliferation of information technology and associated information systems has enabled enterprises to improve business operations and create opportunities for growth through higher levels of efficiencies (Basole and Demillo, 2006). It has also enabled them to seek and maintain greater levels of competitive advantage in their chosen markets.

Consequently, it is not surprising that information technology research and its impact on the enterprise is has been widely studied and is well documented. Some researchers have attempted to establish causal relations between prerequisites for use, such as technical quality, information quality, and use, user satisfaction, and impact (DeLone and McLean 1992); others have concentrated on the relationship between user participation and use, or other indicators of system success Hartwick and Barki (1994); examples of both quantitative and qualitative efforts are noted McKeen et al. (1994); Tait and Vessey (1988); Hirschheim (1985); and Westelius (1996). For these researchers, the prevailing view of computerized information systems was that of a technical construction used by people within the enterprise.

Others followed Nolan's theoretical foundation (Section 5.1.1). Several studies characterized organizational information systems, and identified different criteria of systems "maturity" or "sophistication" (Cheney and Dickson, 1982; Saunders and Keller, 1983; Gremillion, 1984; Mahmood and Becker, 1985; Raymond and Paré, 1992). Among others, Cheney and Dickson (1982) investigated the relationship between what they defined as "technological sophistication" (hardware and software systems, nature of application systems), "organizational sophistication" (information resources management activities) and system performance. One of their most important results was that user performance appeared to be very much influenced by organizational sophistication, but not much by technological sophistication. (Pare and Sciotte, 2001). Also, within the IS usage perspective, Saunders and Keller (1983) referred to IS maturity as the "sophistication of the mix of applications provided by the IS function", focusing more on the nature, content and structure of the information provided. Raymond and Paré (1992) defined IT sophistication as a multi-dimensional construct which includes aspects related to technological support, information content, functional support, and IT management practices.

Other researchers attempted to broaden Nolan's definition, and expand the context of its use (Pare and Sicotte, 2001, Srinivasan and Kaiser, 1987, Raymond, 1988). They developed different formalizations of 'sophistication' using largely overlapping criteria in their respective definitions. Their analyses included variables approached from two perspectives of IS usage: (1) IS management; to include organization, planning, and control of the enterprises' IS and, (2), IS usage, to include the type of technology used and general nature of its functionality. Table 23 provides a brief synopsis of a sample of some of these studies.

Table 23: Theoretical Concepts Associated with IT

Author(s)	Research Concept	Year
Bergeron, and Rasymond	Relationship between IT and business performance	1995
Bergeron, Raymond, Rivard	Organizational theory view of fit and contingency theory	2000
Croteau and Bergeron	Links between strategy, how technology is deployed throughout an organization, and performance	2001
Palanisamy	Models of information systems to enable organizational flexibility	2004
McAfee	Full explication of categories of IT, management involvement, and possible impact on performance	2006
Pare and Sicotte	IT sophistication; the impact of computer-based information systems and organizational performance	2001
Steghuis, Daneva, and van Eck	Correlating enterprise systems usage maturity and architecture maturity for business IT alignment	2004
Raymond, Pare, Bergeron	Looked at organizational structure (sophistication) and IT (sophistication) impacts on performance	1995
Rathnam, Johnsen, Wen	Misalignment of gaps between IT strategy and business strategy	2005
Versteeg, Bouwman	Present a business architecture concept that relates business strategy to IT	2006

However, much as Nolan's definition of maturity was confined to computer-based information systems; the aforementioned formulations were also limited in that only one or two variables were used as indicators of IT sophistication (Pare and Bergeron, 1994). Consequently, both the validity of the construct and the amount of variance that might be explained by these studies is limited (Weil and Olson, 1989). None consider the dimensions of IT and IS at the same time. Further, none consider them as part of a larger measure of maturity.

Proposed Relationships

Many characteristics can be used to describe the robustness of an enterprise's technology infrastructure, which includes both information technology and information systems. Of particular interest to our research is: (1) the extent to which current information systems support enterprise business processes and, (2) the extent to which a given level of support is a function of how technology is structured and deployed throughout the enterprise. We assert that structure implies enterprise architecture; consequently, it is considered as a distinct dimension of our ESA. Collectively, these proposed relationships are entitled: "Technology Structure and Deployment" and "Enterprise Architecture". Information technology and enterprise architecture are, themselves, maturity measures.

Given the criticality of technology infrastructure for today's enterprises, it is postulated that: (1) technology-based support of enterprise processes, a measure of IS maturity, is a contributor to overall enterprise performance and, (2) technology structure / deployment, a measure of IT maturity, is also a contributor to overall enterprise performance, as is EA maturity. Proposed relationships for information systems, information technology, and enterprise are depicted in Table 24 and Table 25, respectfully.

Table 24: Proposed Relationships for Information Systems

	Technology-Based Support of Enterprise Processes (Measurement of IS Maturity
H2(a)	IS and support of strategic layer processes will have a negative relationship with each other.
H2(b)	IS and support of operational layer processes will have a positive relationship with each other.
H2(c)	IS support of operational layer processes will be greater among high performing enterprises than among low performing enterprises.

Table 25: Proposed Relationships for Technology Structure / Deployment

	Technology-Structure / Deployment (Measurement of IT Maturity)
H3(a)	The level of IS maturity will be greater among high performing enterprises than among low performing enterprises.
H3(b)	The level of IT maturity will be greater among high performing enterprises than among low performing enterprises.
H3(c)	Enterprise technology deployment / structure[1] and information system maturity will be greater among high performing enterprises than among low performing enterprises
	Enterprise Architecture / Deployment (Measurement of EA Maturity)
H3(d)	The level of EA maturity will be greater among high performing enterprises than among low performing enterprises.

5.3.3 Enterprise System Architecture Maturity

Given that each dimension of our ESA may have an influence on and interact with each other, they must be considered as a whole. This constitutes the major motivation for the development of assessing the maturity of the ESA in its entirety. Recall that the purpose of constructing a high-level ESA, among others, is to highlight opportunities for efficiency improvements within the enterprise, as well as to serve as a mechanism to improve alignment between various enterprise system dimensions. We also assert that ESA is a predictor of enterprise performance. ESA maturity is taken as the linear combination of the four dimensional maturities (see Chapter 8):

$$\text{ESA}_{\text{Maturity}} = \alpha_1 \, Process_{Maturity} + \alpha_2 \, IT_{Maturity} + \alpha_3 \, IS_{Maturity} + \alpha_4 \, EA_{Maturity}$$

The testable articulation of the relationships embodied in the ESA is presented in Table 26 while the ESA dimensions that constitute ESA maturity are highlighted in yellow in Figure 27.

1 Enterprise technology deployment / structure = IT maturity.

Table 26: Proposed Relationship for ESA Maturity

	ESA Maturity
H4	The level of ESA maturity will be greater among high performing enterprises than among low performing enterprises.

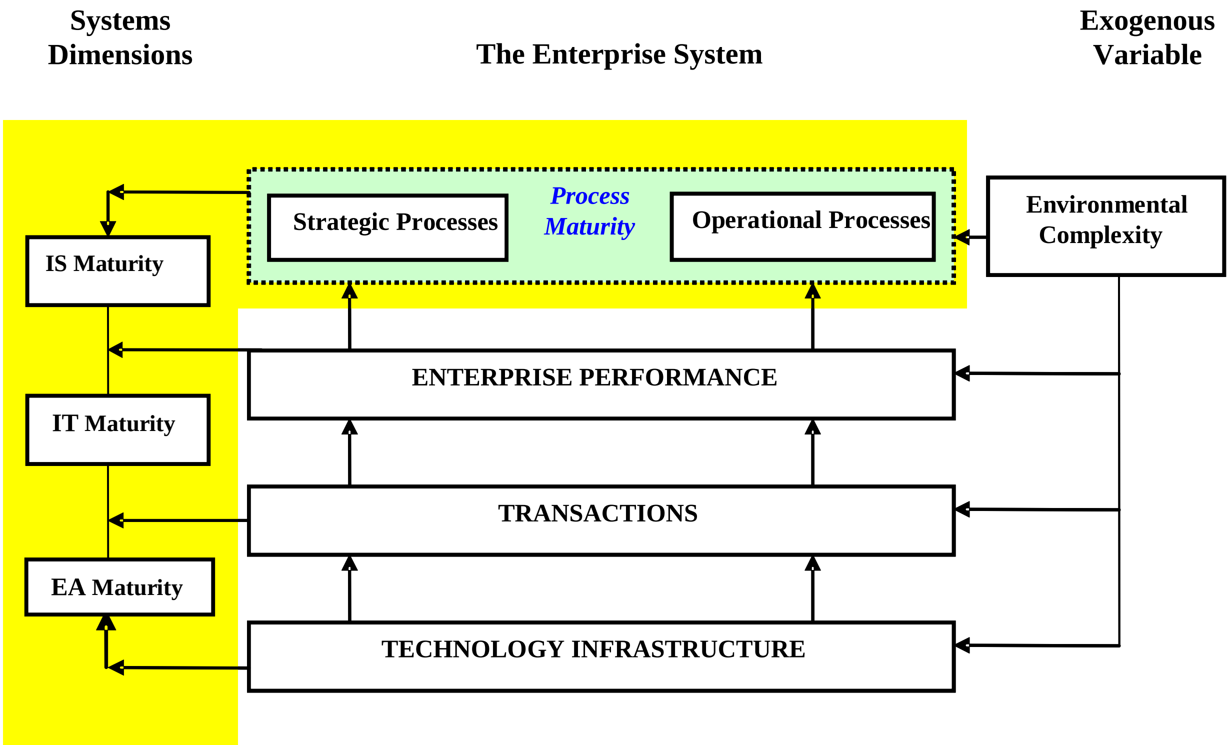
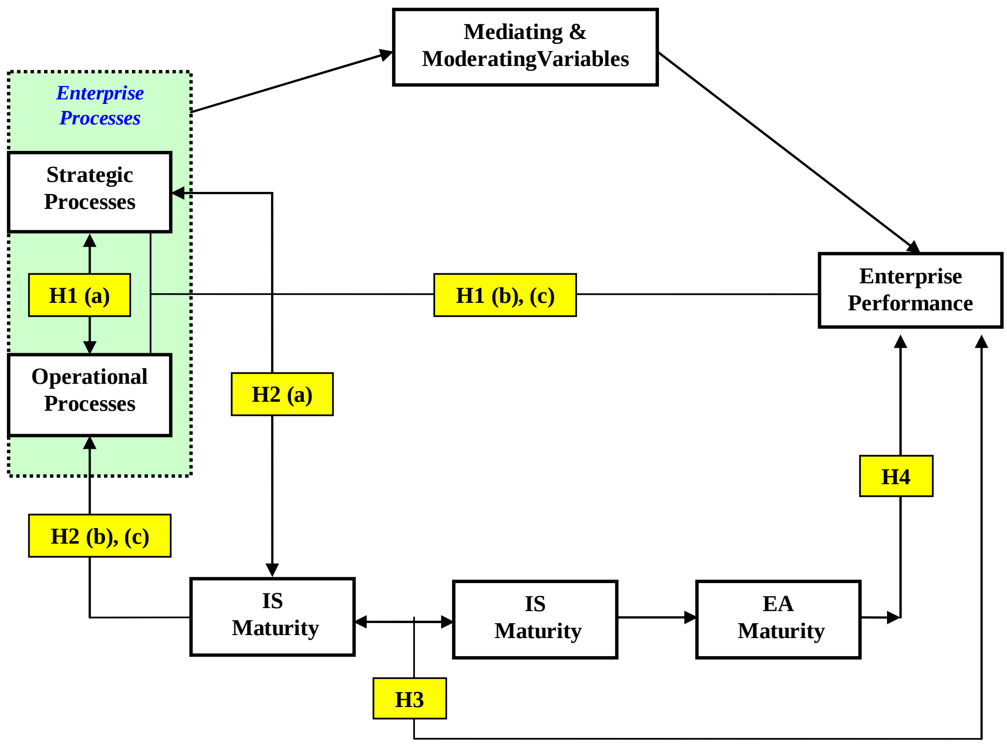


Figure 27: Dimensions of ESA Maturity

It should be noted that each of the four dimensions of the ESA are, themselves, maturity measures. As such, we do not assess the maturity of the dimension; rather, we determine the value of each dimensional maturity and assess its impact as a predictor of enterprise performance (see Chapter 8).

5.3.4 Relationship Model

The relationship model is depicted Figure 28. It articulates our proposed relationships between enterprise processes, the maturity of an enterprise's information systems, information technology, enterprise architecture, and enterprise performance respectively. It should be noted that each of these relationships, and the conceptual



framework into which they are incorporated, emanate from our ESA.

Figure 28: Research and Relationship Model

5. 4 Summary

The proposed relationships that pertain to each ESA dimension and the maturity of the ESA in the aggregate, represent testable articulations of the relationships that have been postulated in previous theoretical discussions. This chapter describes and expands upon the novel concept of ESA maturity.

Initially, the importance of an enterprise maturity assessment was described as having three benefits to the enterprise: (1) from an enterprise structural perspective, deficiencies in how system dimensions are related can help improve integration and interoperability, (2), from an efficiency perspective, to help lower requirements for support and cost as the number of deployed systems are reduced and, (3) from an enterprise performance perspective, Understand how individual maturities; i.e., process, IS, IT, and enterprise architecture, contribute to / influence performance. We note that, at a strategic level, efficiency does not always dominate. As Peter Drucker said, *"You should never try to get really good at something that you should not be doing at all."*

Next, based in part on the theoretical background provided in Chapters 2-4, we introduce our multi-layer, multi-dimensional conceptual framework and assert that it consists of four dimensions: (1) enterprise processes, both strategic and operational, (2) information systems, (3) information technology, and, (4) enterprise architecture. Each can be assessed using several indicators specific to each dimension that are supported by both theory and practice (see Chapter 8). We note that, since each dimension of the ESA may have an influence on and interact with each other, they must be considered as a whole. This constitutes the major motivation for the development of a method to assess the maturity of an ESA, in its entirety.

The following Chapter discusses the context for our study the aerospace and defense industry sector. A synopsis of our research design and the data collection methods used to empirically validate the dimensions herein described is presented in Chapter 7. Chapter 8 discusses the key findings from both our qualitative and quantitative analyses.

CHAPTER 6:
THE AEROSPACE AND DEFENSE INDUSTRY

6.1 Introduction

While relatively new, the aerospace and defense sector has been in the midst of a large-scale, dynamically complex transformation for the past decade. Such a transformation represents substantial change, the magnitude of which can be extraordinarily difficult to successfully effectuate. In the face of such transformation, this Chapter focuses on DoD's ability and capacity to anticipate and respond to changes in its force structure induced by macro-level forces that include, among others: (1) significant consolidation of its industrial base, and (2) the new strategic environment; specifically, the Global War on Terrorism (GWOT) after the events of September 11, 2001, and (3) the largest Base Realignment and Closure (BRAC) in military history.

This Chapter provides, at a high-level, an understanding of the macro and micro-level forces impacting the aerospace and defense industry, and how these forces are shaping the manner in which enterprises in both the public and private sectors respond in terms of enterprise architecture, processes, and technology/systems to support these processes. The Chapter begins with a review of the priorities as outlined by the DoD. While at times it can be difficult to discuss this huge institution as a whole, the DoD's 2006 Quadrennial Defense Review (QDR) report, which defines the most important security threats facing the United States, is good assessment of the Department's priorities (U.S. DoD, 2006). In short, the QDR defines the Department's official roadmap for military and security priorities over the next four years; however, more importantly, it also serves to shape future defense policy which could last through the next decade. The 2006 QDR was the first QDR that incorporated the initial years of what the government has called the GWOT, also referred to the "long war."

6.1.1 Background and Overview

The aerospace and defense industry is a relatively new industry, even though arms manufacturers and purveyors of such arms can be traced for centuries (Rouse, 1996). The roots of today's modern defense industry began around the advent of World War I, were massive armies were mobilized and equipped for combat operations. While the industry's structure was almost totally dismantled after the war, it was rekindled for World War II. In fact, the defense industrial base was significantly expanded as a function of unused capacity in the wake of the Great Depression. Unlike in the aftermath of World War I, military strategy shifted away from a complete dismantling of the industry. The post war strategy entailed maintaining a mobilization capability for two reasons: (1) fear that the development of nuclear weapons would proliferate beyond the U.S., and (2) the possibility of another large scale global war. Once the Cold War ended in the late 1980's, however, there was strong domestic pressure to both dramatically reduce the size of the defense industrial complex, and maintain what was, at that time, the status quo. Since then, and including the first Gulf War in the early 1990's, consolidation has been a way of life in the aerospace and defense industry.

The DoD is the largest single line item of the federal budget. It is charged with coordinating and supervising all agencies and functions of the U.S government relating directly to our national security and the military. It also is clearly an industry in the midst of a dramatic transformation in order to respond to a complex strategic environment that demands greater integration of forces, organizations, and processes. This continues to have a huge impact on those private and public enterprises that serve it, particularly acute as the DoD shifts its emphasis from ships, tanks, etc., to focus on information, knowledge, and timely, actionable intelligence.

6.2.2 Classification by Industry Segment

As was described earlier, the aerospace and defense sector is the largest in terms of budget; it also spans a broad range of industry sub-sectors that are depicted in Figure 29.

Defense Systems

- Airframes
- Marine / Land Systems
- Missiles / Space Systems
- Ordnance
- Sub-Assembly

Defense Electronics

- Avionics Systems
- Communication Systems
- Electronic Systems
- Electronic Warfare
- Sensors and Radar

Government IT Services

- Database Management
- Information Assurance
- Software Development
- Systems Integration
- Training & Simulation

Aerospace

- Avionics / Instrumentation
- Cabin Management
- General Materials
- Operational Components
- Structural Components

Technical Services

- Engineering Services
- Facility Management
- Logistical Support
- Physical Security
- Research & Development

Security Services

- Background Screening
- Biometrics
- Physical Security
- Specialized Services
- Surveillance / Monitoring

Figure 29: Classification by Industry Segment

Large and small private and public companies serve those industry sub-sectors of the defense market described in Figure 29. Those that dominate the market sector in terms of enterprise size and contracts with the DoD are, themselves a small group of publicly traded companies which includes Boeing, General Dynamics, Raytheon, etc. They are know as Lead Systems Integrators (LSIs) since their primary focus is assisting the DoD and federal government in managing large, multi-year, multi-billion dollar procurements.

6.2 Macro-Level Market Forces

A number of forces are shaping the behavior of those enterprises that comprise the defense industrial complex. Some of those include: (1) the global war on terror, (2) transformation of the DoD, and (3), consolidation of the industrial base. Each are briefly described as follows.

6.2.1 The Global War on Terror

U.S. defense strategy is increasingly focused on porous boundaries between political, economic, and military domains. Our enemies are no longer nations or countries supported by large military forces but rather small groups or individuals who seek to harm our country politically and economically through asymmetric threats; i.e., small but deadly assaults that are carried out by enemies who are not tied to a country or nation-state. These emerging threats are compounded as a result of rapid technological advances and the impact of globalization in the early 21st Century.

As a result of the events of September 11, 2001, a paradigm shift in national security occurred based on the emergence of a global, yet internationally fragmented new enemy; a strategic split between conventional and non-conventional capabilities for the DoD. Figure 30, adapted from the 2006 QDR, illustrates the division between conventional and non-conventional engagement scenarios facing our military today.

Engagement Scenarios

Actors (Distinction getting blurred)	Conventional	Non-Conventional
State	Air, sea and land conflict after breakdown of diplomacy: Engagement with uniform soldiers. Examples: Nuclear Arms Race, Gulf War, Afghanistan, Invasion of Baghdad.	Combating counter-insurgent fighters, state-sponsored terrorism. Fighting enemies hiding among population, or training foreign soldiers to fight specific threats. Examples: Iraq Security Operations, Iran Containment
Non State	Low-intensity conflict against specific groups, individuals or participating in a Civil War. Examples: Bosnian Ware, Somalia, Rwanda.	Securing interests or retaliation against small-scale attacks; Fighting Ideology; Homeland protection. Examples: Stopping Al Qaeda attacks, domestic surveillance, tracking money laundering, the drug wars, border surveillance.

Figure 30: Conventional Versus Non-Conventional Security Concerns
(Adapted from the DoD QDR, 2006)

Preparation for non-conventional engagements with other groups or nations requires less emphasis on overall force strength but more strategic preparation. To meet these challenges, the DoD is in the midst of transforming its force structure into one that is more modular, with much greater emphasis on interoperability (both personnel and technological), specialized forces, and cooperation with both domestic and foreign intelligence and law enforcement agencies. Also with this shift towards non-conventional engagement, the battlefield becomes less defined and the DoD may engage these new enemies in direct or indirect ways either on a battlefield or within civilian/urban populations.

Our military, and the defense industrial base that supports it, can no longer prepare for a "cold-war-type" engagement and must transform itself into smaller, more agile, responsive, and effective units. The need to transform the Department of Defense and the U.S. Armed Forces, as well as the organizations and processes that control, support, and sustain them, is compelling. Transformation is more than just acquiring new equipment and embracing new technology. It is rather the all encompassing process of thinking creatively in order to work better together with other parts of the Department, and other agencies within the U.S. Government. It also means working better with industry to leverage new technologies and operational concepts in order to create a U.S. and coalition advantage against current and potential future adversaries.

6.2.2 Transformation Enablers

The Presidential mandate for defense transformation was "to challenge the status quo and envision a new architecture of American defense and homeland security for decades to come." The U.S. has competitive advantages in space technology, information technology, intelligence, and logistics, as well as in global economic reach. A primary focus is to ensure that we retain and capitalize upon these advantages as we transform our military forces. Those within the Department of Defense responsible for transformation are tasked with anticipating the future and, wherever possible, creating it. They must seek partnerships with both public and privately-held enterprises to develop new technologies and capabilities to meet tomorrow's threats as well as those of today.

The Defense QDR cites technology and information connectivity as the primary "force multiplier" that will allow our military services to address the current and expected onslaught of "asymmetric threats". The 2006 QDR was designed to serve as a catalyst to push the Department's transformation, adaptation, and reorientation to produce an integrated joint military force that is more agile, more rapidly deployable, and more capable against emerging threats. The QDR laid out the vision of "Net-Centricity and Net-Centric Warfare" and established this vision as the primary enabler of transformation in the Department.

6.2.3 Network-Centric Concept of Operations

Network-centric operations are characterized by the ability of geographically dispersed forces to attain a high level of shared situation awareness that is exploited to achieve strategic, operational, and tactical objectives. This linking of people, platforms, and decision, among others, into a single network creates a whole that is clearly greater than the sum of its parts. The result is networked forces that operate with increased flexibility, agility, and synchronization. In the process of transforming the way that military forces conduct operations, the result is a force that is more expeditionary, agile, and lethal than the present force, and more capable of employing operational maneuver and precision effects capabilities.

So, how does this translate to businesses in the sector? It seems logical that the net effect of large scale DoD transformation efforts, and the instantiation of that into network centric mode of operation has induced a 'ripple effect' in private industry at the enterprise level: (1) processes, (2) information technology-based and information systems, (2) structure, and (3) centralization versus decentralization of enterprise structure.

6.2.4. The Defense Industrial Complex as a System of Systems

Transformation of the defense industry is large-scale and multi-dimensional in scope. In Chapter 2, the enterprise was characterized as a complex system of systems; in Chapter 4, we introduced our ESA which consists of multiple dimensions; in Chapter 5, we noted that, since each dimension of the ESA may have an influence on and interact with each other, they must be considered as a whole in order to predict how the (enterprise) system will perform in the future. Putting all that together, both the DoD, and the enterprises that serve both it share the characteristics of a system of systems as outlined earlier in Chapter 2 and depicted in Figure 31.

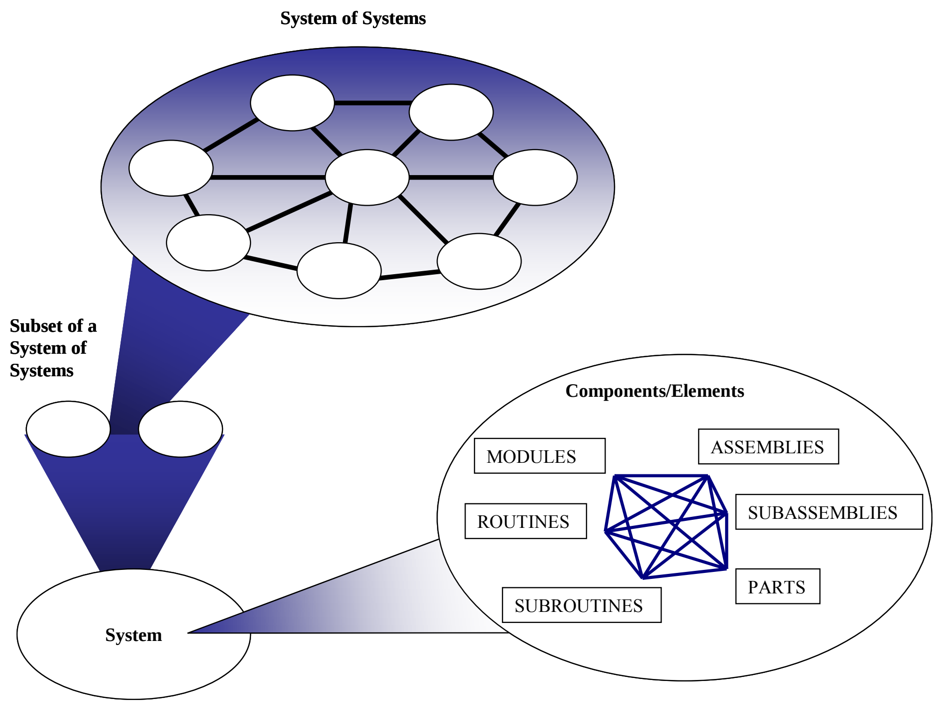


Figure 31: Hierarchy of a System of Systems
(Adapted from Krygiel, 1999)

The DoD has long recognized the importance of exchanging information and sharing services between information systems and the people who use and depend on them (Krygiel, 1999). However, dependence on a high level of interoperability of systems and information has never been more acute. Consequently, the defense department needs to transform its architectural framework and those information technology and information systems that support its underlying processes.

6.2.5 Industrial Base Consolidation

For companies specializing in engineering defense systems, the business climate has changed dramatically since the end of the Cold War. In the mid-1970s, then Chief of Staff of the U.S. Army Edward C. Meyer warned that the United States had a "hollow army." There is now more reason to fear a hollowing out of the industry upon which America's security depends. The U.S. defense industry is still by far the world's largest and most technologically proficient. The U.S. defense budget, $460 billion in FY 2006, is at least 20 percent larger than the aggregate of all its European and Asian allies.

Moreover, this budget is increasing, whereas Europe's budgets are flat or declining. The critical investment portion of the defense budget, covering Research and Development (R&D) on new weapons / weapons systems, is $73.6 Billion in FY 2006, and is growing more rapidly than the overall budget itself. General procurement and operations budgets are growing at a slower pace and forcing the LSIs to focus on providing R&D services, and selling off operational business units that are growing at a slower pace. It is not uncommon for 80% of a major defense programs to be subcontracted to a team of mid-tier contractors that often include previously divested business units.

Since the late 1980's, consolidation has been a fact of life in the defense industry as is depicted in Figure 32.

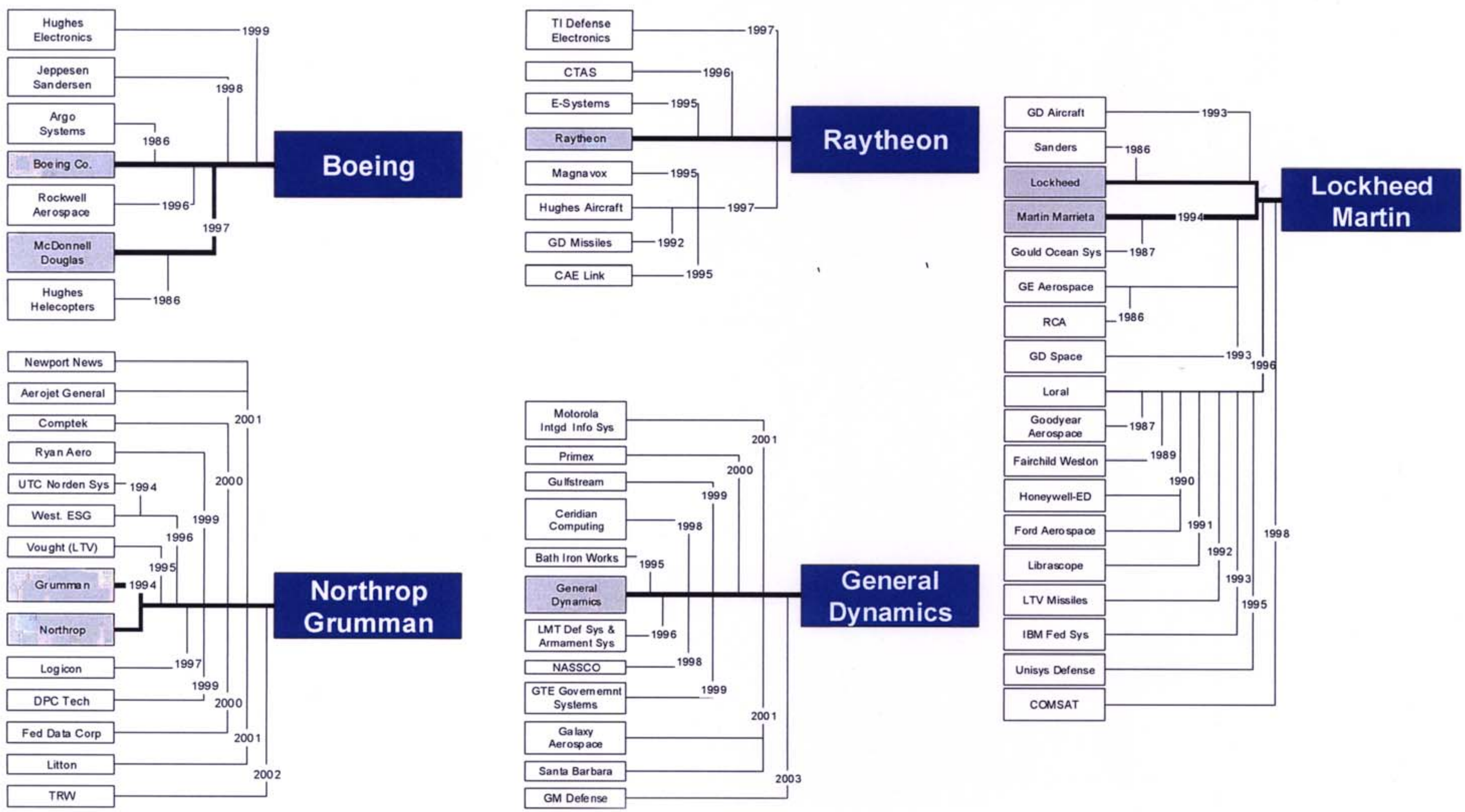


Figure 32: Examples of Defense Industrial Base Consolidation
(Source: U.S. DoD Science Board Study, 2006)

Consolidation of the industrial base into a handful of LSIs has induced challenges to the development of and fielding of systems to which, in turn, has shaped the manner in which enterprises much adapt their structures and business processes. And, it continues at a rapid pace. Since the beginning of the GWOT, Merger and Acquisition (M&A) activity within the defense technology and government services space has proceeded at a frenzied pace. Here, we divide M&A activity into two general categories: (1) government services, primarily IT services, as well as consulting and high-level engineering, (2) defense technology; i.e., military products and component equipment used primarily in military applications. Figure 33 depicts transaction volumes for the defense technology and government IT services segments from 2000–2006, but does not include all transactions conducted over the sampled term.

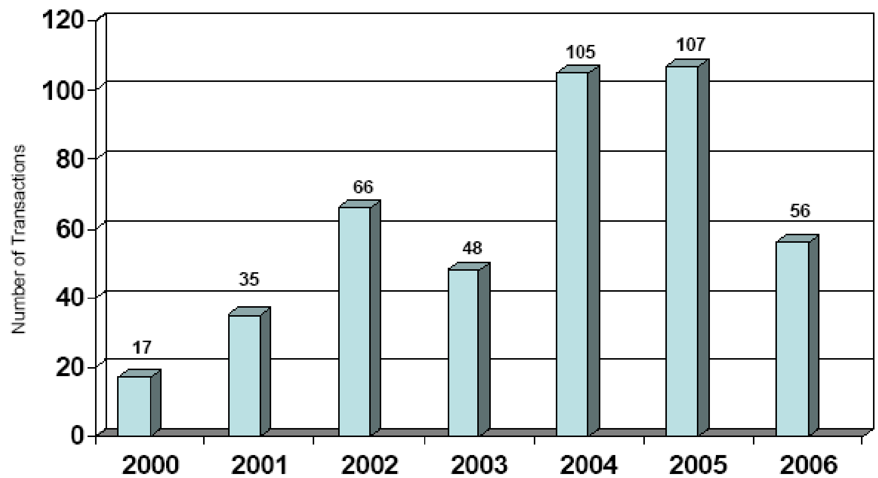


Figure 33: Government IT Services Transaction Volume
(Source: BB&T Capital Markets)

During the period, 434 government services transactions were completed. The average volume per year was 62 deals with 2005 the highest transaction year. It remains to be seen if 2005 will remain the strongest year, or if 2006 is the beginning of a downward trend in Government Services transactions. Furthermore, the largest year over year increase in transactions was noted in the time frame between 2003 and 2004, where the number of completed deals increased 119% year to year. During the period, 843 defense technology transactions were completed, almost double the IT Services rate. The average volume per year was 120 deals with 2005, again, the highest transaction year.

Furthermore, the largest year over year increase in transactions was noted in the time frame between 2004 and 2005, where the number of completed deals increased 64% year over year.

6.3 Micro-Level Market Forces

While defense transformation is the greatest driver of change and opportunity in the industry, other forces are also at work. Moving from macro-level security goals to specific DoD and industry goals, these forces are shaping the response of both DoD and cooperating agencies in order to counter new 21st century threats. Some of these forces include procurement/acquisition, rapid fielding of systems and equipment, information technology and related systems. In this context, the role of the smaller enterprise is presented and discussed.

6.3.1 Procurement / Acquisition Reform

The need to encourage greater interaction between the defense and commercial industries is vital to keeping U.S. military technology the best in the world. Many high-technology commercial products such as electronics are state-of-the-art and changing so fast that DoD's military specifications cannot keep pace. Within the past ten years, Congress has passed several important reforms, among them the Federal Acquisition Streamlining Act, Federal Acquisition Reform Act, Defense Reform Act, and the Federal Activities Inventory Reform Act. This legislation served to promote performance-based contracting, as well as the use of acquisition reform "pilot" programs to test the effectiveness of some reform initiatives. Performance-based contracting defines work to be performed in measurable, mission-related terms, in stark contrast to the previous procedure of defining the work in broad, imprecise terms through a "statement of work". This approach was intended to reduce government costs and improve contractor performance by encouraging more innovative and efficient approaches to government contracts.

In one of its latest, potentially far-reaching decisions, DoD has begun a policy of increasing the importance of "cost" as a factor in deciding on the acceptable performance level of a weapon system. It is likely to force decision-makers to consider trading away some system performance to achieve greater cost savings. The policy moves the DoD and its industrial base away from a major Cold War tenet which was to acquire the best weapons system at almost any cost. With the goal of lower costs and shorter schedules, the policy requires DoD program managers to examine the entire life-cycle of a weapons system including weapons development, production, operation and support and its cost patterns and objectives. DOD has taken steps of its own to reduce or eliminate regulatory barriers, as well as to encourage use of commercial products in military systems. In the view of many experts, however, large government contractors have had difficulty adapting to this aspect of transformation and are losing work to smaller, more nimble enterprises, discussed later in Section 6.3.4

6.3.2 Rapid Fielding of Systems

As another transformation force, rapid fielding has taken on a heightened sense of importance due the nature of military operations in Iraq and Afghanistan. Specifically, the asymmetry and irregularity of the enemy's concept of operation mandates the need to rapidly develop and field new, innovative, and transformational technologies and operational concepts. Rapid acquisition programs are in stark contrast to traditional acquisition processes that tend to be multi-year, multi-billion dollar programs spanning as much as 10-20 years in duration, depending on the system to be procured.

6.3.3 Information Technology / Information Systems

The backbone of the industry's transformation efforts is rooted in how well the defense department is successful in transforming its architectural framework and those information technology and information systems that support underlying processes. As one example, the Department of the Army has stated the following three objectives (U.S. Department of the Army, 2006) in order to transform its force structure from one that is monolithic to one that is more mobile, agile, and flexible:

- Transform the Army to a knowledge and information culture to support decision superiority and achieve the DOD vision of a net-centric environment for warfighting and business operations;

- Establish and manage the architectural framework to support transformation and to enable interoperability of Army and Joint warfighting capabilities;
- Establish governance structures and processes to effectively manage the Army's IT-based capabilities and associated investments to eliminate stove-piped systems and achieve joint interoperability
- And, the federal government is prepared to spend an unprecedented amount of money enhancing IT infrastructure as is depicted in Figure 34.

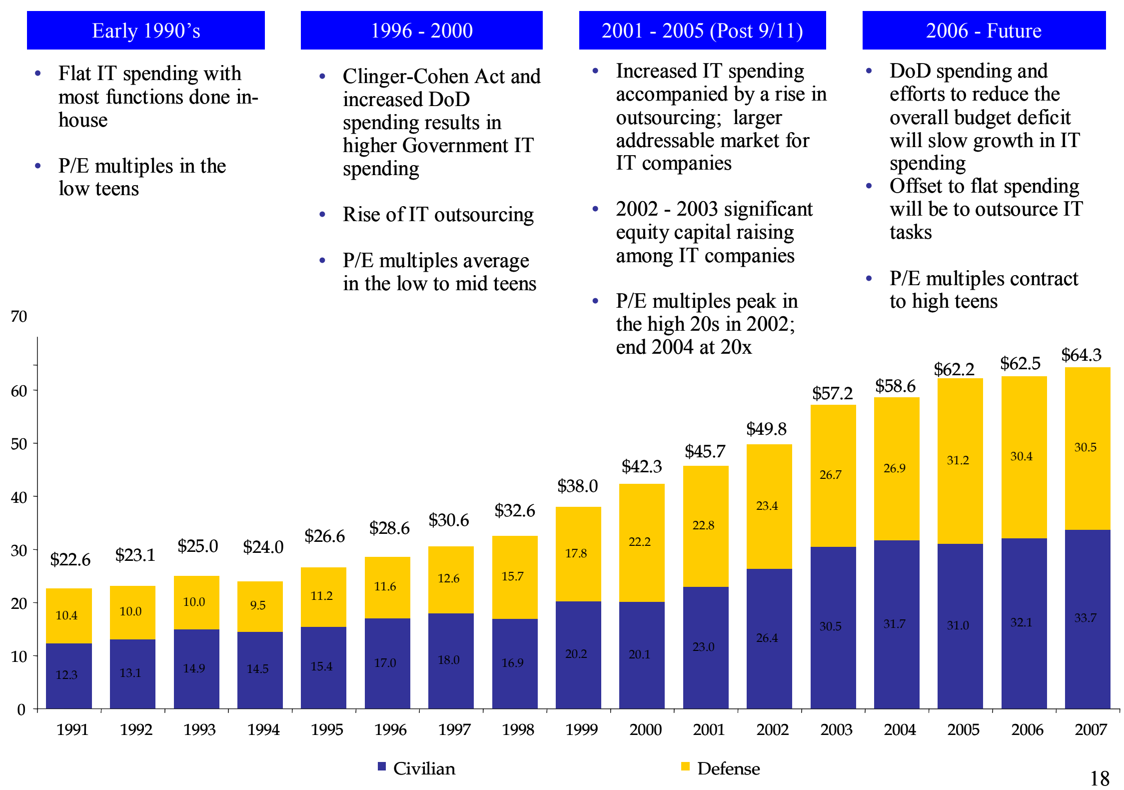


Figure 34: Historical and Projected Federal IT Spending
(Source: Office of Management and Budget)

Harnessing the power of information connectivity defines the concept of net-centricity, an artifact of transforming IT, IS, and the processes it supports. By enabling critical relationships between organizations and people, the Department is able to accelerate the speed of business processes, operational decision-making and subsequent actions. Recent operational experiences in Afghanistan and Iraq have demonstrated the value of net-centric operations. Ground forces were able to reach back to remote UAV pilots in Nevada, via satellite communications, to direct UAVs in support of their operations, achieving a level of air-ground integration that was difficult to imagine just a decade ago. Such connectivity is helping joint forces gain greater situational awareness to attack the enemy.

Achieving the full potential of net-centricity requires viewing information as an enterprise asset to be shared and as a weapon system to be protected. As an enterprise asset, the collection and dissemination of information should be managed by portfolios of capabilities that cut across legacy stove-piped systems. These capability portfolios would include joint network-based command and control, communications, and information fusion. Current and evolving threats highlight the need to design, operate and defend the network to ensure continuity of joint operations.

6.3.4 Transformation Effects: The Role of the Smaller Enterprise

As was previously mentioned earlier, it is not uncommon for 80% of a major defense program to be subcontracted to a team of smaller enterprises. When conducting the web-based expert study that is described later in Chapter 7, 47% of the respondents were senior aerospace and defense industry executives who represent smaller enterprises, defined as having $100 million or less in gross revenue. LSIs such as Lockheed Martin, General Dynamics, and Northrop Grumman struggle to adapt to the military's need for systems and solutions that support smaller and more agile units. This is due in part because their own enterprises may not be architected for interoperability and flexibility. As a consequence, they are largely unable to provide a rapid fielding capability as described earlier, and tend to focus on major platforms such as ships and aircraft. Meanwhile, new technologies and innovative solutions that are mostly being developed by smaller enterprises that are architected to do so.

Consequently, a critical element for DoD to realize its transformation-related goals and objectives is the transformation of its overall partnership with industry in terms of how the Department interacts with its industrial base, and where innovation and informed risk taking are encouraged and rewarded. LSI s dominate the DoD market from a budget perspective; however, the rapid pace of defense transformation favors more agile and responsive partners. The Department has pushed the development and implementation of net-centric systems to small enterprises that can offer greater innovation, flexibility, and cost advantages.

Illustrative Example: The Role of a Smaller Firm

A clear example of a small enterprise quickly responding with an innovative solution that offered greater performance and value than the LSI community is found in satellite-based communications. This is in great demand by forward-deployed troops to deliver both strategic and tactical data. Bandwidth is the information-carrying lifeblood of any network, and network-centric operations require extensive signal bandwidth. The ripple effect of this transformational technology-enabling trend is a driver for both the adjacent technology markets and associated services industry to manage bandwidth more efficiently. The operational military needs to deploy bandwidth in a real-time, hardened, and secure framework. As the demand for forward deployed, real-time utilization of bandwidth increases, new opportunities exist for technological investments, especially in smaller enterprises where a significant amount of intellectual capital is being created.

Prior to the events of 9 / 11, DoD purchased satellite ground terminals from LSIs such as General Dynamics that developed their solutions from the "ground up" based on military specifications (MILSPEC). However, as DoD laid out its communications plan for Operation Iraqi Freedom they realized, through lessons learned in Afghanistan, that current MILSPEC satellite ground equipment would not meet their needs. They approached LSIs and several smaller enterprises and asked for proposed solutions to their emerging communications needs. While the LSIs continued to leverage MILSPEC equipment for their solutions, one enterprise elected to use commercial off-the-shelf components and a highly engineered platform to meet DoD's needs at reduce costs. The end result was a satellite ground terminal that exceeded the MILSPEC capabilities, even in the harsh desert environment, and was priced well below any competition. Today, 10 of the 13 U.S. Army Divisions use this equipment with plans in place to complete the final 3 in the near future. The Marine Corp also utilizes this capability in Iraq and Afghanistan to collect and disseminate video and data from UAV missions; more than

400 such terminals are in use by the military in Iraq, Afghanistan, Western Europe, and the Horn of Africa.

Based on this level of success by a smaller enterprise, and numerous other similar instances, DoD transformation has forced the enterprise, particularly the larger LSIs to think about organizational structure (architecture), processes, and technologies to support those processes.

6.4 Market Sector Financial Analysis / M&A Overview

6.4.1 Budget

Since World War II, defense spending has been driven by DoD preparations to combat any and all threats to U.S. national security. The post-9/11 growth in defense outlays is no exception to this model, as defense spending remains at absolute historical highs.

- Defense spending should maintain its current pace of well above $500 billion per year for the next few years, driven by three equally mission-critical security priorities: (1) continuation of military operations in Iraq and Afghanistan; (2) replacement and repair of equipment used extensively in combat; and (3) continuation of specific modernization and transformational defense initiatives that began in the late 1990s and gained significant momentum in the early 2000s;
- The top-line, macro defense budget growth will have the greatest effect on the valuations of the LSI's; valuations for small and mid-cap firms should be driven by market-share growth, contract wins, client diversification and depth, and specific agency focus;
- Coupled with the historical defense spending level is the strategic split between conventional and non-conventional capabilities. The DoD is now challenged with preparing and engaging in combat with both symmetrical and asymmetrical enemies;

- Over time, non-traditional engagements could present significant new opportunities for industry as the DoD invests more aggressively in new methods to counter asymmetric threats.

Following the attacks of 9/11, the U.S. entered the GWOT and operations in Iraq and Afghanistan. As a result, average defense outlays from 2001–2006 increased to $406 billion, with total spending increasing 56% over the term. Defense outlays should continue to rise through 2012 based on two primary catalysts: (1) Ongoing U.S. operations in Iraq and Afghanistan, (2) Modernization of weapons and the replacement of equipment inventories which are being used at a much higher rate than previously anticipated. As such, equipment and systems continue to dilapidate as a result of current military activities. Consequently, with this increased use, the result has been the DoD's need to extend the useful lives of a number of critical weapons systems, some of which had been produced during the 1950s and 1960s (e.g. B-52 bombers; guardrail intelligence, surveillance, and reconnaissance aircraft). National defense outlays from 1980-2012 (estimated), and DoD and total federal outlays are depicted in Figure 35 and Figure 36 respectfully.

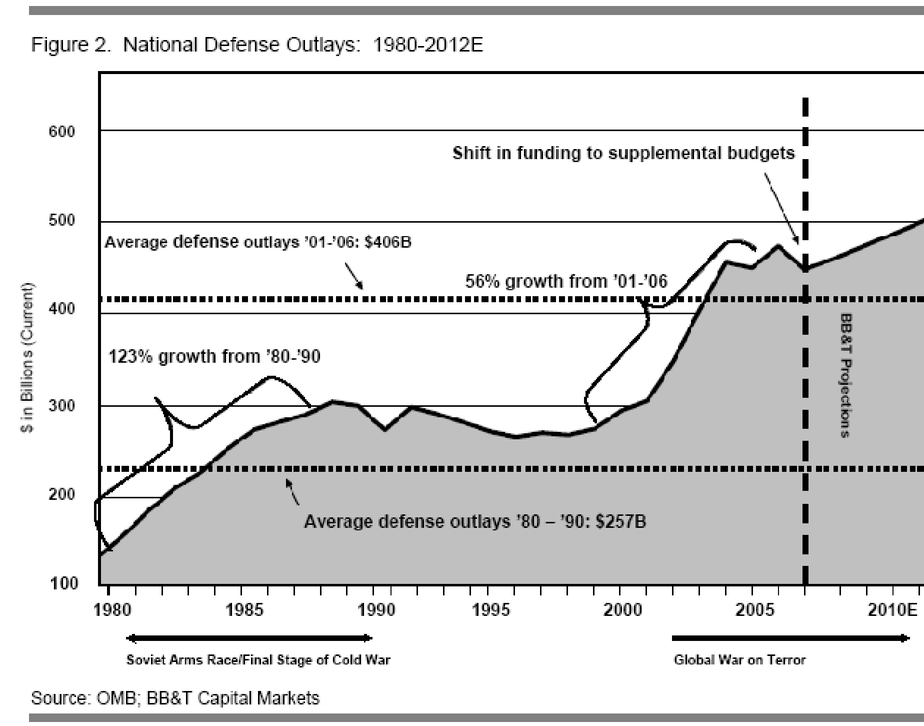


Figure 35: National Defense Outlays from 1980 – 2012 (estimated)

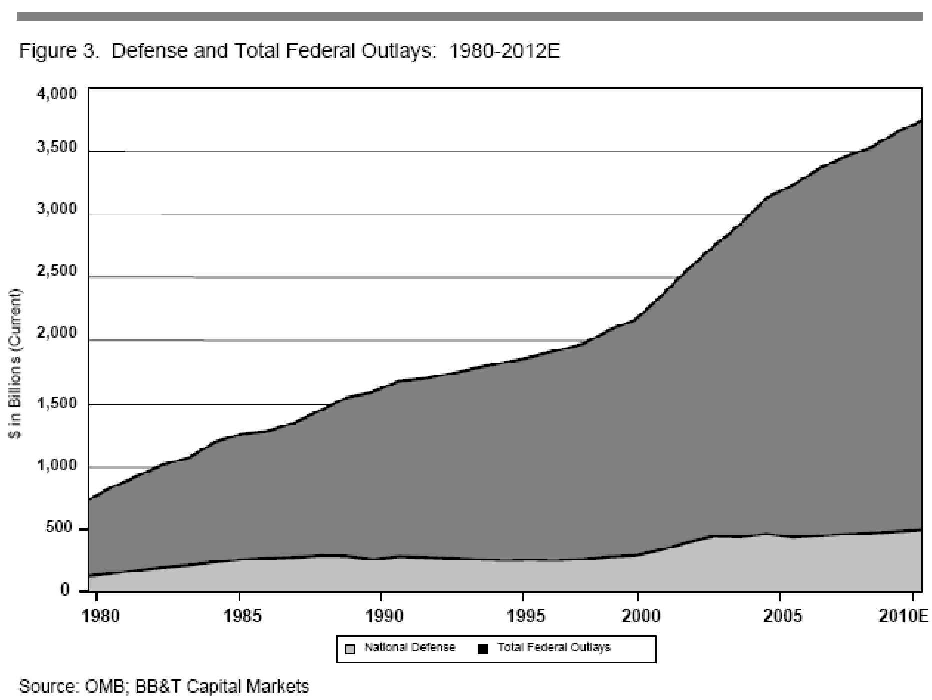


Figure 36: DoD and Total Federal Outlays 1980 – 2012 (estimated)

6.4.2 2008 and Near-Term Spending Environment

The FY'08 budget request, which was released in February 2007, represents $481 billion in defense discretionary budget authority, or $459 billion in defense outlays. With regard to the 2008 budget request, several senior military leaders testified to Congress that from a budget standpoint, the DOD used a "steady state" projection for 2008 and did not forecast any additional resources needed for increased security concerns, specifically Iraq. Figure 37 depicts the total DoD budget authority.

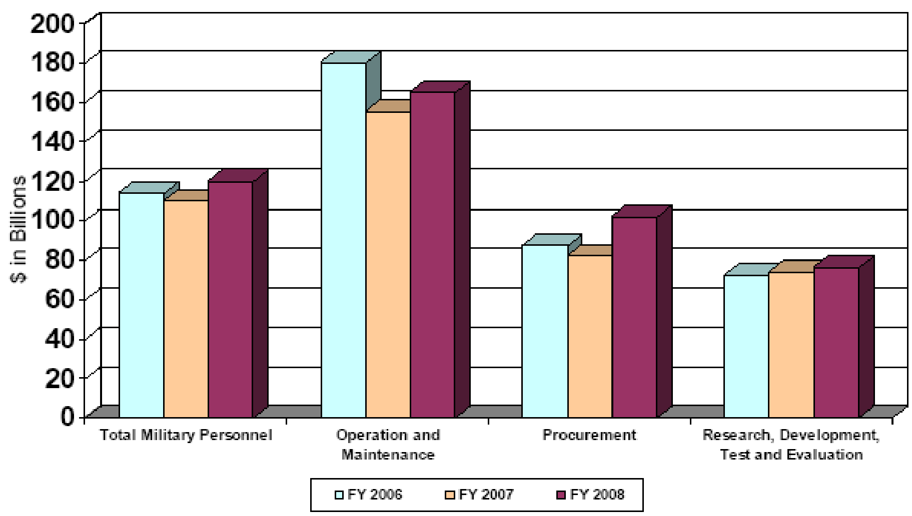


Figure 37: DoD Budget Authority by Major Accounts
(Department of Defense)

The GWOT, particularly the DOD's presence in Iraq and Afghanistan, has driven military spending since 2001 and will continue to be a primary catalyst for overall spending growth in the near future. There are many variables influencing our presence in the region and with a presidential election in 2008, which could lead to a change in leadership in the White House and DOD, a dramatic reversal in Middle East policy is certainly conceivable.

6.5 Summary and Conclusions

Clearly, the aerospace and defense industry sector is in the midst of large-scale, multi-dimensional transformation in order to meet the challenges of a new strategic environment. The new emphasis, with a focus on the dissemination of timely and actionable information, has forced the leaders of both commercial enterprises and the Defense Department to reevaluate the structure of their enterprise to include both processes and information-related technologies. Due to the complexities related to the newly emerging, multi-security threat environment, the DoD will demand outside expertise and lean more heavily on its industry partners in the future; particularly smaller enterprises.

In short, DoD transformation actually entails the transformation of the entire industrial complex, to include commercial enterprises. Building on the theoretical and practical support provided in Chapters 2-4, we assert that the dimensions of this transformation should mirror the dimensions of our ESA that was introduced in Chapter 4: (1) enterprise processes, (2) information systems, (3) information technology, and (4) enterprise architecture.

CHAPTER 7:
RESEARCH DESIGN AND METHODOLOGY

7.1 Introduction

This chapter describes our efforts to investigate the four dimensions of our ESA. This research approach was undertaken based on the lack of consonance between the extant literature and practice concerning the implementation and alignment of information architectures (see chapter 2). First, we provide an overview of each of the two stages of the research design. We then review the data collection methods used to empirically validate the conceptual framework (Chapter 5). The protocol includes a series of ten interviews with senior-level executives and web-based expert survey. The research methodology, the process by which interviewees and survey participants were identified and selected, and the data collection instrument and associated procedures are also discussed.

7.2 Research Design

In order to satisfy the two primary goals of the research, discovery/exploration and model testing, the use of different data collection methods and analysis tools were employed. As was previously explained, the ESA and the conceptual framework that dimensionalized it were developed based on a thorough review of both the knowledge base contained in the extant literature, as well as current models and techniques used by executive-level practitioners. Once developed, a total of thirteen relationships between the dimensions and enterprise performance were proposed. Two primary research methods were then used to explore our research questions and test the relationships.

Both stages of the research design employed qualitative and quantitative research methods in order to fully investigate the ESA dimensions. More specifically, the data collection and subsequent validation processes are conducted in two main stages as depicted in Figure 38.

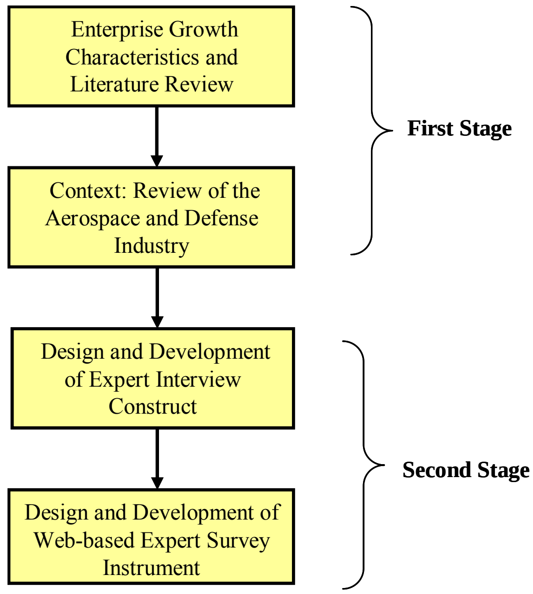


Figure 38: Research Design Overview

7.2.1 Stage I of the Research Design

The dimensions of the ESA, described and depicted in the conceptual model (Chapter 5), were identified based on both an analysis of enterprise growth characteristics and a thorough review of the extant literature. An analysis of the aerospace and defense industry was conducted in order to validate our choice of industry in which to study the dimensions and relationships hypothesized in the conceptual model (see Chapters 2 and 6, respectively, for a more complete description of the methodology, analyses, and results).

7.2.2 Stage II of the Research Design

The first task of this stage of the research design included in a series of ten interviews conducted with senior level industry executives. The interviews were designed to (1) both help build the propositions within the conceptual model, and (2) generate primary, qualitative data to help inform the development of our web-based survey instrument. Development of the survey instrument was the second task in this stage of the protocol. Both tasks are graphically depicted Figure 39.

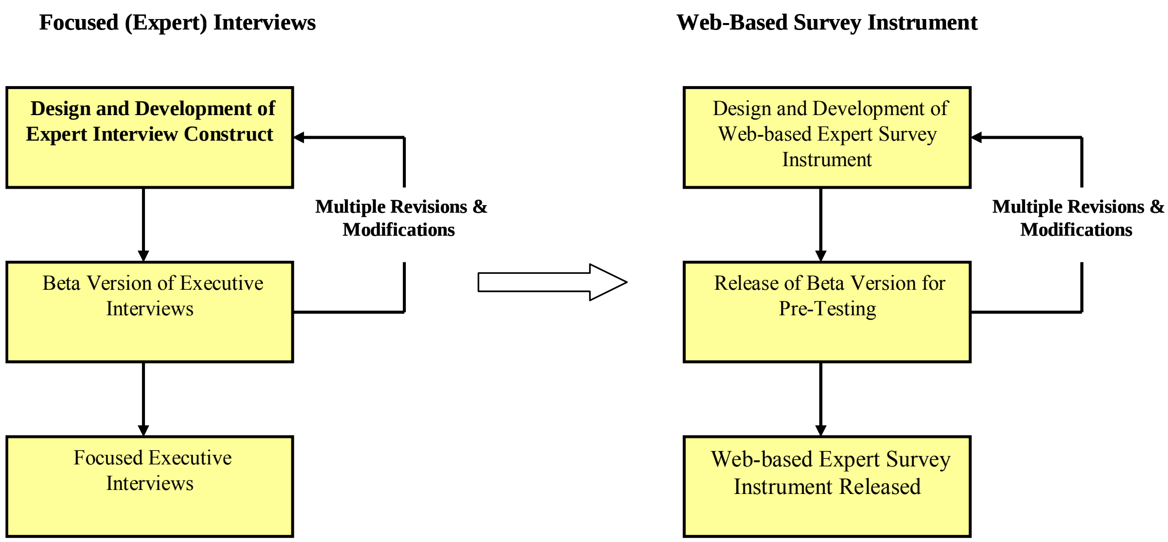


Figure 39: Structure of Stage II of the Research Design

Next, the web-based survey instrument was designed and developed. Three primary objectives drove our data collection and subsequent analysis efforts. The first was to empirically determine the level of maturity of each of the four dimensions of our ESA. The second was to determine the impact, both individually and collectively, of each dimension on enterprise performance. The third was to determine the validity of ESA maturity as a predictor of enterprise performance. The goals of each data collection method are specific to the different parts of the multi-method research design.

7.3 Executive Interviews

The purpose of the interviews with executive-level practitioners is to serve as primary, qualitative data, focused on gaining insights and knowledge on issues primarily relating to processes, information technology-based systems, and architecture. Given that a focal point of the executive interviews was to inform the development of the web-based survey instrument, the interviewees needed to be carefully selected. It was desirable that interviewees possess a clear vision and understand fundamental issues pertaining to enterprise growth in the context of the aerospace and defense industry sector. Consequently, it seemed logical to assume that the more knowledgeable the individual, the better he or she would be able to comment on salient issues. Succinctly, selection of the right experts provides content validity for the development of the survey instrument. Finally, it is critical for interviewees to represent multiple perspectives such that these viewpoints can be compared, amalgamated, and fused into an informed prediction of future directions and trends.

7.3.1 Development of the Interview Protocol

The interview protocol was semi-structured; working with executives from various domains who have experience with enterprise processes and information systems, the protocol was developed over several iterations. First, a series of questions were developed based on the background work that was discussed earlier in Chapter 2, and our experiences as practitioners. The construct for the executive interviews is depicted in Figure 40.

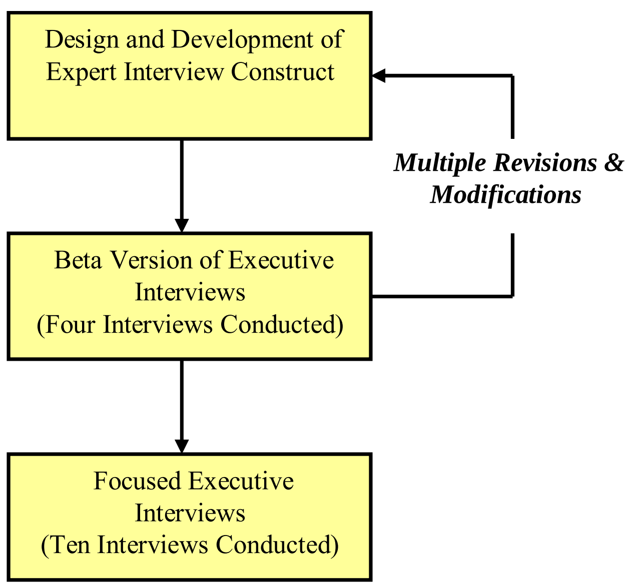


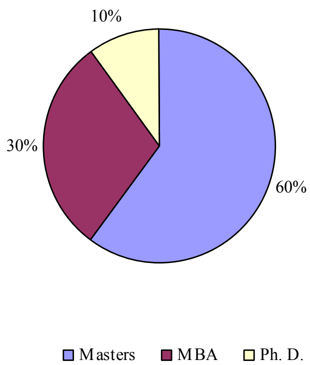
Figure 40: Development of the Expert Interview Protocol

Next, prior to conducting the data collection interviews, a series of four pre-test interviews were staged in order to: (1) solicit feedback on the structure, flow, and duration of the interview, (2) validate the content and topical relevance of the questions, and, (3) help identify other executives who possessed the domain knowledge and expertise to participate in the data collection interviews. In addition, each dissertation committee member reviewed the interview protocol and provided feedback on it and the questions themselves. From these inputs, multiple revisions and modifications of the interview construct were conducted from which a final construct was produced. While some of the practice interviews were conducted using executives from the aerospace and defense industry, their responses were not counted as part of the ten data collection interviews.

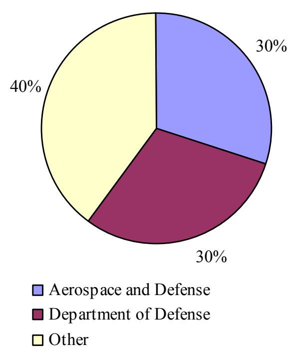
7.3.2 Identification and Selection of Interview Participants

The information solicited for our study required that interviewees possess deep domain knowledge of enterprise business processes and information technology-based systems. As such, it was desirable to select a group of experts who could provide salient opinions on the various dimensions of enterprise growth. The following criteria were used in order to identify eligible participants for both the pre-testing interviews and the data collection interviews: (1) senior-level executive practitioners; i.e., CXO, VP, General Officer (military) who have demonstrated domain experience in enterprise strategy development, particularly from a process perspective, and (2) experts who have detailed knowledge of enterprise information technology-based systems. Based on a list of affiliates and industry members of the Tennenbaum Institute, and our personal relationships, we initially identified a list of 24 prospective participants from which ten who possessed the aforementioned attributes were selected.

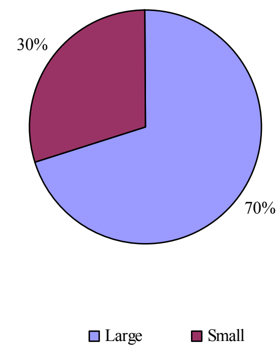
The composition of the final group represents the desired, balanced view for the expert interviews; we deemed that the interviewees possessed significant experience in information technology-based systems, technology strategy, and how information flows through enterprise process. A high-level demographic view of the interviewees is provided in Figure 41 (a-e), and Table 27 respectfully.



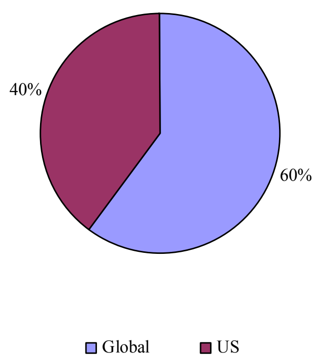
(a) Highest Degree Earned



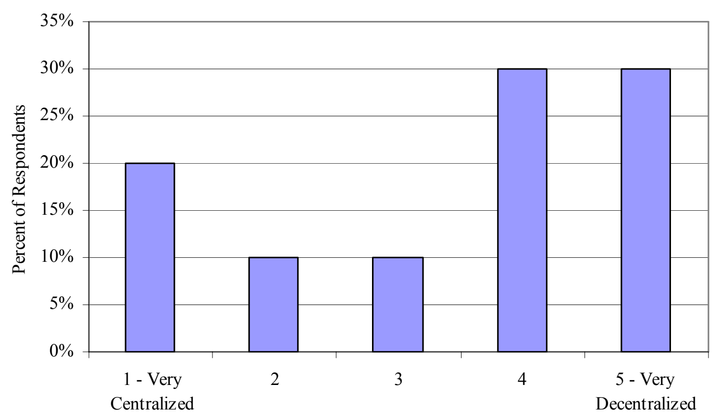
(b) Industry Orientation



(c) Company Size



(d) US versus Global



(e) Degree of Decentralization of Current Information Systems at Interviewee's Company

Figure 41 (a-e): Interviewee Demographic Profile

Table 27: Interviewee Demographic Profile

Interviewee	Total Years Experience	Highest Degree Earned	Job Title	Industry	Company Size	Company Revenue
1	30	MBA	VP Strategy	Facilities Management [2]	300,000	$7 billion
2	30	MS	Chief Strategy Officer	Services / Consulting	1000	$400 million
3	30	MBA	CIO	Aerospace and Defense	90,000	$26 billion
4	36	MS	Assistant Deputy CIO	Department of Defense	1.9 million	$10 billion
5	27	MS	Senior VP	Software / Services	5,000	$500 million
6	38	MS	Deputy CIO	Department of Defense	1.9 million	$10 billion
7	30	MBA	CEO	Software and Services	300	65 million
8	32	MS	CIO	Aerospace and Defense	4,000	$25 billion
9	30	Ph. D.	CTO	Aerospace and Defense	400	$25 billion
10	40	MS	Commanding General	Department of Defense	80,000	$42 billion

7.3.3 Interviews

The objective of the interviews is help modify the proposed relationships in and among the ESA dimensions and enterprise performance, and (2) produce qualitative data to inform the development of our web-based survey instrument. The average duration of the interviews was 1 hour, 45 minutes; the average industry experience per executive was 32.3 years. The interviewees represented both private and public enterprises from the aerospace and defense industry, the DoD, and academia. Thirty percent of those

2 Formerly in Department of Defense

interviewed are executives in ‘small’ institutions, defined here as less that $100 million in gross revenue. Forty (40) percent of those enterprises are U.S.-based.

Once an interview time was scheduled, the interviewee was sent, via e-mail, representative strategic and operational processes. (See Chapter 3). Feedback was solicited in the following five areas (See Appendix E for the complete interview protocol):

- Enterprise Processes: Strategic versus operational: Interviewees were first asked to comment on how they thought about strategic versus operational processes. They were then asked to comment on how well the essence of representative strategic and operational process was captured by those that were sent in advance of the call;
- Coupling Between Strategic and Operational Processes: Using a five point Likert scale, interviewees were asked to assess the extent to which strategic and operational processes are tightly coupled / seamlessly integrated;
- Information Technology-Based System Support of Enterprise Processes: Interviewees were asked to comment on, among other things, the extent to which their enterprise currently maintained an information technology-based system capable of supporting strategic and operational processes, respectfully;
- Development of a Strategic Layer Meta Model: Interviewees were asked to comment on, among other things, the extent to which they would value a technology-based representation of strategic processes;
- Enterprise Architecture: Using a five point Likert scale, interviewees were asked to assess how large a role information technology infrastructure plays in their enterprise; i.e., the interplay between it and enterprise structure / operations.

Given that all interviewees maintained senior-level positions within their respective institutions, all interviews were conducted via phone due to time constraints. Abundant notes were recorded and later carefully transcribed in electronic format.

7.4 Web-Based Survey Instrument

At a high level, the objective of our the web-based survey instrument is to provide data for statistically-based analysis of proposed relationships between multiple variables, and to provide a large enough sample size from which to draw valid conclusions.

7.4.1 Development of the Web-Based Survey

The web-based survey instrument was based, in part, on the qualitative data extracted from the ten executive interviews and investigations conducted in Chapter 2. The protocol used to develop the web-based survey instrument is depicted in Figure 42.

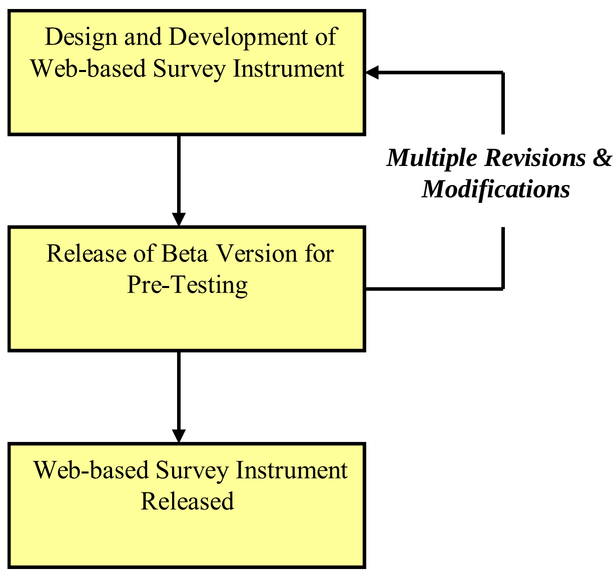


Figure 42: Development of the Web Based Expert Survey Instrument

The development protocol is described in more detail as follows:

- Paper Draft: A paper draft of the survey instrument was produced and reviewed. In all, three iterations were developed based on feedback from multiple executives who had not participated in the interview process, and members of the dissertation committee;
- Online Development: Zoomerang, Inc., was used to further refine the survey and house it online. One of the primary benefits is that it allows respondents to

complete the survey instrument in installments. Work could be saved and finished at a later date, time permitting for the respondent. Given that prospective respondents are were senior-level executives, the decision to include this feature was based on our assumption that this level of flexibility would encourage more participation, hence more survey completions;

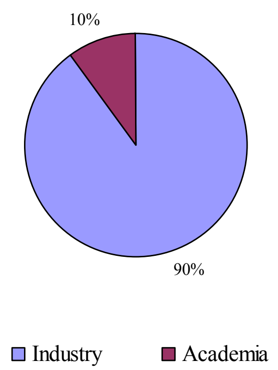
- Beta Testing: Two pre-test or "beta" rounds were conducted. From this feedback, a matrix was constructed that outlined suggested changes per each section of the survey instrument;
- Formal Release: Convinced that the survey instrument was sufficiently "user friendly" in terms of readability, comprehension, and duration, the instrument was deemed ready for formal release.

7.4.2 Identification and Selection of Survey Participants

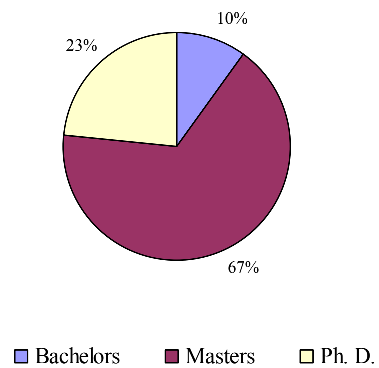
The selection process for the survey participants was based on the same three criteria used to select interviewee participants. However, in order to acquire a large enough sample size from which to draw valid conclusions, we expanded the list of potential participants beyond the experts identified for the interviews. This entailed a multi-faceted approach via the use of personal contacts of the members of the Tennenbaum Institute and outreach to industry executives via databases such as those maintained for the Joint Strike Fighter (JSF) program, and the Lean Aerospace Initiative (LAI). This resulted in the inclusion of significantly more participants for the survey, which was the desired outcome.

Based on these sources, 174 prospective respondents were identified. An e-mail invitation was sent to each individual with a link to the web-based study explaining both the purpose and protocol of the survey. Eighteen (18) invitations were returned due to e-mail delivery failure for various reasons. While 146 prospective participants read the e-mail invitation, 74 registered. Of those that registered and began work on the survey, 60 completed the entire survey, resulting in a response rate of 41.09 %. It should be noted that non-financial incentives were offered to prospective respondents in order to encourage increased participation. These included providing all participants with the aggregate results of the survey instrument. In addition, our online survey instrument also included a feature that allowed respondents to view, in real-time, how their responses compared to others who had completed the survey.

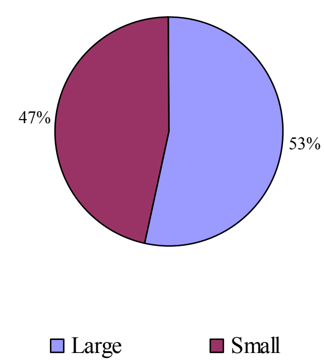
As with the executive interviewees, the composition of the final group represents a balanced view with respondents possessing significant experience in information technology-based systems, technology strategy; and how information flows through enterprise process. A demographic profile of the survey participants is provided in Figure 43 (a-d).



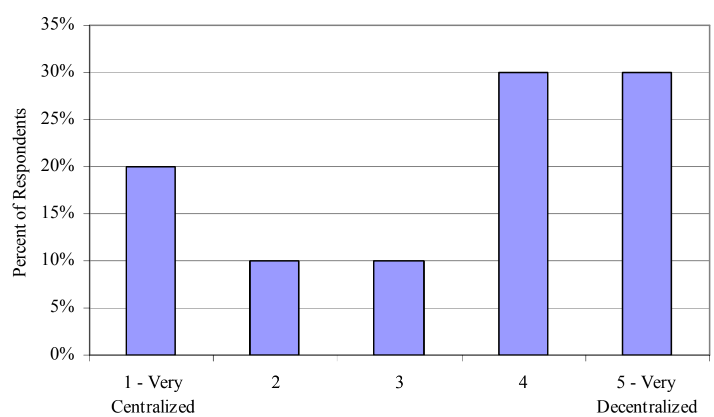
(a) Industry versus Academia



(b) Highest Degree Earned



(c) Company Size



(e) Degree of Decentralization of Current Information Systems at Respondent's Company

Figure 43 (a-d): Demographic Profile of Survey Respondents

7.4.3 Survey Instrumentation

As was previously noted, an objective of the ten expert interviews was to comment on and validate the four maturity dimensions of the ESA. Since these dimensions were identified as a function of the literature review and were referenced to in the survey instrument, a semi-structured approach to the online data collection was also used by Garcia (2006), and Basole (2006). Respondents were informed that the web-based survey instrument would take approximately 20-30 minutes to complete and incorporated seven short sections, briefly described as follows:

- Background Information Questions: Respondents were asked some general question about their background, professional experiences, and their current enterprise;
- Enterprise Processes: Respondents were asked to comment on both strategic and operational processes. Among others, they were asked to rank the relative importance of strategic and operational processes, respectfully, and comment on the extent to which they are different from one another;
- Technology-Based Support of Enterprise Processes: In the preceding section, respondents commented on both strategic and operational processes. In this section, they were asked to comment on the extent to which these processes are, or are not, currently supported by their firm's information systems. In Part A, the questions were directed towards strategic processes; in Part B, these same questions were directed towards operational processes;
- Technology Deployment and Structure: In the preceding sections, respondents commented on enterprise processes and how well those processes are or are not supported by their current information systems. The questions in this section asked them to comment on how those systems are deployed and structured throughout their firm. It was noted that the term ‘IT” meant the technology / technology infrastructure itself, not their firm’s IT department or people who work in that department.
- Enterprise Architecture-Related: Having thus far commented on strategic and operational processes, the extent to which those processes are supported by

current information systems, and how those technologies are structured and deployed in their enterprise, respondents were asked to comment on extent to which these elements are related. The term "enterprise architecture" referred to the elements and relationships, often organized in layers, of an enterprise such as roles, processes, etc., as well as information technology and associated systems.

- Environmental Complexity: The questions in this section ask respondents to comment on the nature of the industry sector within which their enterprise competes;
- Enterprise Performance-Related Questions: The questions in this final section asked respondents to comment on how well their firm has performed / is performing in terms of metrics such as short and long-term profitability, available cash, etc.

See Appendix F for the complete web-based survey instrument.

7.4.4 Pre-Testing

Prior to the formal release of the survey instrument, two beta rounds were conducted. The first involved an examination of the questionnaire by members of the thesis committee. Based on this feedback, certain questions were added, deleted, or reworded in order to add clarity and improve readability and flow. The second pre-test round was conducted by several interviewees whose participation in the survey would not be solicited. Based on their feedback, and convinced that the survey instrument was sufficiently "user friendly" in terms of readability, comprehension, and duration, the instrument was deemed ready for use and was formally released.

7.4.5 The Data Collection Process

Participants were sent an e-mail invitation to the online site where the survey was hosted. There, respondents were informed via an introductory page that their participation was completely voluntary and that failure to complete the survey would not result in any penalties. They were also assured that they could withdraw at any time once they commenced the survey, even after having agreed to participate. Further, all respondents were provided with the contact information, both e-mail and phone, for the principle investigators in the event of questions or comments.

The invitation included a link to the web-based survey and included a temporary username and password, with took participants to the consent form which was completed prior to commencing the survey (See Appendix F). As was previously mentioned, given that our respondents were all busy senior-level executives, a decision was made to incorporate a feature that allowed respondents to complete the survey instrument in installments. In addition, participants were instructed that survey sections could be worked on in any order of their choosing. It was hoped that the combination of these two features would provide maximum flexibility for the respondent, thereby encouraging more participation and hence more completed responses.

7.4.6. Human Subject Review

Prior to obtaining the informed consent of each respondent, the nature, purpose, and objectives of the survey were conveyed. They were assured that strict confidentiality and anonymity would be preserved throughout the data collection process. Since data were to be collected entirely online, respondents were also assured that the data was to be kept secure, with only the principle investigators having access. Participants were informed that no personal, physical risk would be incurred by their participation.

Finally, given the nature of the study; (1) online data collection only, (2) no physical contact with any of the survey respondents, and (3) maintenance of scientific integrity of the protocol, the web-based online survey instrument was deemed to be exempt from an Institutional Review Board (IRB) approval processes.

7.5 Summary

This chapter presented a detailed description of the design of this research effort, and outlined the motivation, theoretical purpose, and justification for the methodology chosen. The use of multiple data collection methods provided the basis for a comprehensive analysis of many of the issues faced by executives as they seek to implement information architectures. The executive interview data provided unique insights into enterprise processes, how well those processes are / are not supported by current information systems, and how those systems are deployed and structured. These data also served to inform the development of our web-based survey instrument that provided more in-depth information concerning enterprise information architectures. The next chapter presents the statistical methods and analysis techniques used, and the findings relative to the research hypotheses presented earlier.

CHAPTER 8:
DATA ANALYSIS AND RESULTS

8.1 Introduction

This chapter presents the data analysis and results of our web-based expert study of the four dimensions used to characterize the level of maturity of our ESA, and how they relate to enterprise performance. A major motivation for these investigations, and the context for their application, is the reduction of enterprise failure rates. Data from both the executive interviews and the web-based expert survey were collected and analyzed based on the initial research questions presented in Chapter 1. The first was to empirically determine the value of each dimension of maturity of our ESA (see Chapter 5). The second was to determine the impact, both individually and collectively, of each dimension on enterprise performance. The third was to determine the validity of ESA maturity as a predictor of enterprise performance. It is our belief that the knowledge derived from these data and subsequent analyses provides a foundation for merging practice and theory to better understand how to categorize enterprise system maturity. By so doing, it also provides the rudiments for a more in-depth understanding of how to predict enterprise performance.

First, the initial data assumptions and preliminary data analyses are presented. Next, an in-depth investigation of proposed relationships is conducted for each ESA dimension (see Chapter 5). In all, twelve proposed relationships across four dimensions are investigated, along with one for ESA maturity, taken as the linear combination of the four dimensional maturities:

- Five for enterprise processes; collectively a measure of process maturity;
- Three for technology-based support of enterprise processes; collectively a measure of information systems maturity;
- Three for technology structure and deployment; collectively, a measure of information technology maturity;

- One for enterprise architecture maturity;
- One for ESA maturity.

8.2 Empirical Analyses: Pre-Testing and Analysis of Survey Data

A summary of the statistical techniques used for the subsequent analyses are presented. We first describe the statistical pre-tests that were conducted so as to ensure the validity of our data, followed by the statistical tests that were conducted in order to evaluate the web-based survey data. As we designed the web-based survey, a function was added so as to preclude respondents from selectively skipping responses. That is, we alleviated the problem of 'missing data' by forcing respondents to answer all questions. This function was designed with the knowledge that some respondents may not complete the survey due to either not wanting to answer selected questions, or being forced to respond in a manner that they deem undesirable. In our survey, fourteen respondents who commenced the survey failed to complete all sections, perhaps in part due to the aforementioned characteristics of the survey construct.

8.2.1 Statistical Pre-Testing

Power Analysis

Clearly, we did not have access to the entire statistical population of interest for our web-based survey effort for several reasons: (1) it is unlikely that all aerospace and defense industry executives deemed eligible to participate in the survey would be willing to do so, (2) even if accessible, the population would be too large to measure, and (3) the measurement process for all eligible executives would be too time-consuming.

Consequently, our sample size of sixty (60) respondents represents a small segment of the observable population. As a result, our analyses about the statistical population of interest are made on the basis of a relatively small amount of data. If the sample size is too low, standard statistical tests may not have the statistical power to detect differences in the data that truly exist; that is, a significant difference may actually exist, but remains undetected. The "beta", or probability of accepting a false null hypothesis, may increase with a decrease in sample size. For the types of statistical analyses performed in this study, a sample size of 60 is a meaningful enough number of respondents in order to conduct the statistical tests described in section 8.2.2.

Non-Response Bias

We assess non-response bias by testing for differences between early and later respondents to the survey. Specifically, the first half of the respondents, 30, were tested against the second half of the respondents, also 30, using the Mann-Whitney test. This test is a nonparametric hypothesis test to determine whether two populations have the same population median. It assumes that the populations are independent and have the same shape. No significant differences ($p<0.05$) were found between the two sets of data, thereby suggesting that non-response bias is highly unlikely. A graphical depiction of the average responses to the questions is presented in Figure 44.

Figure 44: Testing for Non-Response Bias

Residual Analysis:

Residuals are elements of variation unexplained by a fitted model. A careful examination of the residuals enables us to verify whether our assumptions are reasonable and our choice of model is appropriate. Residuals should be (roughly) normal and (approximately) independently distributed with a mean of zero and somewhat constant variance.

In a normal probability plot of residuals, the points should generally form a straight line if the residuals are normally distributed. If the points on the plot depart from a straight line, the normality assumption may be invalid. One can use the probability plot is used with a goodness-of-fit test such as the Anderson-Darling (AD) statistic in order to assess whether or not the residuals are normally distributed. The Anderson-Darling statistic on the plot indicates whether the data are normal. If the P-Value is lower than the chosen a-level, the data do not follow a normal distribution. This measures how well the data follow a particular distribution; the better the distribution fits the data, the smaller this statistic will be. When residuals versus fit is investigated, this plot should show a random pattern of residuals on both sides of zero, as is depicted in Figure 45.

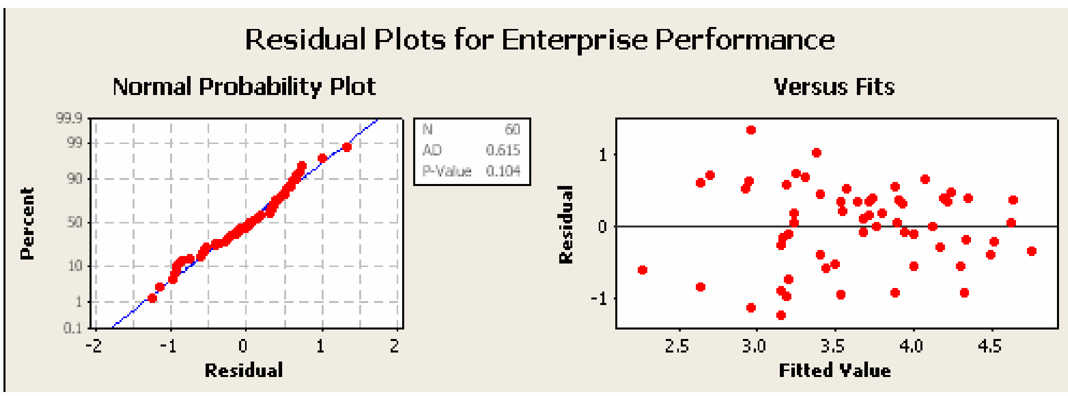


Figure 45: Residual Plots for Enterprise Performance

8.2.2 Statistical Analyses of Web-Based Survey Data

The various statistical used to evaluate the proposed relationships are described as follows.

Pearson Correlation Coefficient and P-Value:

The Pearson Correlation Coefficient, or simply, Correlation Coefficient, assesses whether two random variables are linearly related. The value of the coefficient ranges from -1.0 to 1.0. A value of 1.0 shows that a linear equation describes the relationship perfectly and positively, with all data points lying on the same line and with Y increasing with X.. Conversely, a value of -1.0 shows that all data points lie on a single line but that Y increases as X decreases. A value of 0.0 indicates that a linear model is inappropriate -- that there is no linear relationship between the variables. The P-Value, or observed significance level of the test, that is associated with the coefficient is an important determinant in choosing either to accept or reject the null hypothesis in favor of the alternative. A Type 1 error occurs when a correct null hypothesis is rejected. For the purpose of testing the proposed relationships for each of the four ESA dimensions and ESA maturity, a significance level of $\alpha = 0.05$ is chosen. That is, the probability of making a Type 1 error is 0.05 or 5%.

Regression Analysis:

Linear regression generates an equation to describe the statistical relationship between one or more predictors and the response variable, and is used to predict new observations. It uses the ordinary least squares method which determines the coefficients of the equation by minimizing the sum of the squared residuals. Regression results indicate the direction, size, and statistical significance of the relationship between a predictor variable and response:

- The sign of each coefficient indicates the direction of the relationship;
- The coefficients represent the mean change in the response per one unit of change in the predictor while holding other predictors in the model constant;
- The P-Value for each coefficient tests the null hypothesis that the coefficient is equal to zero (no effect). Therefore, a low p-value suggest that the predictor is a meaningful addition to the chosen model.
- The regression equation predicts new responses based on observed predictor values.

Analysis of Variance (ANOVA) using the General Linear Model (GLM):

The General Linear Model (GLM) is a linear statistical model that does not make any assumption about the distribution of the underlying data. It may be written as $Y = XB + U$ where Y is a matrix with a series of multivariate measurements, X is a matrix that might be a design matrix, B is a matrix containing parameters that are usually to be estimated and U is a matrix containing residuals. For our web-based survey, responses were captured using a five point Likert scale. The GLM allows us to assess the relationship between the response to one question versus another, as well as the relationship between a set of responses (to a set of questions) versus another set of responses.

Best Subsets Regression:

This is an approach to variable selection when building a model based on several predictor variables. It enumerates all possible variable selections and displays the results in terms of R2, adjusted R2, and Mallows Cp. A model that contains a Mallows Cp value that most closely equals the number of predictor variables is considered the most adequate model.

Principal Component Analysis (PCA):

In order to verify that the web-based survey questions accurately capture the theorized concepts and factors, Principal Component Analysis (PCA) is used to analyze the responses. PCA is a subset of factor analysis techniques which allows for a more parsimonious treatment of multiple variables based on the correlation matrices of chosen questions. By using PCA, we are able to extract the maximum amount of variance for each calculated factor, thereby providing an identification of factors that are highly correlated. For our web-based survey, PCA combines multiple questions into one factor that measures the underlying construct without losing any of the important variability indicated by the responses. The aggregated, principal factors are then used in the testing of the proposed relationships.

8.2.2 ESA Dimensional Analyses and ESA Maturity

The analysis for each ESA dimension is presented in its own section, 8.3 through 8.5, respectively. An analysis of ESA maturity is presented in section 8.6. For each section, one sub-section is allocated for the data collection and subsequent analysis of each proposed relationship. A table is presented at the beginning of each section delineating the proposed relationships that will be investigated in the following sub-sections. In all, thirteen proposed relationships are investigated; to make it easier for the reader to follow, the table is repeated at the beginning of each sub-section in order to highlight the specific relationship tested in that section. At the end of each section, a summary table is presented that depicts: (1) the specific relationships tested in that section, (2) a summary of the analyses that were conducted in order to investigate the relationship, and (3) the result of the analyses.

Each dimensional analysis follows a similar format. First, the proposed relationships that are being tested are presented along with the questions from the web-based expert survey used to evaluate them. Next, we describe the analyses conducted and present graphical depictions of the results. Salient observations based on the results are then noted and discussed. When applicable, information from the executive interviews is used to highlight findings from the web-based survey.

8.3 ESA Dimensional Analysis: Enterprise Processes

This section of the survey was designed in order to assess the level of maturity of enterprise processes and its relationship with performance. Respondents were asked to comment on the general nature of both strategic and operational processes, and the extent to which they are or are not coupled. They were also asked to comment on the extent to which their enterprise uses capability / process maturity models, as well as mechanisms to link business operations to the enterprise's stated strategy. The enterprise processes-related relationships that are investigated in the following sections are depicted in Table 28.

Table 28: Proposed Relationships for Enterprise Process Dimension

	Enterprise Processes
H1 (a)	Strategic layer processes and operational layer processes are different.
H1 (b)	Strategic and operational processes that are tightly coupled will have a positive relationship with enterprise performance.
H1 (c)	The use of capability / process maturity models will not have a positive relationship with enterprise performance.
H1 (d)	The use of capability / process maturity models will not have a positive relationship with the use of mechanisms to link business operations to strategy.
H1 (e)	The level of process maturity will be greater among high performing enterprises than among low performing enterprises.

8.3.1 Strategic Versus Operational Processes

This proposed relationship examines the extent to which the strategic and operational layer processes are different. This is a fundamental assertion and a cornerstone of the research effort. Question 10 from the survey: “To what extent do you agree that strategic processes are different than operational processes?” was used to investigate the relationship. The specific relationship is depicted in Table 29.

Table 29: Differences in Strategic and Operational Processes

H1 (a)	**Strategic layer processes and operational layer processes are different.**
H1 (b)	Strategic and operational processes that are tightly coupled will have a positive relationship with enterprise performance.
H1 (c)	The use of capability / process maturity models will not have a positive relationship with enterprise performance.
H1 (d)	The use of capability / process maturity models will not have a positive relationship with the use of mechanisms to link business operations to strategy.
H1 (e)	The level of process maturity will be greater among high performing enterprises than among low performing enterprises.

Based on the following analysis, relationship H1 (a) is accepted; Figure 46 displays the overall response to Question 10:

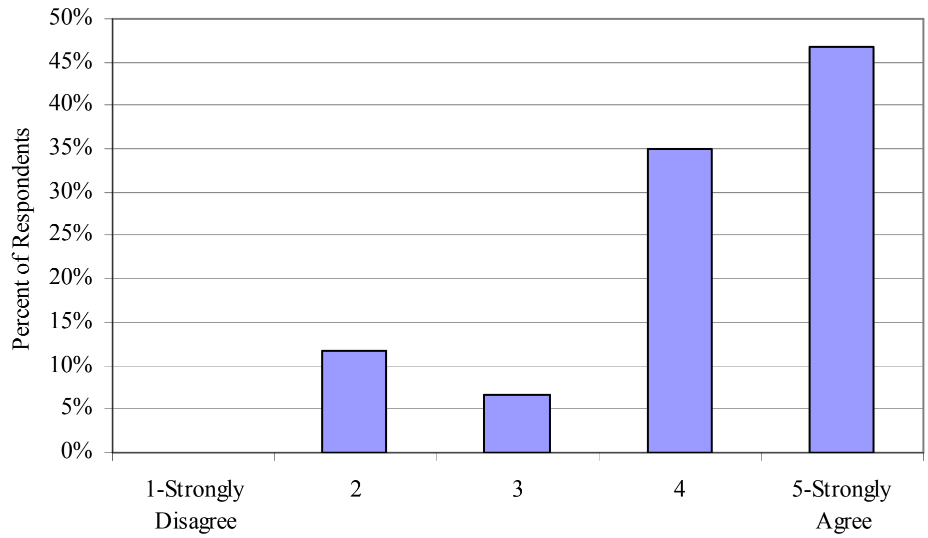


Figure 46: Strategic Processes Versus Operational Processes

For the subsequent analysis, a rating of ≥ 4 implies that respondents were of the opinion that strategic processes are indeed different than operational processes. Conversely, a rating of ≤ 2 or lower implies that respondents were of the opinion that no salient difference exists between them. Based on these data, the relationship was then tested using a binomial distribution whereby the probability of the processes being either the same or different, is equal. In other words:

$$p(\text{processes are the same}) = p\ (\text{processes are different}) = 0.5,$$

where p ( ) is the probability function. The resulting distribution from this analysis is depicted in Figure 47.

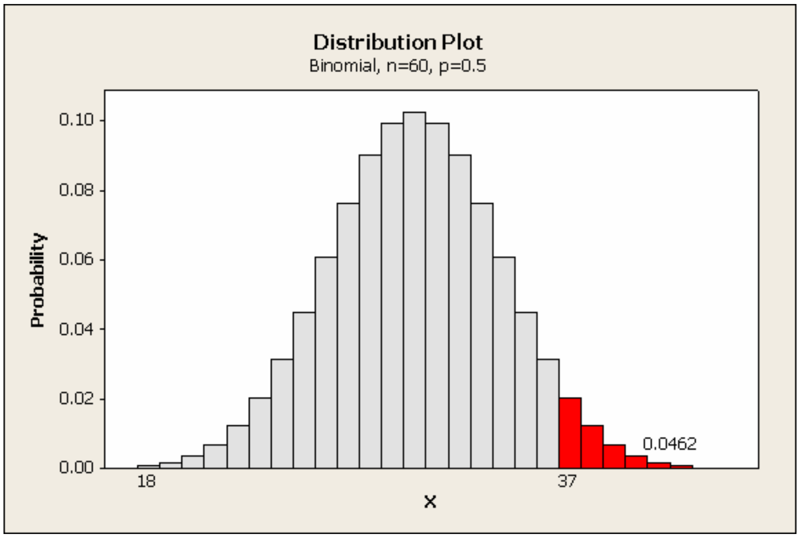


Figure 47: Binomial Distribution Plot for n = 60, p = 0.5

It should be noted that at least 37 responses with a rating of ≥ 4, shaded in red in Figure 47, were needed in order to reject the null hypothesis at $\alpha = 0.05$. From these data, we conclude that a statistically significant difference exists between strategic layer and operational layer processes.

Other Observations / Discussion:

The fact that executives indicated that they believe that the focus and intent of strategic processes are fundamentally different than operational processes was expected. Data collected from the executive interviews supports the data collected from the survey. It is worth noting that each interview commenced with the question: "How do you think about strategic versus operational processes?" Select comments from the interviewees relative to both strategic and operational processes, respectively, are noted below:

Interviewee Comments: Strategic Process:

- The major difference between them is: "simply today versus tomorrow things";
- "Strategy: is goal-driven; it is the future looking back; operational processes are more data-driven";
- One respondent spoke at length about the specific characteristics of strategy and strategic processes: "Here's how I think about the characteristics of strategy:

nonlinear; not directly correlated to today; always look at the future; choice focus; executives typically don't understand what they need; they are way too precise on information that often doesn't matter; they don't start with a choice focus and the information needed to support those choices; they really need to understand what strategic choices to make and the information to support those choices"

Interviewee Comments: Operational Process:

- "Here are some characteristics of operations: keeping business as it stands now and running well; ensure that we're meeting goals for the current year; difference is like the difference between steering an aircraft carrier and a speedboat";
- "The difference between strategy and operations and their respective processes is encapsulated by 3 things: timescale, scope, and depth";
- "99% of the people in a company are operations-focused; they tend to be prejudiced and biased toward day-to-day things"

Interviewees were also asked to comment on how they apportioned their time between strategic and operational processes. Eight of ten interviewees responded that they spend more than 90% of their time on operations-related processes and issues. For comparison, one executive provided a detailed breakdown of time allocation: "In the aggregate, I spend about most of my time on operations-related things but it breaks down something like this:

- 1/3rd: Executive level matters; of that (50%strategic, 50% operational).
- Weekly staff meetings including the 5 EVP's / strategy / BD / CTO / CFO
- Strategic business reviews whereby all attend
- 1/3rd: Enterprise operations (66% strategic applications for what we're doing on a daily basis)
- 1/3rd: Communication plan (people and customers), and evangelism / spreading the word in the market about what we're doing"

8.3.2 Process Coupling

For technology and systems engineering-centric enterprises such as those in the aerospace and defense sector, the challenge of creating and sustaining competitive advantage goes beyond the drive for cost reductions. We postulate that operational efficiencies and other enterprise performance enhancing synergies may emanate due to closer alignment / coupling between operational and strategic processes. We also postulate that such alignment / coupling will have a positive effect on overall enterprise performance. Specifically, we investigate the proposed relationship depicted in Table 30.

Table 30: Coupling Between Enterprise Processes

H1 (a)	*Strategic layer processes and operational layer processes are different.*
H1 (b)	**Strategic and operational processes that are tightly coupled will have a positive relationship with enterprise performance.**
H1 (c)	*The use of capability / process maturity models will not have a positive relationship with enterprise performance.*
H1 (d)	*The use of capability / process maturity models will not have a positive relationship with the use of mechanisms to link business operations to strategy.*
H1 (e)	*The level of process maturity will be greater among high performing enterprises than among low performing enterprises.*

The construct and execution of both strategic and operational processes is critical to enterprise performance (see Chapter 3). Relationship H1 (b) examines the extent to which tightly coupled strategic and operational processes result in better enterprise performance. Two factors were used in order to test this relationship: (1) survey Question 11: "To What Extent do You Agree That Strategic and Operational Processes Are Coupled / Integrated in Your Firm?", and (2) seven components that measure enterprise performance: short-term profitability, long-term profitability, customer satisfaction/loyalty, financial resources/liquidity, available cash/investment capacity, people capabilities/execution, and industry perception of their enterprise as a "thought leader". It is noteworthy to mention that six of the seven performance criteria are focused more on operational versus strategic considerations since enterprises currently use predominantly financial metrics in order to evaluate performance (see Chapter 2).

Based on the following analyses, relationship H1 (b) is accepted; i.e., an enterprise exhibits greater performance when a tighter coupling exists between its strategic and operational processes. Figure 48 displays the overall response to Question 11:

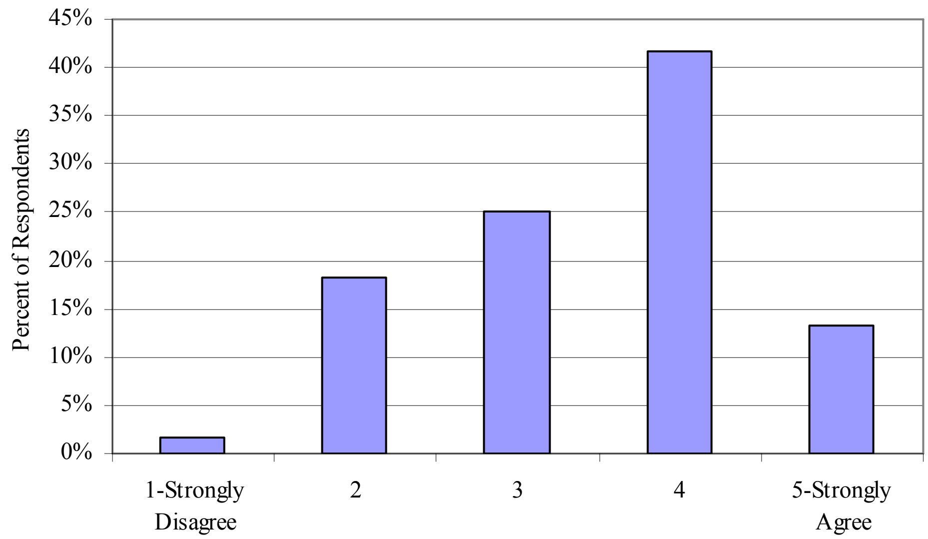


Figure 48: Processes Coupling Within an Enterprise

Next, we test average enterprise performance versus the response to Question 11 about process coupling. In order to assess performance, respondents were asked to rate, on a scale from 1, “Very Weak”, to 5, “Very Strong”, the performance of their enterprise relative to its industry sector (aerospace and defense) average, or to comparable organizations and or competitors against the seven components of enterprise performance listed above.

It is important to note the following distinction: the term "overall enterprise performance" is a collective measure of the seven different performance-related questions asked in the survey. Therefore, each respondent has his / her own score for enterprise performance. AEP, or "average enterprise performance", is taken as the average of all enterprise performance scores within each category of response to Question 11, on a scale from 1, "Strongly Disagree", to 5, "Strongly Agree". The result of this analysis, that enterprise performance improves as processes are more tightly coupled, is depicted in Figure 49.

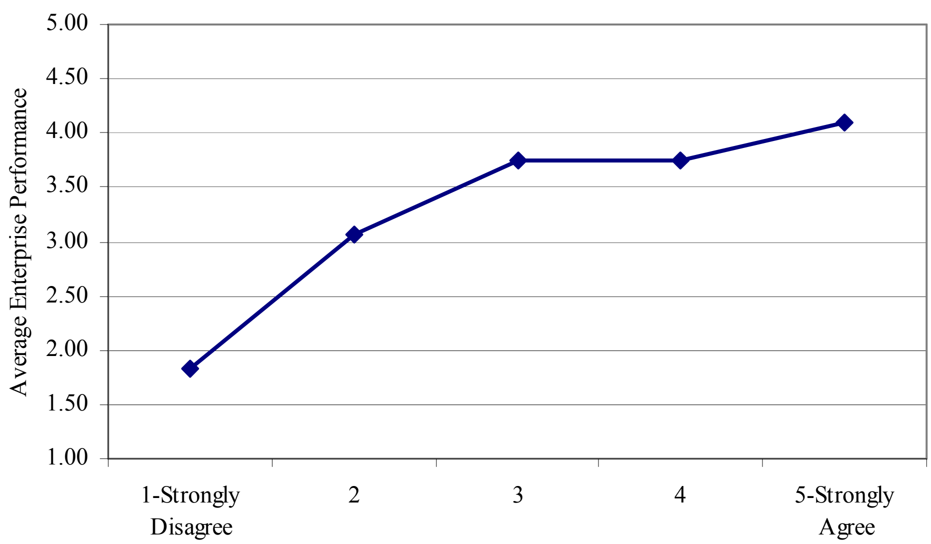


Figure 49: Average Enterprise Performance versus Degree of Process Coupling

A more in-depth analysis was conducted via the following three analyses: Linear Regression, Correlation Coefficient, and ANOVA using GLM.

- Linear Regression: A linear regression of Enterprise performance on the Degree of Process Coupling was performed resulting in a P-Value of 0.001, an R2 of 17.7%, and an adjusted R2 of 16.3%. The slope of the fitted line is 0.338.
- Correlation Coefficient and P-Values: Figure 50 depicts the correlations between the response to Question 11 and enterprise performance, as well as each of the seven measures of enterprise performance.

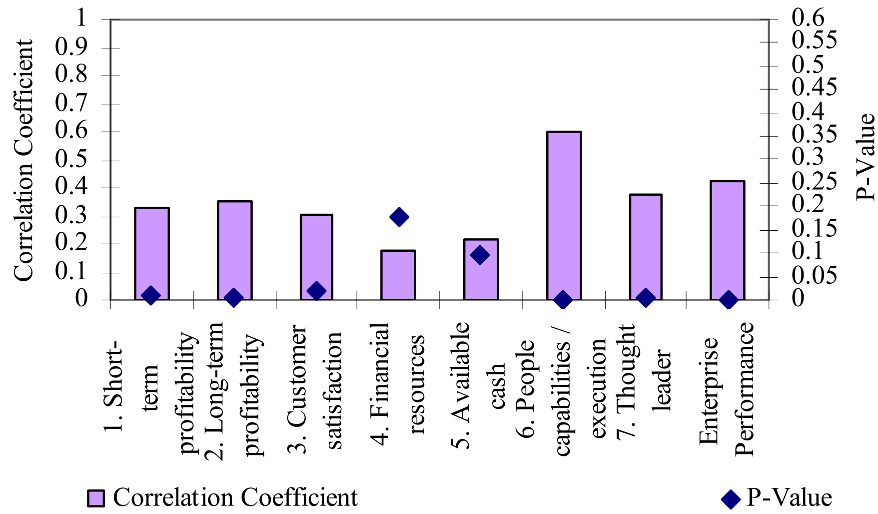


Figure 50: Correlation and Significance: Degree of Process Coupling and Enterprise Performance

As depicted in Figure 50, the degree of process coupling is highly correlated with overall enterprise performance, but has a lower and insignificant correlation with both financial resources and available cash.

<u>ANOVA using GLM</u>: A GLM of Enterprise performance on the Degree of Process Coupling was performed resulting in a P-Value of 0.012, an R2 of 14.47%, and an adjusted R2 of 11.46%. Figure 51 shows the change in the level of mean enterprise performance relative to changes in the level of the predictor variable, degree of process coupling. To conduct ANOVA using GLM, the predictor and response variables can be assigned a relative ranking based on their scores obtained using a five point Likert scale as follows:

- Score of less than or equal to 2 Low
- Score between 2 and 4 Medium
- Score greater than or equal to 4 High

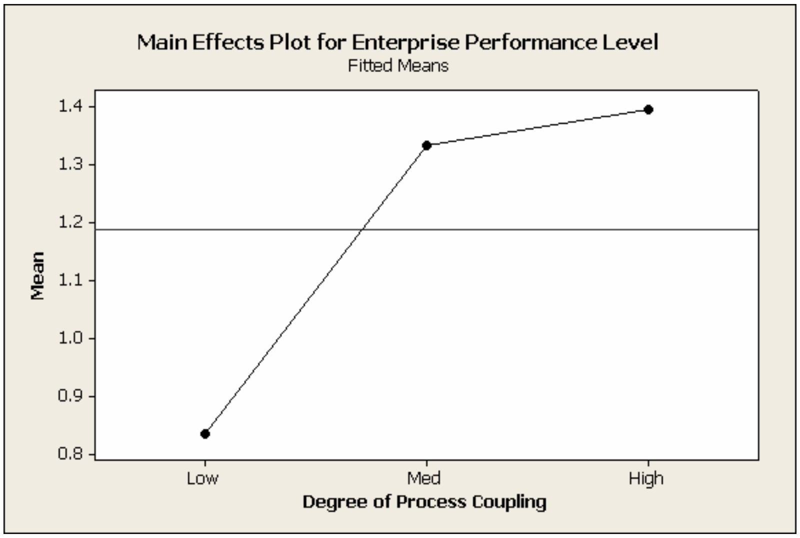


Figure 51: Main Effects Plot: Relationship H1 (b)

Both the above tests, respectively, show that coupling between strategic and operational processes is a predictor of enterprise performance.

General Observations / Discussion:

Executive interviewees were also queried about process coupling; in fact, the data collected from the interviews motivated its inclusion in the web-based survey. Interviewees were asked the following question: "On a Scale from 1 to 5, With 5 Being Tightly Coupled / Seamlessly Integrated, and 1 Not Being Integrated at All, How Would You Assess the Extent to Which the Respective Processes Are Coupled"? Across the 10 interviewees, the average response was 2.15. This may indicate that most executives believe that their strategic and operational processes are not very coupled / integrated. Some observations are noted from the interview data:

- "My preference would be to have them much more tightly coupled, but that's hard in a decentralized organization";
- One executive actually provided a score of -1.0: "It's beyond no correlation: strategy is run purely as a periodic process";
- "Doing strategy is not a very customary thing; its done in more of an ad hoc manner, and hard to couple with other processes";

- "Executives tend to adapt strategic processes only to the data that they have; by doing this they are not correcting for operational biases. The problem is they don't have nearly as much information to do things that are strategic versus things that are operational; so, sometimes they are coupled, sometimes they are completely separated"

In order to attain amplifying information, we asked interviewees who in the organization determines the extent to which processes are/are not coupled? Five of the ten interviewees responded to the question; all were in agreement that the CEO and or the senior leadership team set the culture of the organization, so it "is a management decision".

8.3.3 Maturity Models Versus Enterprise Performance

The objective of this proposed relationship is threefold: (1) ascertain the extent to which an enterprise employs capability / process maturity models, (2) understand the relationship between such models, and (3) determine whether or not enterprise performance is affected by the employment of such artifacts. The specific relationship is depicted in Table 31.

Table 31: Capability / Process Maturity Models versus Enterprise Performance

H1 (a)	*Strategic layer processes and operational layer processes are different.*
H1 (b)	*Strategic and operational processes that are tightly coupled will have a positive relationship with enterprise performance.*
H1 (c)	**The use of capability / process maturity models will not have a positive relationship with enterprise performance.**
H1 (d)	*The use of capability / process maturity models will not have a positive relationship with the use of mechanisms to link business operations to strategy.*
H1 (e)	*The level of process maturity will be greater among high performing enterprises than among low performing enterprises.*

Question 13 from the survey: "To What Extent do you Agree That Your Firm Uses Capability / Process Maturity Models That Describe the Characteristics of Effective Processes?", and the seven components that measure enterprise performance described earlier were used to test this proposed relationship. Based on the following analysis, hypothesis H1 (c) is rejected; Figure 52 displays the overall response to Question 13:

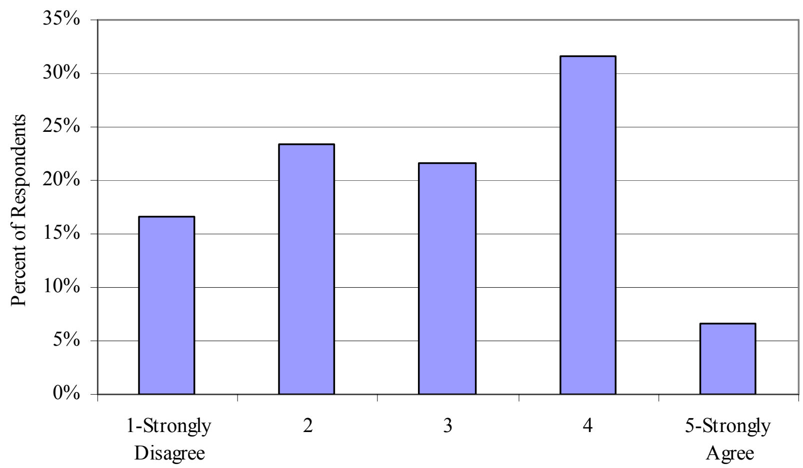


Figure 52: Extent to Which Capability/ Process Maturity Models Are Used Within an Enterprise

Next, we test average enterprise performance versus the response to Question 13 about the use of capability/process maturity models. In order to assess performance, respondents were asked to rate, on a scale from 1 (Very Weak), to 5 (Very Strong), the performance of their firm relative to the industry sector (aerospace and defense) average, or to comparable organizations and or competitors against seven specific. The result of this analysis, that average enterprise performance increases with the use of capability/process maturity models, is depicted in Figure 53.

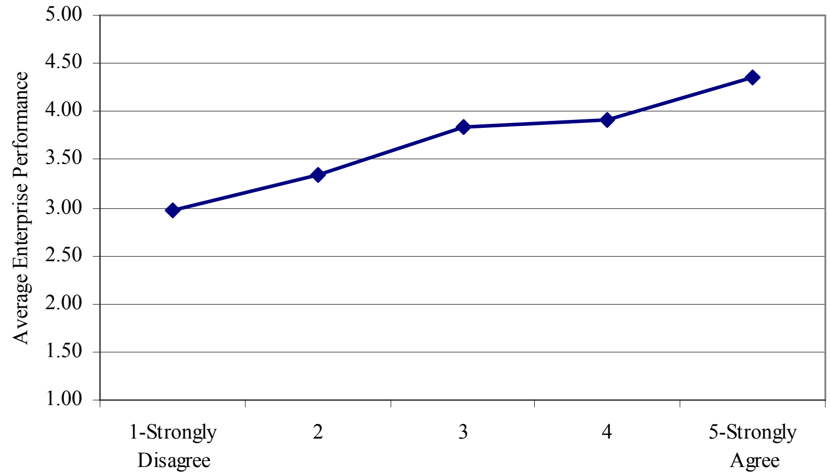


Figure 53: Average Performance versus Use of Capability / Process Maturity Models

A more in-depth analysis was conducted via the following three analyses: Linear Regression, Correlation Coefficient, and ANOVA using GLM.

<u>Linear Regression</u>: A linear regression of enterprise performance on the "Use of Capability / Process Maturity Models" was performed resulting in a P-Value of 0.000, an R2 of 23.4%, and an adjusted R2 of 22.1%. The slope of the fitted line is 0.317. A linear regression of the "Thought Leader" measure of enterprise performance on the response to Question 13 was also performed. This resulted in a P-Value of 0.483, an R2 of 0.9%, and an adjusted R2 of 0.0%. The slope of the fitted line is 0.0682.

<u>Correlation Coefficient and P-Values</u>: Figure 54 depicts the correlations between the response to Question 13 and each of the seven measures of enterprise performance.

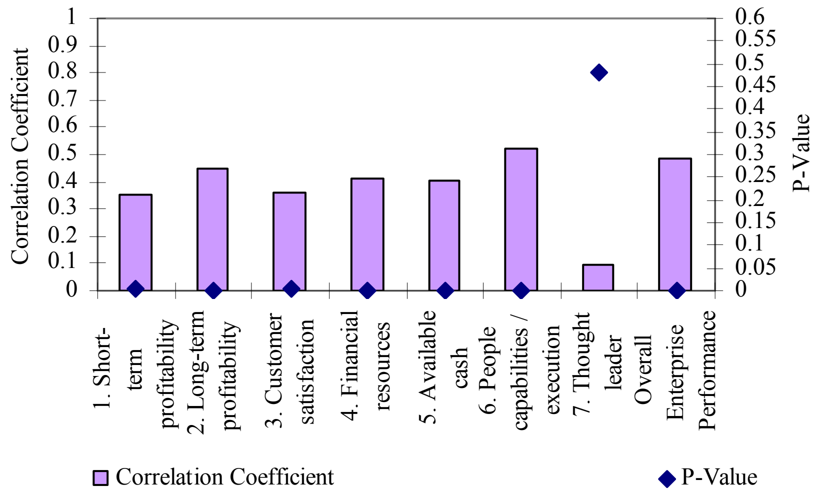


Figure 54: Correlation and Significance:
Use of Capability / Process Maturity Models and Enterprise Performance

From Figure 54, overall enterprise performance shows a high correlation with the use of capability/process maturity models. However, this is in stark contrast to the result obtained when the predictor variable is compared to the correlation and P-Value obtained for the "Thought Leader" measure. Of the seven measures of enterprise performance, only this measure is not operations-focused. This might indicate that the degree of process coupling is stronger for enterprises that are more operations-focused that strategic in orientation.

ANOVA using GLM: A GLM of enterprise performance on the Use of capability / process maturity models was performed resulting in a P-Value of 0.006, an R2 of 16.34%, and an adjusted R2 of 13.41%. Figure 55 shows the change in the level of mean enterprise performance relative to changes in the level of the predictor variable, the use of capability / process maturity models.

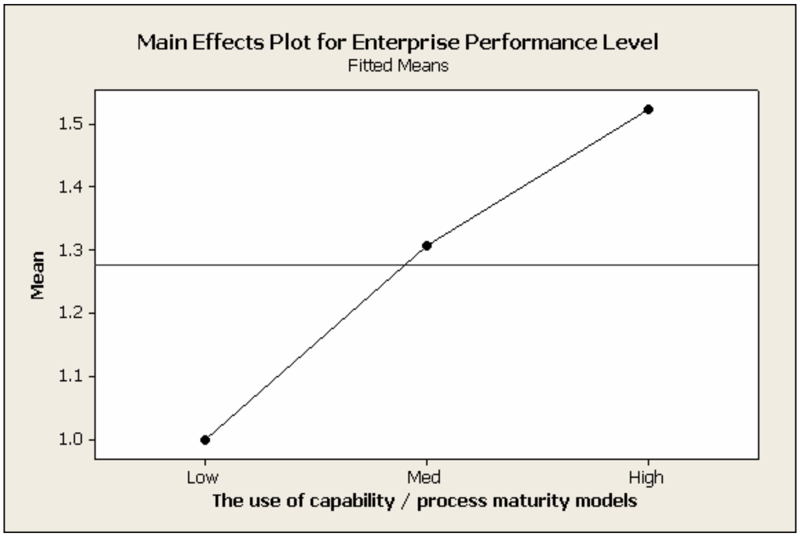


Figure 55: Main Effects Plot: Relationship H1 (c)

Further, a GLM of the "Thought Leader" measure of enterprise performance on the "Use of Capability / Process Maturity Models" question was performed. This results in a P-Value of 0.216, an R2 of 5.23%, and an adjusted R2 of 1.90%. This is consistent with the result obtained from correlations above.

Other Observations / Discussion:

Results from the interview data are compared to the average response to Question 13. Interviewees were asked to comment, qualitatively, as about the extent to which their enterprise employs capability / process maturity models. Seven of ten responded no; several interviewees were not aware of such models. The average survey response to Question 13 was 2.88. This may indicate that survey respondents neither strongly agreed nor disagreed. Other observations are noted as follows:

- Correlation to the "Thought Leader" measure; both the Pearson correlation and GLM indicate no relation;
- Given the fact that 6 out of 7 performance questions are operations-focused, the strong correlation is suggestive of the fact that enterprises have adequate levels of capability / process maturity models that are oriented towards the operational processes;

- The strongest correlation was with people capabilities / execution: for that survey respondents indicated that the enterprise has very good process models.

8.3.4 Business Operations and Strategy Linkages

In the following, survey respondents were asked to comment on the extent to which capability / process maturity models are used in conjunction with tools that help translate the strategic objectives of the enterprise into measures of operational performance. Perhaps the most well known of these mechanisms is the Balanced Scorecard which was described earlier in Chapter 4. (See Appendix G for a list of other such mechanisms). The specific relationship to be evaluated is depicted in Table 32

Table 32: Business Operations and Strategy Linkages

H1 (a)	*Strategic layer processes and operational layer processes are different.*
H1 (b)	*Strategic and operational processes that are tightly coupled will have a positive relationship with enterprise performance.*
H1 (c)	*The use of capability / process maturity models will not have a positive relationship with enterprise performance.*
H1 (d)	**The use of capability / process maturity models will not have a positive relationship with the use of mechanisms to link business operations to strategy.**
H1 (e)	*The level of process maturity will be greater among high performing enterprises than among low performing enterprises.*

The following questions from the survey were used to test the relationship:

Q. 12	"To what extent do you agree that your firm uses a balanced set of metrics to translate your firm's mission statement into quantifiable measures to gauge whether or not the desired result is being achieved"?
Q. 13	"To what extent do you agree that your firm uses capability / process maturity models that describe the characteristics of effective processes"?

Based on the following analysis, relationship H1 (d) is rejected, Figure 56 displays the overall responses to Questions 12 and 13.

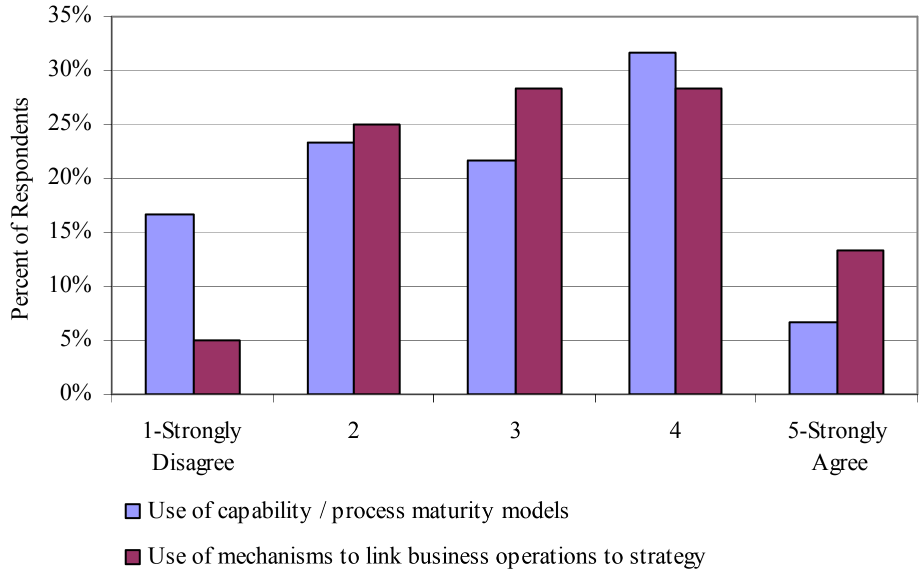


Figure 56: Responses to Questions 12 and 13

Figure 57 depicts the average response to Question 12 versus each category of response to Question 13.

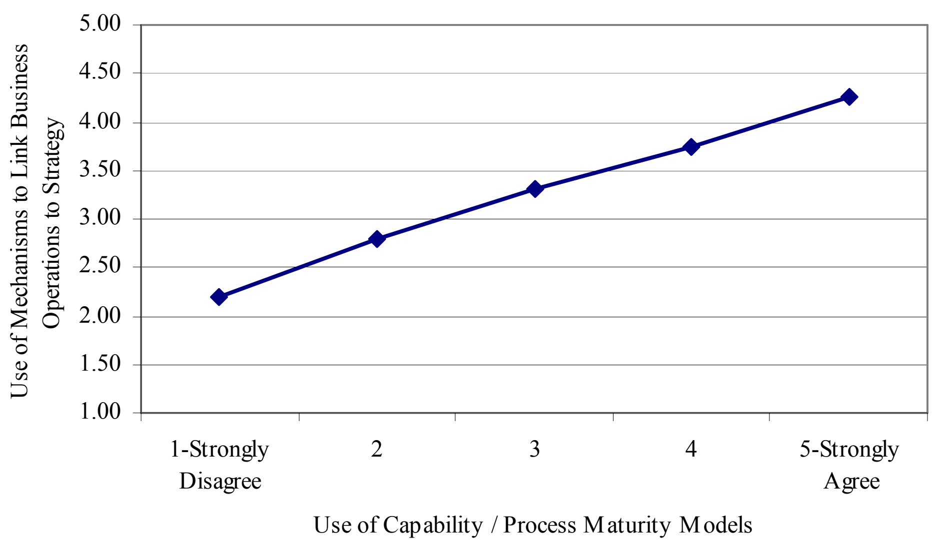


Figure 57: Models versus Mechanisms to Link Strategy to Operations

A more in-depth analysis was conducted via the following three analyses: Linear Regression, Correlation Coefficient, and ANOVA using GLM.

Linear Regression: A linear regression of the response to Question 12 on the response to Question 13 was performed resulting in a P-Value of 0.001, an R2 of 30.4%, and an adjusted R2 of 29.2%. The slope of the fitted line is 0.503.

Correlation Coefficient and P-Values: Figure 58 depicts the correlations between the response to Question 12 and the response to Question 13.

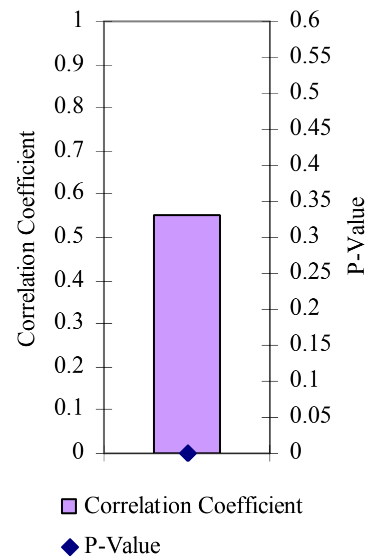


Figure 58: Correlation and Significance: Use of Capability / Process Maturity Models and use of Mechanisms to Link Business Operations to Strategy

ANOVA using GLM: A GLM of the response to Question 12 -- on the response to Question 13 -- was performed resulting in a P-Value of 0.000, an R2 of 23.82%, and an adjusted R2 of 21.15%. Figure 59 shows the change in the level of the response to Question 12 [mechanisms to link business operations to strategy], relative to changes in the level of the predictor variable, Question 13 [use of capability / process maturity models].

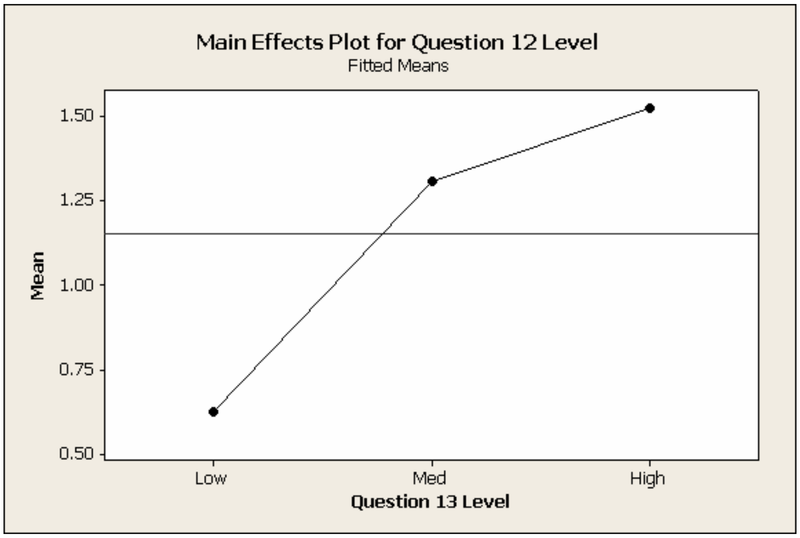


Figure 59: Main Effects Plot: Relationship H1 (d)

Other Observations / Discussion

It has already been shown that the employment of capability / process maturity models has a positive effect on enterprise performance, even though the interview data revealed that seven of ten executives said their enterprise did not employs capability / process maturity models. Here, five of ten interviewees commented that their organizations did not employ a balanced scorecard of similar mechanism. It is also noted that the average response to Question 12 was 3.2 which may be indicative of a "middle-of-the-road" response in that some executives are aware of the existence and potential benefits of such mechanisms, while others are not. For those executives that indicated that their organizations did not employ such a mechanism, the general consensus seemed to be that they are not "doing that now, but it's a logical next step given all the initiatives we've undertaken to try to connect our business and technology folks". However, given that both the Pearson correlation and GLM show a strong relationship between the two, this may indicate that enterprises that are process-driven tend to focus on both.

8.3.5 Process Maturity and Enterprise Performance

Thus far, we have shown that both interviewees and survey respondents agree that there are significant differences between processes that are strategic and those that are operational. It has also been shown that both a tight coupling of these processes, and the use of capability/process maturity models, each have a positive correlation with enterprise performance. Here, process maturity is taken as the amalgam of the following: (1) process coupling, (2) the use of a set of balanced metrics to translate the firm's mission into actionable tasks and activities, and (3) the use of capability / process maturity models. The proposed relationship between process maturity and enterprise performance is depicted in Table 33.

Table 33: Business Operations and Strategy Linkages

H1 (a)	*Strategic layer processes and operational layer processes are different.*
H1 (b)	*Strategic and operational processes that are tightly coupled will have a positive relationship with enterprise performance.*
H1 (c)	*The use of capability / process maturity models will not have a positive relationship with enterprise performance.*
H1 (d)	*The use of capability / process maturity models will not have a positive relationship with the use of mechanisms to link business operations to strategy.*
H1 (e)	**The level of process maturity will be greater among high performing enterprises than among low performing enterprises.**

The following questions collectively measure the level of process maturity within the enterprise and are used along with the seven indicators that measure enterprise performance to test the proposed relationship:

Q. 11	"To what extent do you agree that strategic and operational processes are coupled / integrated in your firm"?
Q. 12	"To what extent do you agree that your firm uses a balanced set of metrics to translate your firm's mission statement into quantifiable measures to gauge whether or not the desired result is being achieved"?
Q. 13	"To what extent do you agree that your firm uses capability / process maturity models that describe the characteristics of effective processes"?

Based on the following analysis, proposed relationship H1 (e) is accepted; Figure 60 displays the overall responses to Questions 11, 12, and 13:

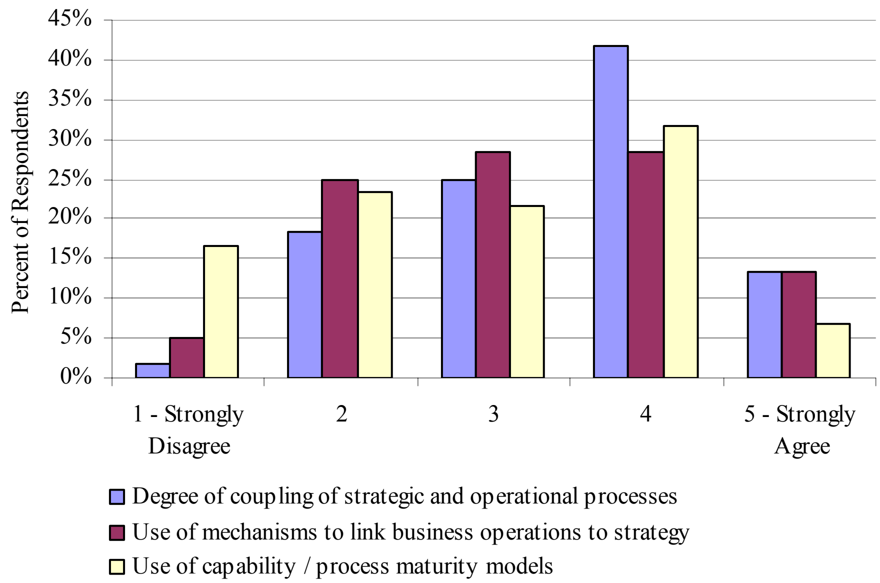


Figure 60: Responses to Questions 11, 12 and 13

A more in-depth analysis was conducted via the following three analyses: Linear Regression, Correlation Coefficient, and ANOVA using GLM.

<u>Linear Regression</u>: A linear regression of enterprise performance on Process Maturity was performed resulting in a P-Value of 0.000, an R2 of 42.9%, and an adjusted R2 of 41.9%. The slope of the fitted line is 0.597 and is depicted in Figure 61.

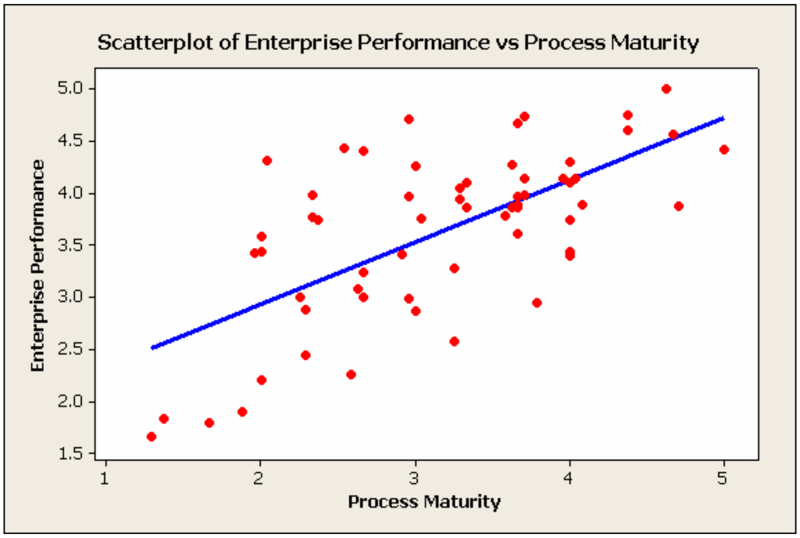


Figure 61: Linear Regression of Enterprise Performance on Process Maturity

A summary of the regression analysis is depicted in Table 34.

Table 34: Prediction of Enterprise Performance From Process Maturity

Enterprise Performance = 1.74 + 0.597 Process Maturity

Predictor	Coef	SE Coef	T	P
Constant	1.7434	0.2973	5.86	0.000
Process Maturity	0.59653	0.09035	6.6	0.000
S = 0.611593	R-Sq = 42.9%	R-Sq(adj) = 41.9%		

Correlation Coefficient and P-Values: Figure 62 depicts the correlations between Process Maturity and each of the seven measures of enterprise performance, as well as enterprise performance. We see that there is a high degree of correlation with enterprise performance as well as each of the seven components of enterprise performance.

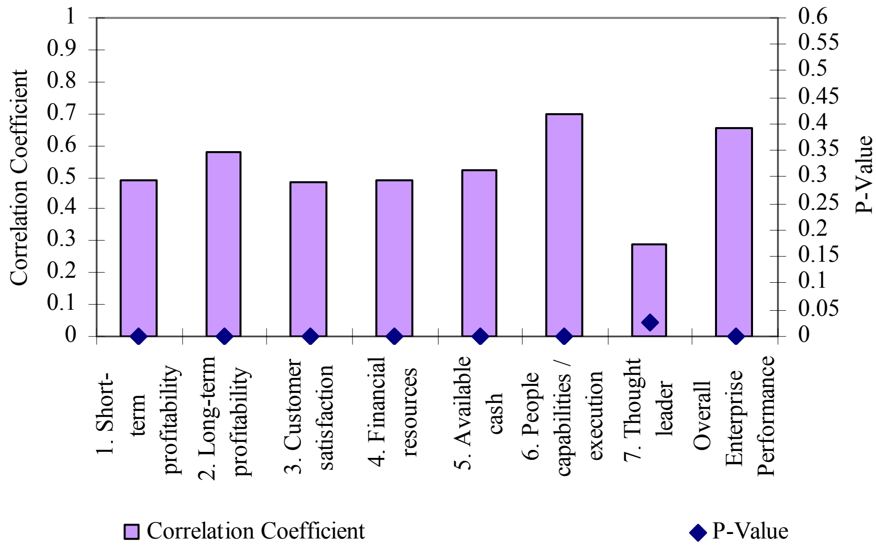


Figure 62: Correlation and Significance: Process Maturity and Enterprise Performance

ANOVA using GLM: A GLM of enterprise performance on the level of Process Maturity was performed resulting in a P-Value of 0.000, an R2 of 32.17%, and an adjusted R2 of 29.79%. Figure 63 shows the change in mean enterprise performance level relative to changes in the level of the predictor variable, the level of process maturity.

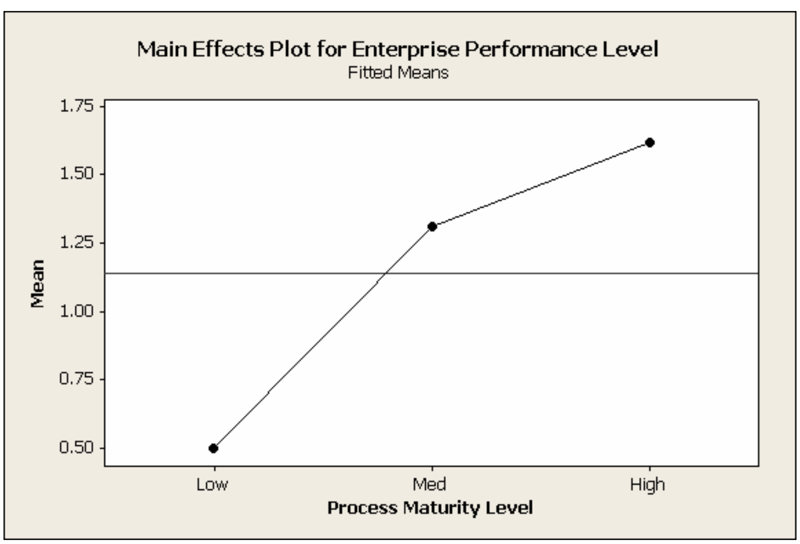


Figure 63: Main Effects Plot: Relationship H1 (e)

8.3.6 Summary

The investigation of process maturity is the first in a series of four analyses in order to determine the overall maturity of the ESA. Analysis of the survey data indicate that a correlation exists between process maturity and higher enterprise performance. This may indicate that enterprises that are more process-driven tend to perform better than those that are not. A summary of the enterprise process-related relationships, specific analyses conducted, and the outcome of each is presented in Table 35.

Table 35: Enterprise Processes

	Proposed Relationship	**Analyses Conducted**	**Outcome**
Enterprise Processes (Measurement of Process Maturity)			
H1 (a)	Strategic layer processes and operational layer processes are different.	• Hypothesis testing using Binomial Distribution	Accepted
H1 (b)	Strategic and operational processes that are tightly coupled will have a positive relationship with enterprise performance.	• Correlation Coefficient and P-Value • Linear Regression • ANOVA using General Linear Model (GLM)	Accepted
H1 (c)	The use of capability / process maturity models will not have a positive relationship with enterprise performance.	• Correlation Coefficient and P-Value • Linear Regression • ANOVA using GLM	Rejected
H1 (d)	The use of capability / process maturity models will not have a positive relationship with the use of mechanisms to link business operations to strategy.	• Correlation Coefficient and P-Value • Linear Regression • ANOVA using GLM	Rejected
H1 (e)	The level of process maturity will be greater among high performing enterprises than among low performing enterprises.	• Correlation Coefficient and P-Value • Linear Regression • ANOVA using GLM	Accepted

8.4 ESA Dimensional Analysis: Technology-Based Support of Enterprise Processes

This section builds on the investigation of strategic and operational processes. Here, respondents were asked to comment on the extent to which these processes either are or are not supported by their enterprise's current information systems. Specifically, we investigated this, the second dimension of the ESA, a measurement of information systems maturity, via three proposed relationships: (1) information systems and strategic processes, (2) information systems and support of operational processes, and (3) information support of operational processes and enterprise performance. The following hypotheses around technology-based support of enterprise processes are depicted in Table 36.

Table 36: Proposed Relationships for Technology-Based Support of Enterprise Processes

Technology-Based Support of Enterprise Processes (Measurement of IS Maturity)	
H2 (a)	Information systems and support of strategic layer processes will have a negative relationship with each other.
H2 (b)	Information systems and support of operational layer processes will have a positive relationship with each other.
H2 (c)	Information system support of operational layer processes will be greater among high performing enterprises than among low performing enterprises.

8.4.1 Information Systems and Strategic Layer Processes

Here, we investigate the relationship between an enterprise's information systems and how well they support its strategic processes. The specific relationship to be evaluated is depicted in Table 37.

Table 37: Information Systems and Strategic Layer Processes

H2 (a)	**Information systems and support of strategic layer processes will have a negative relationship with each other.**
H2 (b)	*Information systems and support of operational layer processes will have a positive relationship with each other.*
H2 (c)	*Information system support of operational layer processes will be greater among high performing enterprises than among low performing enterprises.*

Questions 15 - 19 from the web-based survey were used to test this relationship. Respondents were asked to indicate the extent to which their enterprise's current information systems are able to support and / or enable the execution of the following strategic processes.

"For questions 15 to 19, please indicate the extent to which your firm's current information systems support / enable the execution of the following strategic processes".

Q. 15	Acquiring situation awareness
Q. 16	Enterprise strategy development
Q. 17	Strategic decision making
Q. 18	Communication of intent
Q. 19	People strategy

Based on the following analysis, proposed relationship H2 (a) is rejected. In order to provide a more thorough investigation of information system support of strategic processes, we began by ascertaining: (1) the relative importance of each strategic process, and (2) the relative value of each process to be supported / represented by an information system. Using Question 8 as the measurement factor, the relative ranking of each strategic process was tabulated; Question 21 was used as the measurement factor for determining the value each process to be supported by an information system. Those data are depicted in Figure 64.

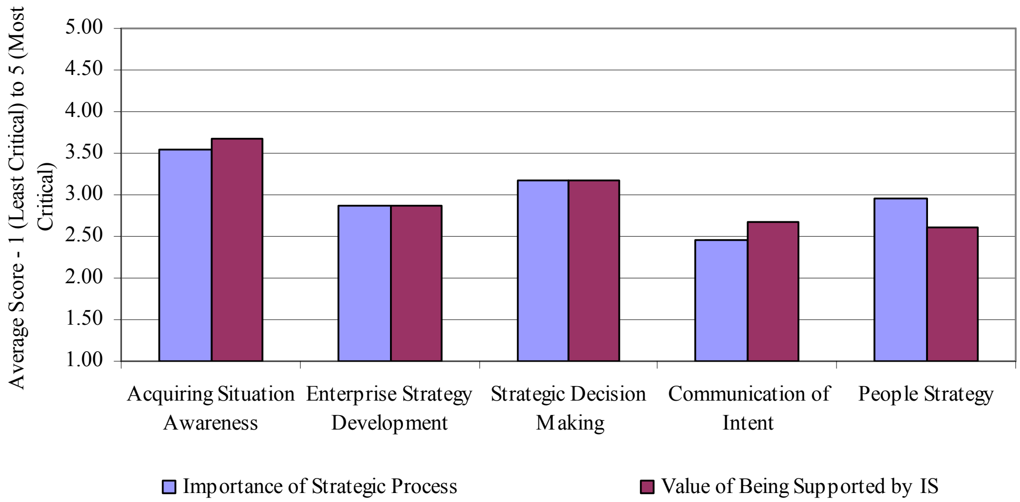


Figure 64: Relative Importance-Level Ranking of Strategic Processes

Respondents indicated that acquiring and maintaining situational awareness is the most important of all the strategic processes; they also indicated that this strategic process would be the most valuable to be supported by an information system. The two are highly correlated with a Correlation Coefficient of 0.451, and a P-Value of 0.000. It should also be noted that the ranking of the top three strategic processes, “Situation Awareness”, “Strategic Decision Making”, and “Enterprise Strategy Development”, follows the same pattern for the value of it being supported by an information system. For the strategic processes “Communication of Intent” and “People Strategy”, respectively, the relative rank did not match the value of being supported by an information system.

Other Observations / Discussion:

In general, five survey respondents indicated that strategic processes are not supported by current information systems; i.e., a score of less than or equal to 2. However, when respondents who scored 3 or less were considered, the number of respondents who felt that strategic processes are not supported by current information systems increased from 5 to 27. These data are depicted in Figure 65.

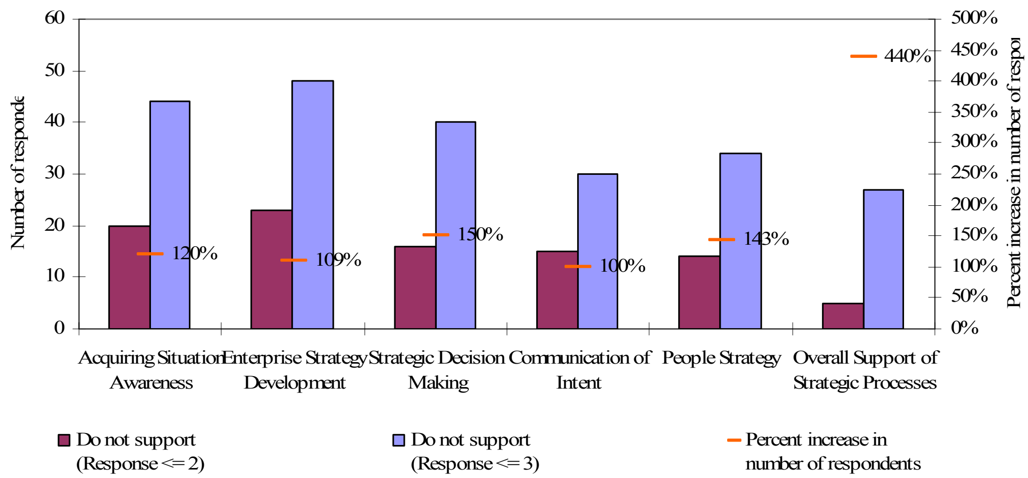


Figure 65: Information Systems and Support of Strategic Layer Processes

Consequently, with 27 of 60 respondents scoring 3 or less, this may indicate: (1) that the nature of how these processes either are or could be supported by current information systems is not clear, (2) it is not within the executives' purview to know or be concerned with the extent to which these processes are supported, and (3) This may indicate that a large number of executives do not perceive that information systems support strategic processes.

In order to seek further clarity, an additional analysis was conducted that compared the rank of each strategic process, enterprise performance, and information system support of that process. For each of the five strategic processes, its relative ranking was graphed alongside each of the seven performance questions, and respondent preferences for information system support of that processes (please see Appendix G for these graphs). Results indicate that for each strategic process for which support by an information system was low; i.e., a score of 2 or less, aggregate enterprise performance was lower than the aggregate enterprise performance for which support by an information system was high; i.e., a score of greater than 4. Further, the same result was attained when the analysis was conducted using each dimension of enterprise performance instead of aggregate enterprise performance.

It is interesting to note from the interview data that 8 of 8 interviewees (note: only eight interviewees were solicited) commented that current information systems do not support strategic level processes. In fact, there were strong reactions from each interviewee. The following observations and comments were noted:

- Several respondents commented that operational processes have a strategic component to them, and vice-versa. Take for example, the strategic process of SA. In order to maintain a high degree of situational awareness, information must be gleaned from both from internal operations and from sources exogenous to the enterprise. This may indicate that the orientation of enterprise information systems is skewed toward capturing internal / transactional data versus those data exogenous to the enterprise. Consequently, it is unclear whether or not executives believe that current information systems exist to adequately represent / capture the external view of the enterprise;
- "IT and IS does a BAD job on anything that is not transactional in nature"
- "IT/IS is OK for some communications; there are some web-based tools that help. Also for HR, but they are largely transaction driven and defensive in nature. In other words, it's not really helping executives in the strategic planning process"
- Multiple respondents indicated that the order in which the strategic processes were listed in survey Question 8 is how they would rank them in order of importance: acquiring situation awareness, enterprise strategy development, strategic decision making. When the criteria of less than or equal to 3 criteria is applied, these top three strategic processes are not supported by current information systems.

Based on their commentary that their enterprise's current information systems do not support strategic processes, interviewees were asked to comment on: (1) whether or not strategic processes can be supported, and (2) the extent to which they would value a technology-based representation of strategic processes such that they could better visualize and understand problems and /or issues that are germane to such processes. Responses to the first question were mixed. Most interviewees commented that it was possible, but may not be likely due to organizational structure; however: most were of the opinion that it “makes sense to try, particularly for the most important processes such as situation assessment”. Others commented that cost may be a factor in that the “cost of supporting a process could not exceed the value of the system being employed”.

Responses to the second question were solicited from 8 of the 10 interviewees. None were opposed to such a representation. One respondent deemed such a representation to be the “holy grail”, but would probably be very hard to produce; another respondent commented that: “in the absence of such a tool, we’re really had to find a way to work around in order to gain strategic / predictive insights. We do this by using a combination of things: ‘greybeards’, organizations within our own activities, and development planning, that is, planting seeds for desired future technology.”

8.4.2 Information Systems and Operational Layer Processes

Next, we investigated the relationship between an enterprise’s information systems and its operational processes. The specific relationship evaluated is depicted in Table 38.

Table 38: Information Systems and Operational Layer Processes

H2 (a)	*Information systems and support of strategic layer processes will have a negative relationship with each other.*
H2 (b)	**Information systems and support of operational layer processes will have a positive relationship with each other.**
H2 (c)	*Information system support of operational layer processes will be greater among high performing enterprises than among low performing enterprises.*

Questions 22 -26 from the web-based expert survey were used to test this hypothesis. Respondents were asked to indicate the extent to which their enterprise's current information systems are able to support and / or enable the execution of the following operational processes.

"For questions 22 to 26, please indicate the extent to which your firm's current information systems support / enable the execution of the following operational processes.	
Q. 22	Project and program management
Q. 23	Supply chain management
Q. 24	Finance / financial management
Q. 25	Customer service / quality assessment
Q. 26	Human capital management

Based on the following analysis, relationship H2 (b) is rejected. Respondents indicated that the operational process "Customer Service / Quality Assessment" is the most important of all the operational processes. In general, only ten survey respondents indicated that operational processes are supported by current information systems (a score of 4 or more). However, when respondents who scored 3 or more were considered, the number of respondents who feel that operational processes are supported by current information systems increased from 10 to 46. Consequently, with 36 of 60 respondents scoring 3, this may indicate that the nature of how these processes either are supported, or could be supported, by their current information systems is not clear. This result may also suggest that it is not within the executives' purview to know or to be concerned with the extent to which these processes are supported.

Other Observations / Discussion:

Figure 66 depicts two interpretations of the responses to the questions used in order to assess information systems and support of operational processes. The first interpretation, depicted in magenta, shows the aggregate number of responses received that are greater than or equal to 4. A response of greater than or equal to four indicates a relatively strong view that information systems support operational processes. However, as previously determined, an aggregate number 37 responses is needed to statistically conclude that information systems support operational processes. Since the total number of responses for every operational process is less than 37, we reject the proposed relationship between information systems and operational processes.

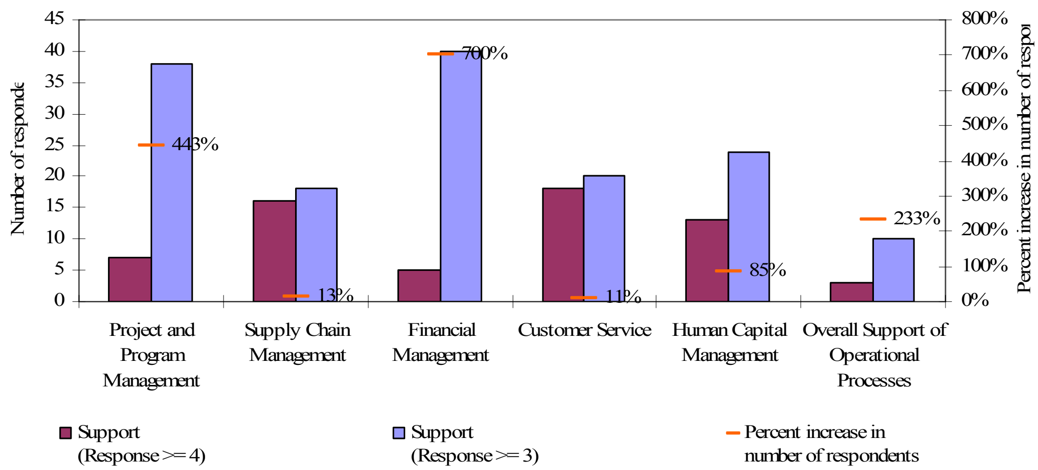


Figure 66: Information Systems and Support of Operational Layer Processes

The second interpretation, depicted in blue, considers all responses that are ≥ 3; the percentage increase in the number of respondents per operational process is also depicted. Here, we see that even with this less strict interpretation, not all operational processes are supported by enterprise formation systems. Only two operational processes, "Project and Program Management", and "Financial Management" are supported by information systems

The results from the survey respondents are incongruous with the interview results in that each interviewee commented that their enterprise information systems not only support operational processes, but they should support the operational processes because that's what they were designed to do. This is because operational processes are mostly focused on capturing transactional data, which is the essence of operational processes.

8.4.3 Operational Layer Processes versus Enterprise Performance

For our final evaluation in this section, we investigate the extent to which information system support of operational processes affects enterprise performance, as is depicted in Table 39.

Table 39: Operational Layer Processes versus Enterprise Performance

H2 (a)	*Information systems and support of strategic layer processes will have a negative relationship with each other.*
H2 (b)	*Information systems and support of operational layer processes will have a positive relationship with each other.*
H2 (c)	**Information system support of operational layer processes will be greater among high performing enterprises than among low performing enterprises.**

Questions 22 through 26 from the web-based survey were used in order to investigate this relationship

For questions 22 to 26, please indicate the extent to which your firm's current information systems support / enable the execution of the following operational processes.	
Q. 22	Project and program management
Q. 23	Supply chain management
Q. 24	Finance / financial management
Q. 25	Customer service / quality assessment
Q. 26	Human capital management

Based on the analyses, the relationship H2 (c) is accepted. A more in-depth analysis was conducted via the following three analyses: Linear Regression, Correlation Coefficient, and ANOVA using GLM.

Linear Regression: A linear regression of enterprise performance on the support of operational processes was performed resulting in a P-Value of 0.000, an R2 of 46.5%, and an adjusted R2 of 45.5%. The slope of the fitted line is 0.771 and is depicted in Figure 67.

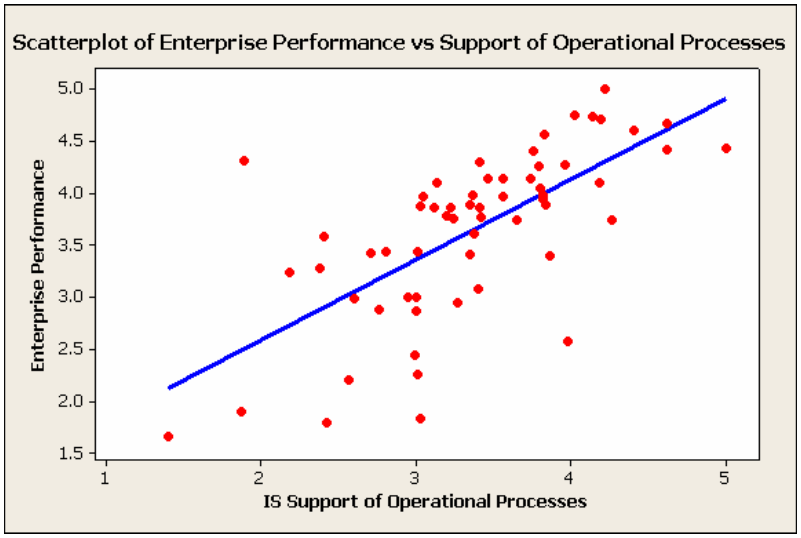


Figure 67: Enterprise Performance versus Support of Operational Processes

Correlation Coefficient and P-Values: Figure 68 depicts the correlations between support of operational processes and enterprise performance, as well as each of the seven measures of enterprise performance.

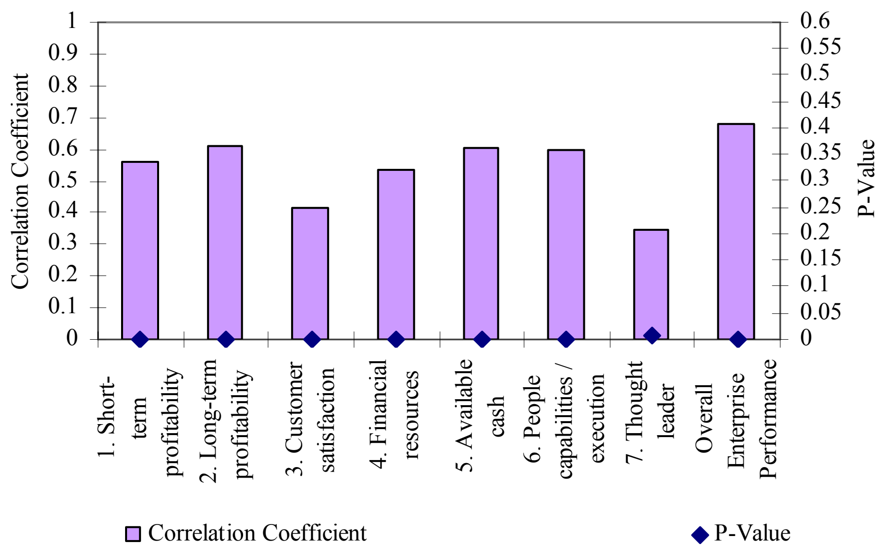


Figure 68: IS Support of Operational Processes and Enterprise Performance

ANOVA using GLM: A GLM of enterprise performance was conducted on information system support of operational processes, resulting in the main effects plot depicted in Figure 69.

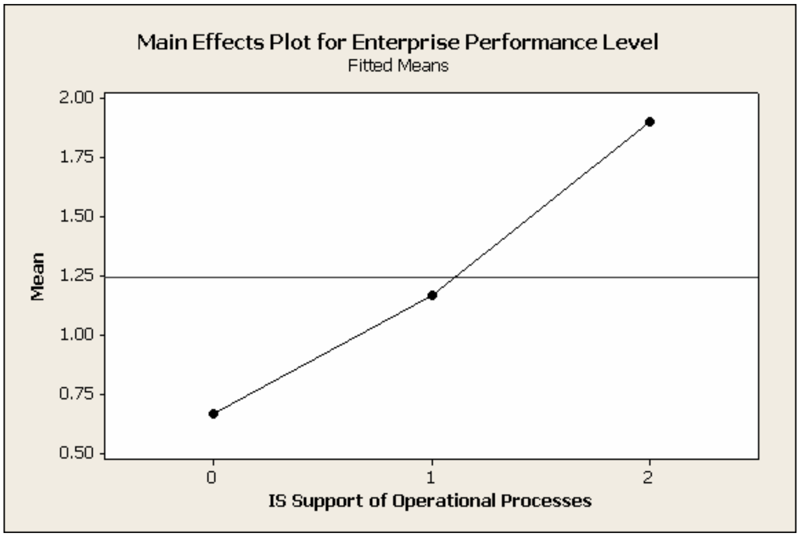


Figure 69: Main Effects Plot: Relationship H2 (c)

Figure 69 shows the change in mean enterprise performance level relative to changes in the predictor variable, the level information system support of operational processes.

Other Observations / Discussion

Based on the data and subsequent analyses, there is a statistically significant result when comparing support of operational processes and enterprise performance.

8.4.4 Summary

The investigation of information systems maturity is the second of four analyses undertaken in order to determine the level of maturity of an enterprise system architecture. The following sections provide an analysis of enterprise technology structure/deployment (information technology maturity), and enterprise architecture, and ESA maturity, respectively.

A summary of the technology-based support of enterprise processes, our measurement of IS maturity, specific analyses conducted, and the outcome of each is presented in Table 40.

Table 40. Technology-Based Support of Enterprise Processes

Proposed Relationship		Analyses Conducted	Outcome
Technology-Based Support of Enterprise Processes			
H2 (a)	IS and support of strategic layer processes will have a negative relationship with each other.	• Hypothesis testing using Binomial Distribution	Rejected
H2(b)	IS and support of operational layer processes will have a positive relationship with each other.	• Hypothesis testing using Binomial Distribution	Rejected
H2 (c)	IS support of operational layer processes will be greater among high performing enterprises than among low performing enterprises.	• Correlation Coefficient and P-Value • Linear Regression • ANOVA using GLM	Accepted

8.5 ESA Dimensional Analysis: Technology Structure / Deployment and Enterprise Architecture

The previous section provided an examination of how current information systems either do or do not support enterprise processes. In this section, we provide an analysis how technology is structured and deployed throughout the enterprise. Comments were also solicited about enterprise architecture. The relationships pertaining to technology deployment / structure and enterprise architecture are depicted in Table 41.

Table 41: Proposed Relationships: IT Maturity and EA Maturity

Technology Structure / Deployment (Measurement of IT Maturity)	
H3 (a)	The level of IS maturity will be greater among high performing enterprises than among low performing enterprises.
H3 (b)	The level of IT maturity will be greater among high performing enterprises than among low performing enterprises.
H3 (c)	Enterprise technology deployment / structure3 and information system maturity will be greater among high performing enterprises than among low performing enterprises.
Enterprise Architecture (Measurement of EA Maturity)	
H3 (d)	The level of EA maturity will be greater among high performing enterprises than among low performing enterprises.

8.5.1 Level of Information System Maturity and Enterprise Performance

Building on the analyses that were conducted in the following section, we now investigate the impact of information systems maturity and enterprise performance. Specifically, the proposed relationship is articulated and highlighted in Table 42.

Table 42: IS Maturity versus Enterprise Performance

H3 (a)	**The level of IS maturity will be greater among high performing enterprises than among low performing enterprises.**
H3 (b)	*The level of IT maturity will be greater among high performing enterprises than among low performing enterprises.*
H3 (c)	*Enterprise technology deployment / structure4 and information system maturity will be greater among high performing enterprises than among low performing enterprises.*
H3 (d)	*The level of EA maturity will be greater among high performing enterprises than among low performing enterprises.*

Given the interviewee responses concerning technology deployment and structure, we probed further into the disparity between what current information technology-based

3 Enterprise technology deployment / structure = IT Maturity
4 Enterprise technology deployment / structure = IT Maturity

systems are able to provide, versus: (1) what executives feel they need to have or would like to have in order to make better strategic decisions, and (2) the information they feel they need in order to make strategic versus operational decisions. The following questions were used to measure enterprise information system maturity:

"For questions 15 to 19, please indicate the extent to which your firm's current information systems support / enable the execution of the following strategic processes"	
Q. 15	Acquiring situation awareness
Q. 16	Enterprise strategy development
Q. 17	Strategic decision making
Q. 18	Communication of intent
Q. 19	People strategy
"For questions 22 to 26, please indicate the extent to which your firm's current information systems support / enable the execution of the following operational processes".	
Q. 22	Project and program management
Q. 23	Supply chain management
Q. 24	Finance / financial management
Q. 25	Customer service / quality assessment
Q. 26	Human capital management
Q. 28	"To what extent do you agree that a gap exists between the information you have access to via your current information systems, versus the information you feel you need to have or would like to have to make better strategic decisions"?
Q. 29	"To what extent do you agree that a gap exists between the information you currently have access to, and the information you feel you need to have access to, to make strategic versus operational decisions"?

Based on the following analysis, hypothesis H3 (a) is accepted. In order to test the hypothesis, three analyses were conducted: linear regression, correlation coefficient, and ANOVA using GLM.

<u>Linear Regression</u>: A linear regression of enterprise performance on information systems Maturity was performed resulting in a P-Value of 0.000, an R2 of 47.1%, and an adjusted R2 of 46.2%. The slope of the fitted line is 0.875 and is depicted in Figure 70.

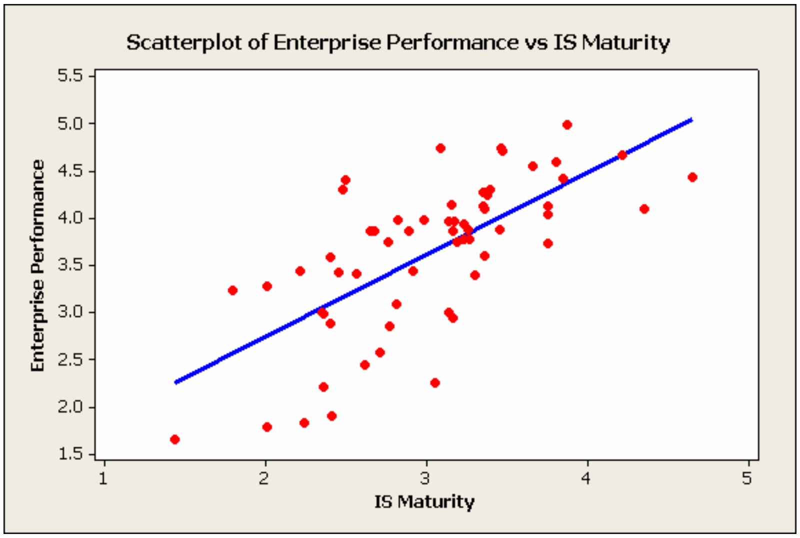


Figure 70: Linear Regression of Enterprise Performance on IS Maturity

A summary of the regression analysis to evaluate information systems maturity as a predictor of enterprise performance is depicted in Table 43.

Table 43: Prediction of Enterprise Performance from IS Maturity

Enterprise Performance = 0.990 + 0.875 IS Maturity

Predictor	Coef	SE Coef	T	P
Constant	0.9900	0.3759	2.63	0.011
IS Maturity	0.8755	0.1218	7.19	0.000
S = 0.588725	R-Sq = 47.1%	R-Sq(adj) = 46.2%		

Correlation Coefficient and P-Values: Figure 71 depicts the correlations between IS Maturity and each of the seven measures of enterprise performance as well as enterprise performance.

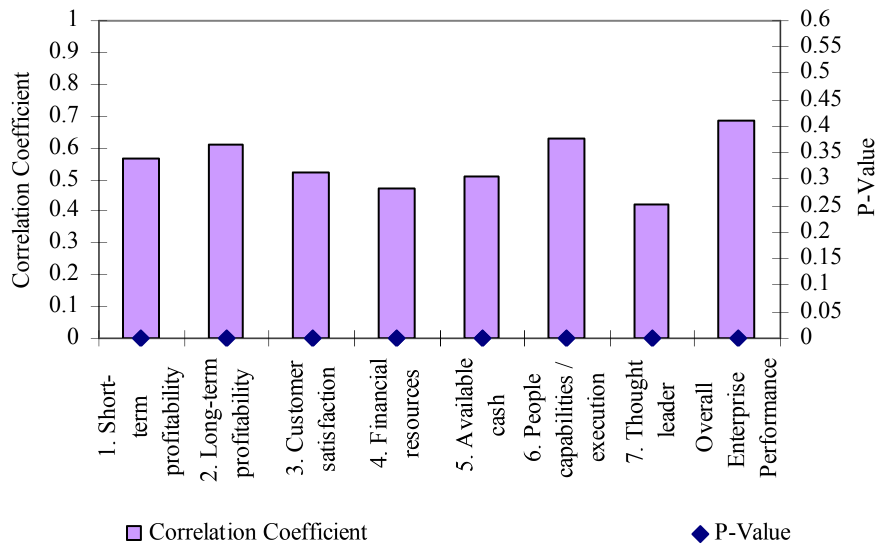


Figure 71: Correlation and Significance: IS Maturity and Enterprise Performance

ANOVA using GLM: A GLM of enterprise performance on the level of IS Maturity was performed resulting in a P-Value of 0.013, an R2 of 14.17%, and an adjusted R2 of 11.16%.

Figure 72 shows the change in the level of mean enterprise performance relative to changes in the level of the predictor variable, information systems maturity. That is, as we shift from low to higher levels of IS maturity performance also increases.

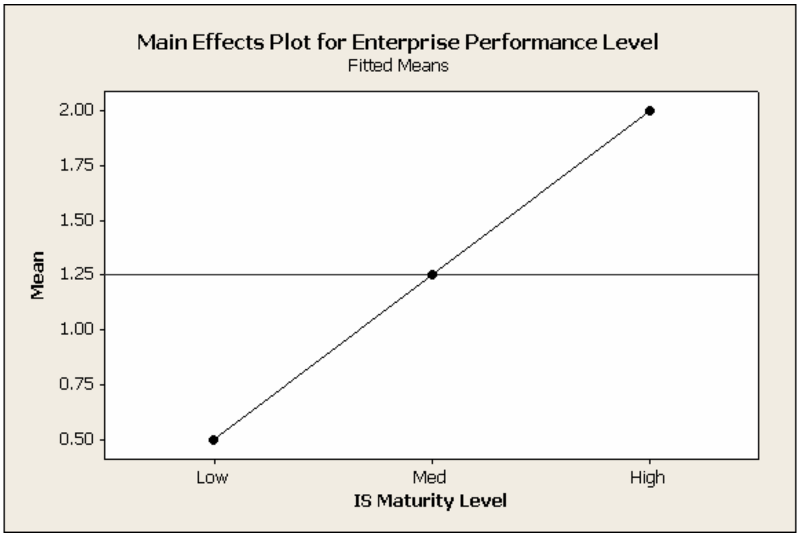


Figure 72: Main Effects Plot: Relationship H3 (a)

Other Observations / Discussion

Recall that survey questions 15-19 were also used to test the relationship between information technology-based systems. Here, in order to facilitate a more robust analysis, survey questions 22 – 26 were included. Our analysis concludes that the level of IS maturity is greater among high performing enterprises than among low performing enterprises. Interview data that were collected provide amplifying commentary. For ease of synthesis, comments from the respondents were considered as either "bad" practices, or "good" practices. It should be noted that a mechanism was not designed into the interview protocol so as to assess "high performance" versus "low performance" enterprises

An observation about each is noted as follows:

- "Bad Practices": Information technology/systems are "the enemy of being responsive" to the external environment, particularly customers. It was further pointed out that the development of such systems involves a two year backlog, and that a direct correlation exists between backlog and a lack of responsiveness.

- "Good Practices": Conversely, one aerospace industry executive commented that the: "key to an adaptable, flexible workforce is the IT/IS network", and that by maintaining such a network, "the business and technology guys know what each other is doing".

8.5.2 Information Technology Maturity and Enterprise Performance

Here, we build on the analysis conducted in the previous section that considered information systems. However, noting the differences between how information technology and information systems are defined (see Chapter 4), we investigate the relationship between information technology maturity and enterprise performance. The specific relationship evaluated is depicted in Table 44.

Table 44: IT Maturity versus Enterprise Performance

H3 (a)	*The level of IS maturity will be greater among high performing enterprises than among low performing enterprises.*
H3 (b)	**The level of IT maturity will be greater among high performing enterprises than among low performing enterprises.**
H3 (c)	*Enterprise technology deployment / structure5 and information system maturity will be greater among high performing enterprises than among low performing enterprises.*
H3 (d)	*The level of EA maturity will be greater among high performing enterprises than among low performing enterprises.*

The following questions measured the level of IT Maturity of the enterprise, and are used to test this relationship:

5 Enterprise technology deployment / structure = IT Maturity

Q. 31	"To what extent do you agree that executives are willing to invest resources and themselves to fill your firm's information technology needs"?
Q. 32	"To what extent do you agree that information technology is selected so as to be consistent with and supportive of the firm's business objectives"?
Q. 33	"To what extent do you agree that executives choose to be involved in the process of evaluating the business impact of your firm's information technology"?
Q. 34	"To what extent do you agree that the role of your firm's information technology is effectively communicated throughout the enterprise"?
Q. 35	"To what extent do you agree that you understand how information technology supports your firm"?
Q. 36	"To what extent do you agree that other executives have an understanding of how information technology supports your firm"?
"In questions 37 - 40, please comment on the extent to which you agree that your firm's technology structure:"	
Q. 37	Hinders the execution of business strategies?
Q. 38	Informs the formulation of business strategies?
Q. 39	Hinders the firm's ability to attain a stronger competitive position within your market sector?
Q. 40	Has a significant level of importance in your organization / design?
Q. 41	To what extent do you agree that your firm's computer-based systems do not exchange information with each other internally, and with external applications?

Based on the following analysis, hypothesis H3 (b) is accepted. A more in-depth analysis was conducted via the following three analyses: Linear Regression, Correlation Coefficient, and ANOVA using GLM.

<u>Linear Regression</u>: A linear regression of enterprise performance on information technology maturity was performed resulting in a P-Value of 0.000, an R2 of 42.8%, and an adjusted R2 of 41.8%. The slope of the fitted line is 0.762 and is depicted in Figure 73.

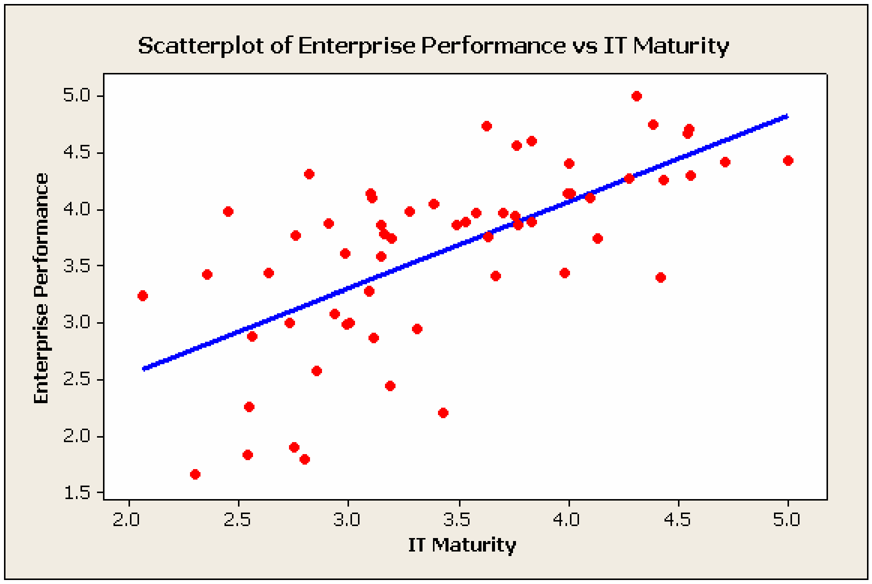


Figure 73: Liner Regression of Enterprise Performance on IT Maturity

A summary of the regression analysis to evaluate IT maturity as a predictor of enterprise performance is depicted in Table 45.

Table 45: Prediction of Enterprise Performance from IT Maturity

Enterprise Performance = 1.02 + 0.762 IT Maturity

Predictor	Coef	SE Coef	T	P
Constant	1.0174	0.4055	2.51	0.015
IT Maturity	0.7620	0.1158	6.58	0.000
S = 0.612393	R-Sq = 42.8%	R-Sq(adj) = 41.8%		

Correlation Coefficient and P-Values: Figure 74 depicts the correlations between IT Maturity and each of the seven measures of enterprise performance as well as enterprise performance.

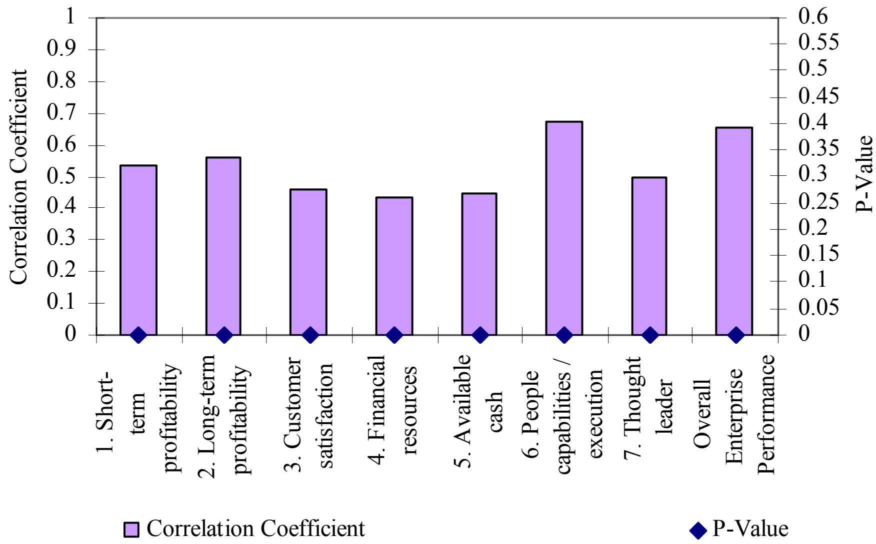


Figure 74: Correlation and Significance: IT Maturity and Enterprise Performance

ANOVA using GLM: A GLM of enterprise performance on the level of IT Maturity was performed resulting in a P-Value of 0.000, an R2 of 28.24%, and an adjusted R2 of 27.00%. No respondent scored a "low" score, i.e., a rating of ≤ 2, for IT Maturity. This is not surprising, given that 52 out of 60 respondents answered "4" or "5" to Question 51 in the survey: "To what extent do you agree that the rate of technological change is shaping your industry?" One would expect such enterprises not to have a low level of information technology maturity.

Figure 75 shows the change in the level of mean enterprise performance relative to changes in the level of the predictor variable, information technology maturity. That is, as we shift from low to higher levels of IT maturity performance also increases.

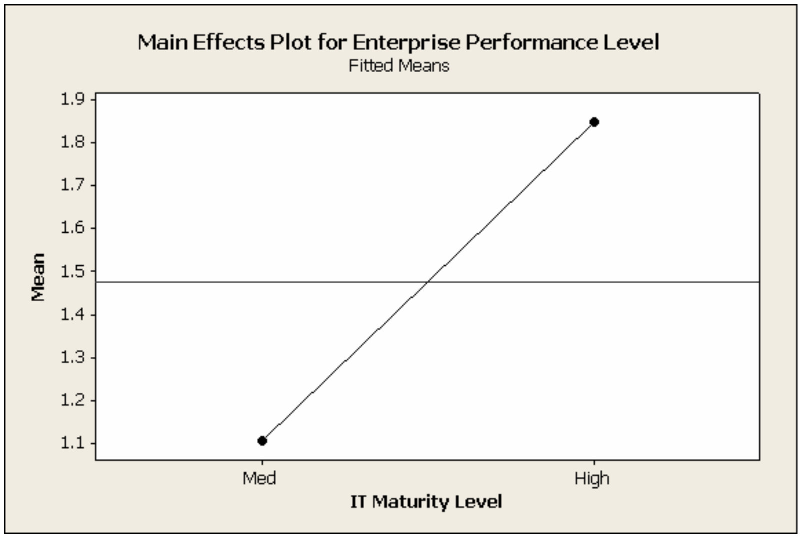


Figure 75: Main Effects Plot: Relationship H3 (b)

Other Observations / Discussion

The interaction of business processes and technology-based systems plays a critical role in enterprise operations. Interview data that were collected augment the survey data. Given the magnitude of decisions relating to restructuring of existing technology-based systems, deploying emerging ones, or altering an enterprise's architecture, interviewees were asked to comment on whom made such decisions. Recall that of the ten interviewees, five were either CIO's or CTO's, while the remaining interviewees held various other CXO titles.

In summarizing these data, regardless of position, the first response was typically focused on: "what am I buying". There was unanimity in that decisions to purchase such systems were made by management based on standards established by the 'technical guys'. One CTO commented that information technology professionals cast themselves as "approvers", not "doers". Another salient observation was the difference in timescale between the users of technology and the developers of technology; that is, user demands for increased technical functionality and/or new systems dramatically outstrips the ability of the developer to create it. This timescale mismatch may also induce various interoperability issues between new and "legacy" systems. One interviewee, a retired military general officer noted that these types of interoperability issues: "make it hard to make transformational changes."

8.5.3 IT Maturity and IS Maturity vs. Performance

An enterprise's information systems and information technologies each contribute to its technology deployment / structure and information system maturity respectively. The collective responses to survey questions used to test H3 (a) and H3 (b), respectfully, are used to test this proposed relationship that is depicted in Table 46.

Table 46: Technology Deployment and IS Maturity vs. Performance

H3 (a)	*The level of IS maturity will be greater among high performing enterprises than among low performing enterprises.*
H3 (b)	*The level of IT maturity will be greater among high performing enterprises than among low performing enterprises.*
H3 (c)	***Enterprise technology deployment / structure[6] and information system maturity will be greater among high performing enterprises than among low performing enterprises.***
H3 (d)	*The level of EA maturity will be greater among high performing enterprises than among low performing enterprises.*

Based on the following analysis, hypothesis H3 (c) is accepted. Three analyses were conducted: linear regression, correlation coefficient, and ANOVA using GLM.

Linear Regression: A linear regression of enterprise performance on the IS & IT Maturity was performed resulting in a P-Value of 0.000, an R2 of 51.7%, and an adjusted R2 of 50.9%. The slope of the fitted line is 0.940 and is depicted in Figure 76.

6 Enterprise technology deployment / structure = IT Maturity

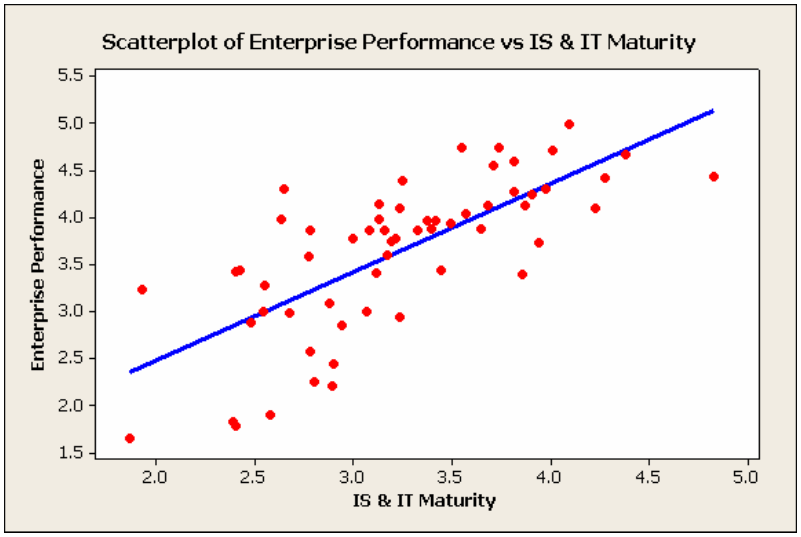


Figure 76: Linear Regression of Enterprise Performance on IS and IT Maturity

Correlation Coefficient and P-Values: Figure 77 depicts the correlations between IS & IT Maturity and enterprise performance, and each of the seven measures of enterprise performance.

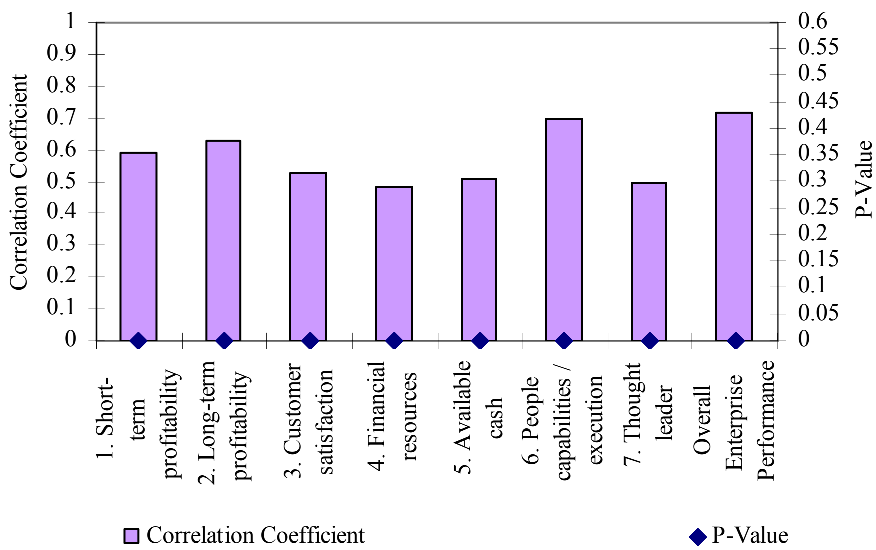


Figure 77: Correlation and Significance: IS and IT Maturity and Enterprise Performance

ANOVA using GLM: A GLM of enterprise performance on the level of IS & IT Maturity was performed resulting in a P-Value of 0.001, an R2 of 23.11%, and an adjusted R2 of 20.41%. Figure 78 shows the change in the level of mean enterprise performance relative to changes in the level of the predictor variables, IT maturity and IS maturity. That is, as we shift from low to higher levels of IT and IS maturity performance also increases.

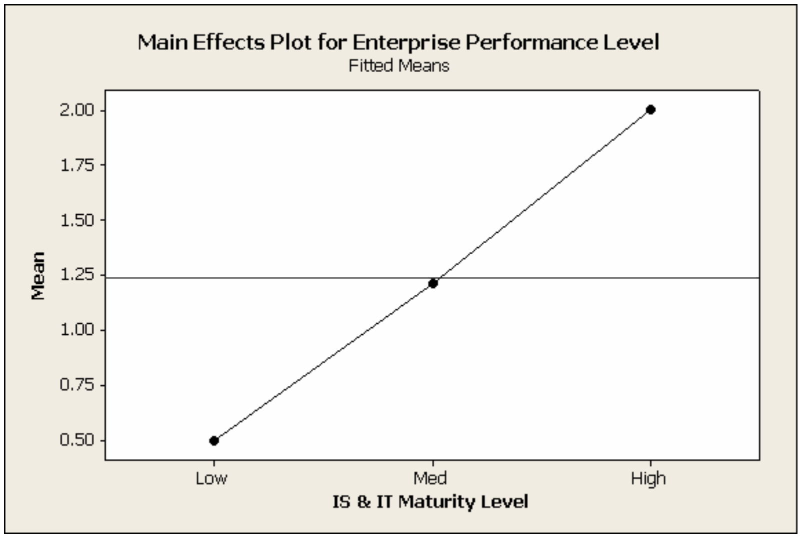


Figure 78: Main Effects Plot: Relationship H3 (c)

Other Observations / Discussion:

The previous two sections considered information systems maturity, and information technology maturity, respectively, with enterprise performance. Here, we consider the combination of the two and their collective relationship with enterprise performance. Taken individually, it was shown that respective maturities were greater in higher performance enterprises that in lower performing enterprises. Given that we used them together, we expected our analysis to show a similar result, and it did.

8.5.4 Enterprise Architecture Maturity Versus Performance

In the web-based expert survey, enterprise architecture was addressed along with technology deployment and structure, our measure of information technology maturity. Specifically, the relationship between enterprise architecture and enterprise performance is investigated as depicted in Table 47.

Table 47: Enterprise Architecture Maturity versus Performance

H3 (a)	*The level of IS maturity will be greater among high performing enterprises than among low performing enterprises.*
H3 (b)	*The level of IT maturity will be greater among high performing enterprises than among low performing enterprises.*
H3 (c)	*Enterprise technology deployment / structure7 and information system maturity will be greater among high performing enterprises than among low performing enterprises.*
H3 (d)	**The level of EA maturity will be greater among high performing enterprises than among low performing enterprises.**

The following questions were used to measure enterprise architecture maturity of the enterprise

Q. 43	"To what extent do you agree that your enterprise architecture or design plays a critical role in helping to align strategic processes with operational processes"?
Q. 45	"To what extent do you agree that your firm uses an architecture framework, such as the Federal Enterprise Architecture Framework (FEAF), etc".?
Q. 46	"To what extent do you believe that your firm has a mature enterprise architecture"?

Based on the following analysis, relationship H3 (d) is accepted. Three analyses: linear regression, correlation coefficient, and ANOVA using GLM were conducted and are discussed as follows:

7 Enterprise technology deployment / structure = IT Maturity

Linear Regression: A linear regression of enterprise performance on the EA Maturity was performed resulting in a P-Value of 0.009, an R2 of 11.3%, and an adjusted R2 of 9.8%. The slope of the fitted line is 0.280 and is depicted in Figure 79.

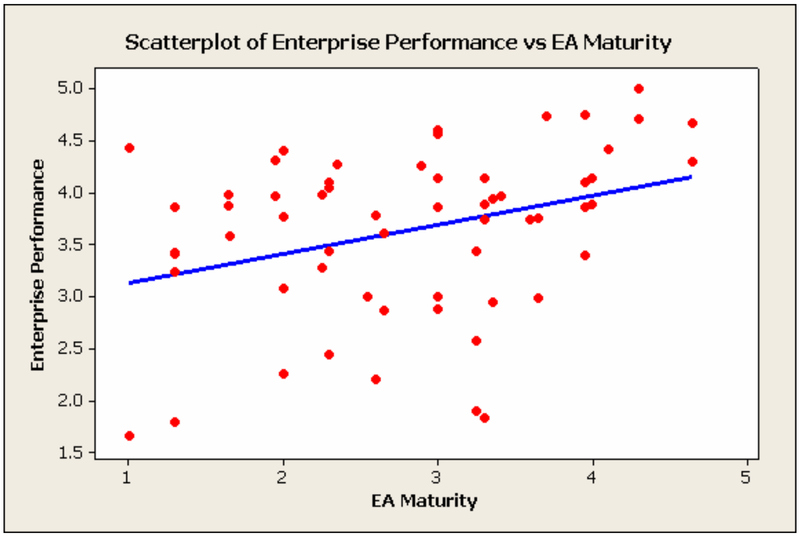


Figure 79: Linear Regression of Enterprise Performance on EA Maturity

A summary of the regression analysis to evaluate enterprise maturity as a predictor of enterprise performance is depicted in Table 48. In comparison to process maturity, information technology maturity, and information systems maturity, enterprise architecture maturity is the most inferior predictor of enterprise performance. A comparative summary of the regression analysis statistics for each dimensional maturity is presented in section 8.6.

Table 48: Prediction of Enterprise Performance from EA Maturity

Enterprise Performance = 2.85 + 0.280 EA Maturity

Predictor	**Coef**	**SE Coef**	**T**	**P**
Constant	2.8475	0.3063	9.30	0.000
EA Maturity	0.2803	0.1031	2.72	0.009
S = 0.762360	R-Sq = 11.3%	R-Sq (adj) = 9.8%		

Correlation Coefficient and P-Values: Figure 80 depicts the correlation between enterprise architecture maturity, enterprise performance, each of the seven components of enterprise performance, as well as overall enterprise performance.

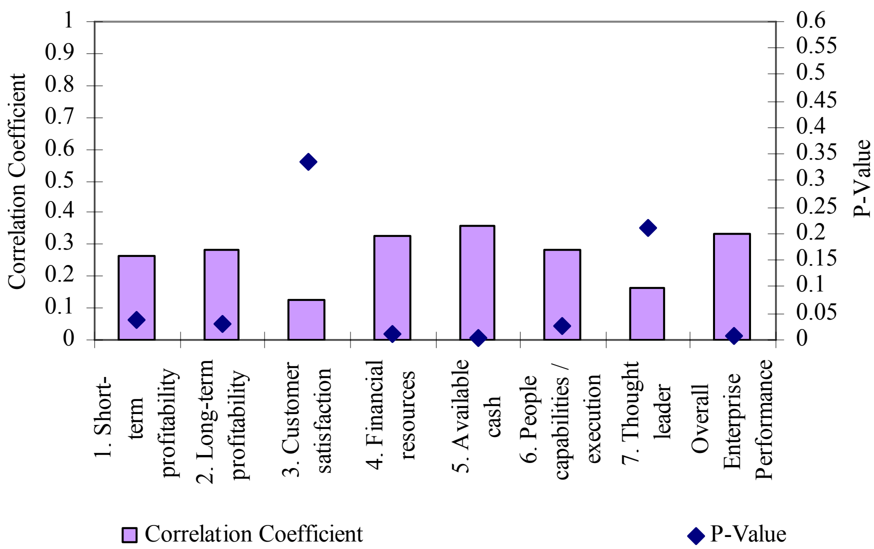


Figure 80: Correlation and Significance: EA Maturity and Enterprise Performance

First, when looking at the correlation coefficient for each of the seven components of enterprise performance and overall enterprise performance, enterprise architecture maturity is somewhat correlated to overall enterprise performance. However, when the correlation coefficients for each of the other dimensional maturities are compared to overall enterprise performance (see Table 37, section 8.6), EA maturity is significantly less.

ANOVA using GLM: A GLM of enterprise performance on the level of EA Maturity was performed resulting in a P-Value of 0.007, an R2 of 15.85%, and an adjusted R2 of 12.90%. Figure 81 shows the change in mean enterprise performance level relative to changes in the level of EA maturity.

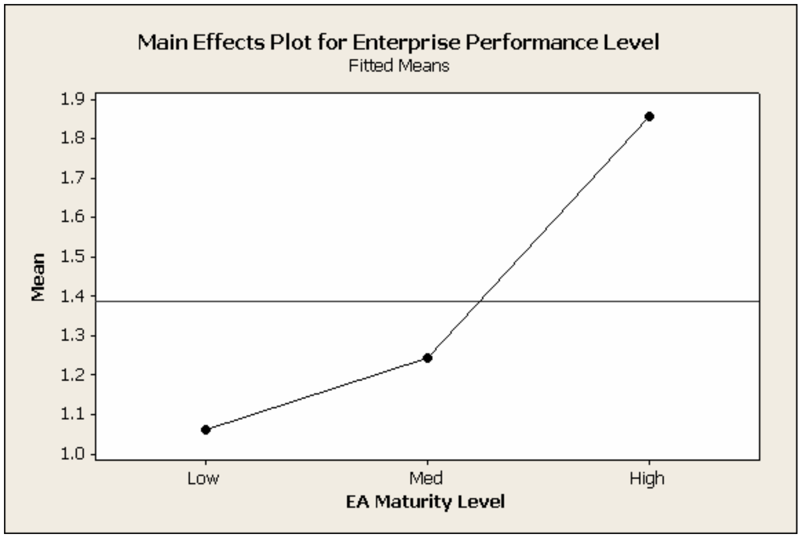


Figure 81: Main Effects Plot: Relationship H3 (d)

Other Observations / Discussion:

In theory, enterprise architecture provides the context for the development of an enterprise's capabilities. It also provides the infrastructure for the internal aspects of monitoring and managing for strategic success. Additionally, architectures serve to highlight gaps within the enterprise's structure whereby, left unaltered, achievement of certain goals and objectives may not be readily facilitated. Thus, it can both serve as a catalyst for, and facilitator of, enterprise transformation efforts in terms of structure and capabilities. Succinctly, it is just another piece of information about the internal environment of the organization.

Given that no precise agreed upon definition of enterprise architecture exists, the limitation of investigating the level of maturity of an enterprise architecture based on data collected from three questions is recognized. However, the questions asked of the survey respondents are at the core of an architecture's function; to help align strategic and operational processes with each other and enterprise information systems.

In order to ascertain a more robust understanding of enterprise architecture, we turn once again to the interview data. Interviewees were asked to comment on the following four items: (1) how big a role information technology infrastructure plays in organizational structure and operations, (2) whether or not an enterprise architecture is established in their organization, (3) the extent to which their enterprise uses an enterprise architecture framework, and (4) how their enterprise architecture considers strategic and operational processes.

Using a five point Likert scale, with 1 being critical, and 5 not very important, respondents were asked to asses the interplay between their information technology infrastructure and organizational structure operations. The rationale for asking this question is based one of two prevailing views of architecture (see Chapter 2) whereby an enterprise's information technology infrastructure is taken as its enterprise architecture. There was an interesting bifurcation in the responses. Five of the ten interviewees responded that IT played a critical role, ranking it 1 / 5; two of the five hold technical positions within the enterprise. Two others, both holding technical positions, ranked IT not critical, or 5 / 5; other responses indicate that IT infrastructure plays a neutrally important role in organizational structure and operations.

There is no single commonly agreed-upon definition of "architecture" in relation to enterprises or systems, and architectures differ in style, focus, and level of detail (see Chapter 4 for a more complete discussion). Given the lack of precision in both defining and understanding the concept of enterprise architecture, the fact enterprise architecture maturity is not a good predictor of enterprise performance is expected. As corroborated by the interview data, enterprise architecture is fairly novel concept and is not yet widely adopted or deployed in the industry. As a result, a lack of consensus exists within both public and private sector enterprises about what constitutes an enterprise architecture. Further, the word 'architecture' is a fairly loaded word and often means different things to executives in different roles and with different backgrounds. For example, some interview respondents were unable to differentiate between enterprise architecture and the architecture of their information technology-based systems. For some, enterprise architecture equals information technology infrastructure. Comments from some survey respondents also indicate such misalignment of understanding. It is recognized that the survey questions attempt to capture the nature of enterprise architecture deployment, but may have limited capability due to the vagueness of the concept of enterprise architecture. That said, an analysis of the all the data supports the notion that enterprise architecture maturity alone can not be used as a predictor of enterprise performance.

Only one of ten interviewed indicated that they were aware that their organization used an enterprise architecture framework; one other was aware that the organization was working on it. Similarly, none of the ten interviewed were of the opinion that their enterprise architecture accommodated both strategic and operational processes. On the topic of whether or not an enterprise architecture is established in their organization, comments were mixed. They ranged from: "If you talk about enterprise architecture, the average line executive doesn't have a clue as to what you are talking about"; "EA exists only in the minds of the IT community"; and "to the extent that we have one, it's housed somewhere in IT", to: "yes, and it plays a critical role in the things I've been outlining here".

8.5.5 Summary

Results from the data collection and analyses conducted in the previous four sections are summarized and presented in Table 49.

Table 49: Summary of Results: Technology Structure / Deployment

Proposed Relationship		Analyses Conducted	Outcome
Technology Structure / Deployment (Measurement of IT Maturity)			
H3(a)	The level of IS maturity will be greater among high performing enterprises than among low performing enterprises.	• Correlation Coefficient and P-Value • Linear Regression • ANOVA using GLM	Accepted
H3(b)	The level of IT maturity will be greater among high performing enterprises than among low performing enterprises.	• Correlation Coefficient and P-Value • Linear Regression • ANOVA using GLM	Accepted
H3(c)	Enterprise technology deployment / structure and information system maturity will be greater among high performing enterprises than among low performing enterprises.	• Correlation Coefficient and P-Value • Linear Regression • ANOVA using GLM	Accepted
Enterprise Architecture (Measurement of EA Maturity)			
H3(d)	The level of EA maturity will be greater among high performing enterprises than among low performing enterprises.	• Correlation Coefficient and P-Value • Linear Regression • ANOVA using GLM	Accepted

8.6 Enterprise System Architecture Maturity

Previously, survey respondents commented on the dimensions of our ESA; strategic and operational processes, the extent to which those processes are supported, or not, by current information systems, and how those technologies are structured and deployed throughout the enterprise. An assessment of each dimension of maturity was considered based on an investigation of multiple relationships that pertain to each. We tested the strength of univariate models that predict enterprise performance on each of the 4 dimensional maturities; process, IS, IT, and EA, one at a time. Table 50 depicts the results from those analyses. It is observed that, of the four dimensional maturities, IS maturity is the best predictor of enterprise performance.

Table 50: Summary of Univariate Models to Predict Enterprise Performance

Dimensional Maturity (Predictor Variable)	Adjusted R2 (%)	Associated Regression Equation
Process Maturity	41.9	EP8 = 1.74 + 0.597 ProcessMaturity
IS Maturity	46.2	EP = 0.990 + 0.875 ISMaturity
IT Maturity	41.8	EP = 1.02 + 0.762 ITMaturity
EA Maturity	9.8	EP = 2.85 + 0.280 EAMaturity

Based on the adjusted R2 values from Table 50, it is observed that the relative contribution of EA maturity as a predictor of enterprise performance is significantly less that the contribution of the other dimensional maturities. It is also noted that the contributions from process and IT dimensional maturities are nearly the same.

However, we surmise that net effect on enterprise performance is not solely affected by any one aspect of the enterprise; multiple effects must be considered contemporaneously in order to generate a more robust view of enterprise performance (see Chapter 5). That said, the next logical step to further our understanding of

8 “EP” stands for Enterprise Performance

performance prediction is to devise a quantitative measure that collectively captures the effects of all four maturities, and investigate that against enterprise performance.

The focus of this section is twofold: (1) construct a measure of ESA maturity, and (2) determine the extent to which ESA maturity itself can be used as a predictor of enterprise performance. The specific relationship used in this evaluation is depicted in Table 51.

Table 51: Proposed Relationship for ESA Maturity

ESA Maturity	
H4	The Level of ESA Maturity Will Be Greater Among High Performing Enterprises Than Among Low Performing Enterprises

Recall that the purpose of constructing a high-level ESA (see Chapter 4) is to introduce the enterprise as an integrated amalgam of sub-systems; that is, as a system-of-systems rather than a simple aggregation of discrete processes, functions, tasks, and activities. The ESA was elucidated as a 'higher-order' form of a typical business architecture by virtue of an additional layer for strategic processes that is separate and distinct from an operational process layer. Consequently, the manner in which we dimensionalize our ESA may serve to improve alignment between various enterprise system dimensions, thereby creating opportunities for efficiency improvements within the enterprise.

In this section, ESA maturity is tested as a predictor of enterprise performance. Results from our data collection and subsequent analyses of various levels of process, information system, information technology, and enterprise architecture maturity, respectively, are presented and discussed in the previous sections. The viability of each was tested, discretely, as a predictor of enterprise performance.

As a first step, we define ESA maturity to be the summation of the four dimensional maturities:

$$ESA_{Maturity} = \alpha_1 \, Process_{Maturity} + \alpha_2 \, IT_{Maturity} + \alpha_3 \, IS_{Maturity} + \alpha_4 \, EA_{Maturity}$$

8.6.1 Analysis and Results

Our approach to overall enterprise performance prediction involves taking all four dimensional maturities into account at the same time, defined above as ESA maturity. The purpose of the subsequent analyses is threefold: (1) determine the coefficients, α 1 – α 4, in order to assess the relative contribution of each predictor variable to ESA maturity, (2) assess the strength of ESA maturity as a predictor of enterprise performance, and (3) compare the result to the other models developed for each of the four dimensional maturities.

Next, we conduct a PCA analysis in order to extract the maximum variance from all four dimensional maturities. From this analysis, we are then able to calculate ESA maturity as the linear combination of each of the four dimensional maturities using the factors obtained from the PCA[9]. In a manner similar to the method followed in the previous sections, a more in-depth investigation was conducted via the following three analyses: Linear Regression, Correlation Coefficient, and ANOVA using GLM.

Linear Regression: A linear regression of overall enterprise performance on ESA Maturity was performed resulting in a P-Value of 0.00, an R^2 of 48.4%, and an adjusted R^2 of 47.6%. The slope of the fitted line is 0.868 and is depicted in Figure 82.

9 From PCA: ESA Maturity = 0.491*Process Maturity + 0.523*IS Maturity + 0.531*IT Maturity + 0.452*EA Maturity

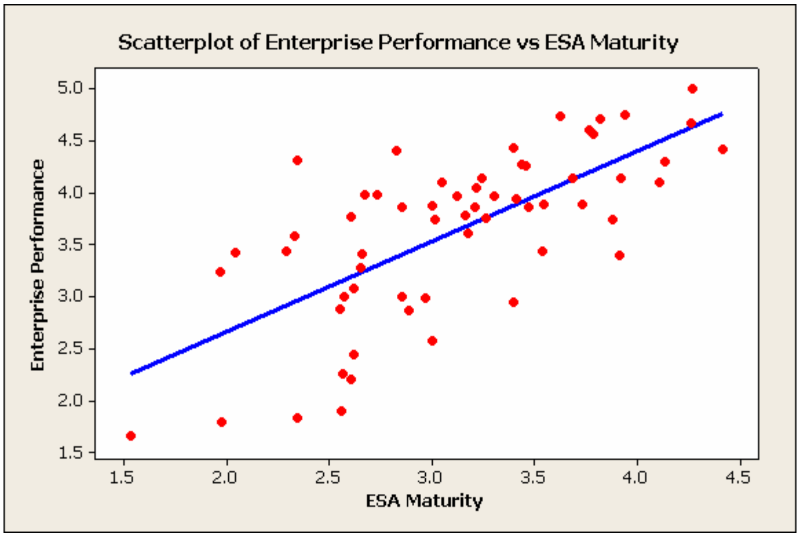


Figure 82: Enterprise Performance versus ESA Maturity

The summary statistics for the above linear regression gives rise to the model depicted in Table 52.

Table 52: Linear Regression Summary Statistics

Enterprise Performance = 0.926 + 0.868 ESA Maturity

Predictor	Coef	SE Coef	T	P
Constant	0.9263	0.3746	2.47	0.016
Process Maturity	0.8679	0.1176	7.38	0.000
S = 0.581185	R-Sq = 48.4%	R-Sq (adj) = 47.6%		

Correlation Coefficient and P-Values: ESA maturity is shown to have the following correlations with overall enterprise performance and each of the seven components of enterprise performance as depicted in Figure 83.

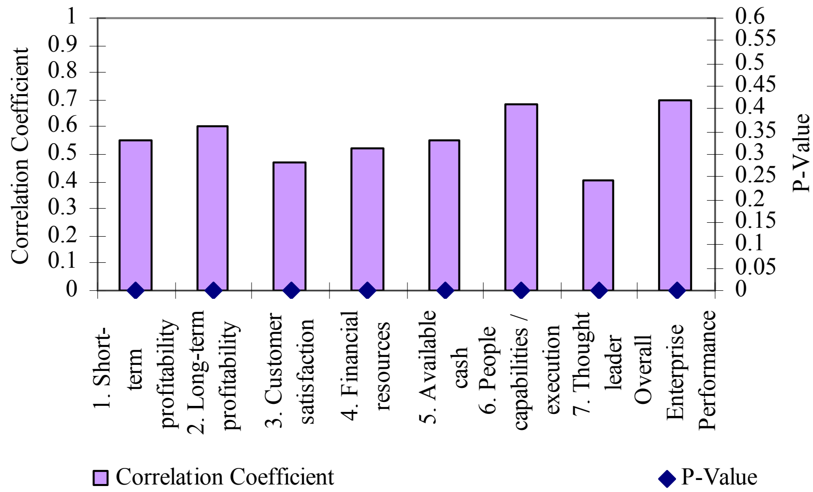


Figure 83: ESA Maturity: Correlation and Significance

ANOVA using GLM: A GLM give an adjusted R2 value of 24.38% and a P-Value of 0.000 as seen from the GLM results that are depicted in Table 53.

Table 53: ANOVA for Enterprise Performance Level

Analysis of Variance for EP Level, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
ESAM Level	2	5.3167	5.3167	2.6583	10.51	0.000
Error	57	14.4167	0.2529			
Total	59	19.7333				
S = 0.502915		R-Sq = 26.94%		R-Sq (adj.) = 24.38%		

Figure 84 shows the change in the mean enterprise performance level relative to changes in the level of predictor variable, level of ESA maturity.

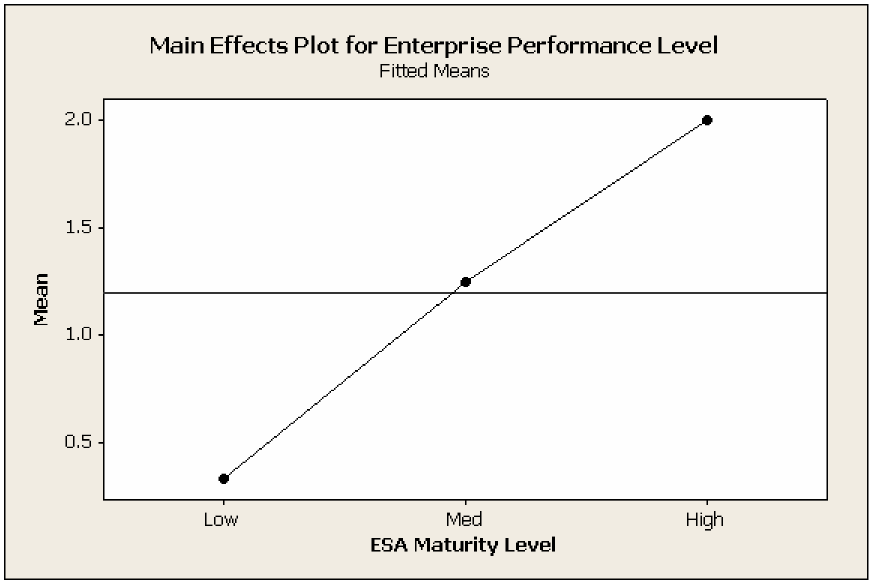


Figure 84: Main Effects Plot: Relationship H4

A further investigation for predicting enterprise performance was conducted using Best Subsets Regression (BSR). Recall from section 8.2.4 that BSR is an approach to variable selection when building a model based on several predictor variables. It enumerates all possible variable selections and displays the results in terms of R2, adjusted R2, and Mallows Cp. A model that contains a Mallows Cp value that most closely equals the number of predictor variables is chosen as the most adequate model. When compared side-by-side, the model that uses ESA Maturity is shown to be the best model. These data are depicted in Table 54.

Table 54: Results from Best Subsets Regression

No. of Var.	Adjusted R2 (%)	Mallows Cp	Process Mat	IS Mat10	IT Mat	EA Mat	Regression Equation
1	46.2	16.4		X			EP11 = 0.990 + 0.875 ISMat
1	41.9	22.1	X				EP = 1.74 + 0.597 ProcessMat
1	41.8	22.3			X		EP = 1.02 + 0.762 ITMat
1	9.8	65.4				X	EP = 2.85 + 0.280 EAMat
1	47.6	2.0	The predictor is ESA Maturity				EP = 0.926 + 0.868 ESAMat
2	54	6.8	X	X			EP = 0.808 + 0.339 ProcessMat + 0.580 ISMat
2	52.8	8.4	X		X		EP = 0.774 + 0.380 ProcessMat + 0.482 ITMat
2	50.3	11.7		X	X		EP = 0.606 + 0.571 ISMat + 0.380 ITMat
2	45.3	18.4		X		X	EP = 0.980 + 0.864 ISMat + 0.0156 EAMat
2	40.9	24.1	X			X	EP = 1.72 + 0.588 ProcessMat + 0.0168 EAMat
2	40.9	3.0			X	X	EP = 1.02 + 0.793 ITMat - 0.039 EAMat
3	55.9	5.3	X	X	X		EP = 0.546 + 0.296 ProcessMat + 0.391 ISMat + 0.282 ITMat
3	53.7	8.1	X	X		X	EP = 0.840 + 0.363 ProcessMat + 0.608 ISMat - 0.0687 EAMat
3	53.6	8.2	X		X	X	EP = 0.765 + 0.415 ProcessMat + 0.560 ITMat - 0.132 EAMat
3	50	13		X	X	X	EP = 0.604 + 0.584 ISMat + 0.427 ITMat - 0.0704 EAMat

10 "Mat" stands for Maturity
11 "EP" stands for Enterprise Performance

Table 55 Thus far, we have determined the coefficients, α 1 – α 4, depicted in order to assess the relative contribution of each predictor variable to ESA maturity. We also show the strength of ESA maturity as a predictor of enterprise performance and compare it to the other models developed for each of the four dimensional maturities in Table 55.

Table 55: Summary Data

	Correlation Coefficient	Linear Regression adjusted R2	GLM adjusted R2	Mallows Cp	Slope of Fitted Line
Process Maturity	65.50%	41.90%	29.79%	22.1	0.597
IS Maturity	68.60%	46.20%	11.60%	16.4	0.875
IT Maturity	65.40%	41.80%	27.00%	22.3	0.762
EA Maturity	33.60%	9.80%	12.90%	65.4	0.280
ESA Maturity	69.60%	47.60%	24.38%	2.0	0.868

Figure 85 graphically depicts the summary statistical data from the Correlation Coefficient, Linear Regression adjusted R2, and the GLM adjusted R2 values from the table above:

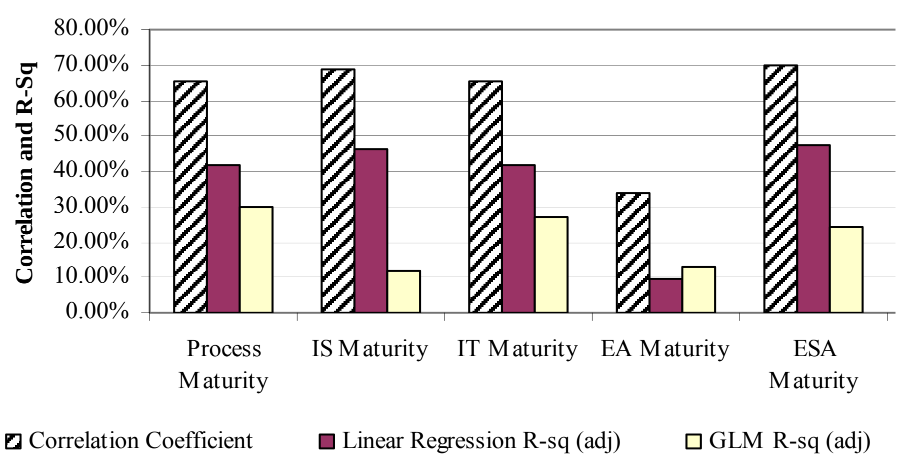


Figure 85: Individual Maturities versus Performance versus Each Dimensional MaturityObservations / Discussion:

Based on the data collection and subsequent analyses, the following observations are noted:

- The slopes of fitted lines indicate that the most improvement in enterprise performance is achieved through improvements in IS maturity, followed by IT maturity, then process maturity, respectively. This is supported by the fact that information-based technologies are critical to those enterprises that compete in the aerospace and defense sector. For example, more than 80% of the survey respondents indicated a ranking of greater than or equal to 4 to question 51: “To what extent do you agree that the rate of technological change is shaping your industry sector?”
- The measure ESA maturity was constructed by first conducting a PCA analysis in order to extract the maximum variance from all four dimensional maturities. Then, we calculated ESA maturity as the linear combination of each of the four dimensional maturities using the factors obtained from the PCA. ESA maturity was defined as the linear combination of process, IT, IS, and EA maturities, respectfully, and is shown as the strongest predictor of enterprise performance.

8.7 Summary

This chapter presents the data analysis and results for our web-based study, as well as select results from the ten executive interviews. Three primary objectives drove our data collection and subsequent analysis efforts. The first was to empirically determine the value of each dimension of maturity of our ESA (see Chapter 5). The second was to determine the impact, both individually and collectively, of each dimension on enterprise performance. The third was to determine the validity of ESA maturity as a predictor of enterprise performance.

Using various statistical methods, we demonstrate the viability of our model assumptions via an investigation of several proposed relationships among each of the four ESA dimensions. In all, thirteen proposed relationships are investigated. A summary of each proposed relationship, respective analyses conducted, and the outcome of each is depicted in Table 56, Table 57, Table 58, and Table 59 respectively.

Table 56: Enterprise Processes

Proposed Relationship		Analyses Conducted	Outcome
Enterprise Processes (Measurement of Process Maturity)			
H1 (a)	Strategic layer processes and operational layer processes are different.	• Hypothesis testing using Binomial Distribution	Accepted
H1 (b)	Strategic and operational processes that are tightly coupled will have a positive relationship with enterprise performance.	• Correlation Coefficient and P-Value • Linear Regression • ANOVA using General Linear Model (GLM)	Accepted
H1 (c)	The use of capability / process maturity models will not have a positive relationship with enterprise performance.	• Correlation Coefficient and P-Value • Linear Regression • ANOVA using GLM	Rejected
H1 (d)	The use of capability / process maturity models will not have a positive relationship with the use of mechanisms to link business operations to strategy.	• Correlation Coefficient and P-Value • Linear Regression • ANOVA using GLM	Rejected
H1 (e)	The level of process maturity will be greater among high performing enterprises than among low performing enterprises.	• Correlation Coefficient and P-Value • Linear Regression • ANOVA using GLM	Accepted

Table 57: Support of Enterprise Processes

Proposed Relationship		Analyses Conducted	Outcome
Technology-Based Support of Enterprise Processes (Measurement of IS Maturity)			
H2 (a)	IS and support of strategic layer processes will have a negative relationship with each other.	• Hypothesis testing using Binomial Distribution	Rejected
H2 (b)	IS and support of operational layer processes will have a positive relationship with each other.	• Hypothesis testing using Binomial Distribution	Rejected
H2 (c)	IS support of operational layer processes will be greater among high performing enterprises than among low performing enterprises.	• Correlation Coefficient and P-Value • Linear Regression • ANOVA using GLM	Accepted

Table 58: Technology Structure / Deployment

Proposed Relationship		Analyses Conducted	Outcome
Technology Structure / Deployment (Measurement of IT Maturity)			
H3 (a)	The level of IS maturity will be greater among high performing enterprises than among low performing enterprises.	• Correlation Coefficient and P-Value • Linear Regression • ANOVA using GLM	Accepted
H3 (b)	The level of IT maturity will be greater among high performing enterprises than among low performing enterprises.	• Correlation Coefficient and P-Value • Linear Regression • ANOVA using GLM	Accepted
H3 (c)	Enterprise technology deployment / structure and information system maturity will be greater among high performing enterprises than among low performing enterprises.	• Correlation Coefficient and P-Value • Linear Regression • ANOVA using GLM	Accepted
Enterprise Architecture (Measurement of EA Maturity)			
H3 (d)	The level of EA maturity will be greater among high performing enterprises than among low performing enterprises.	• Correlation Coefficient and P-Value • Linear Regression • ANOVA using GLM|	Accepted

Table 59: ESA Maturity

Proposed Relationship		Analyses Conducted	Outcome
ESA Maturity			
H4	The level of ESA maturity will be greater among high performing enterprises than among low performing enterprises.	• Correlation Coefficient and P-Value • Linear Regression • ANOVA using GLM • Best Subsets Regression	Accepted

Data collected from a series of ten interviews with executives, mostly from the aerospace and defense industry sector, were used to supplement the survey data. These data provided additional insights from which we add several additional conclusions.

The results presented in this Chapter provide an excellent foundation for future research. Based on our empirical results, we are of the opinion that the construction of a singular model or tool capable of predicting future enterprise performance is extraordinarily difficult. Taking an integrated, multi-dimensional approach, the following may lead to a more robust understanding of enterprise performance prediction: (1) development of an ESA maturity assessment framework, (2) development of a strategic layer analysis tool, and (3) enterprise system simulation. Each are briefly described in the following Chapter.

CHAPTER 9:
CONCLUSIONS

9.1 Summary

The interaction of business processes and technology-based systems plays a critical role in today's enterprises, particularly as enterprises progress from one phase of growth the next. However, decisions made to either restructure existing technology-based systems, deploy emerging ones, or make alterations to an enterprise's architecture are inherently difficult based on a lack of understanding of the nonlinear dynamics that underlie various enterprise functions. They are often further complicated by exogenous factors such as competitive forces and industry dynamics, both of which shape the structure and response of an enterprise. Enterprises must quickly adapt and respond to such endogenous and exogenous change. This dissertation has addressed this need in the context of the aerospace and defense industry (see Chapter 6). However, this need is ubiquitous across most industries. Because of these factors, emergent behaviors of enterprises are difficult to understand and model, thereby making prediction of enterprise performance an enormously complex undertaking.

We did not undertake this study with the goal of developing a singular model capable of capturing the vast interactions and complexity that exists between and among the various dimensions of an enterprise system. Rather, we set forth to take an incremental step toward showing how enterprise performance might be predicted. In order to do so, we developed a conceptual framework (see Chapter 5) which extended our notion of an Enterprise System Architecture (ESA) (see Chapter 4). The framework identified and categorized key dimensions of an enterprise system that contribute to and influence enterprise performance: (1) enterprise processes, (2) technology-based support of enterprise processes [information systems], (3) technology structure and deployment [information technology], and (4) enterprise architecture. Ten executive interviews and a web-based study of aerospace and defense industry experts were then conducted. Based on the data collected and subsequent analyses, we evaluated our conceptual model by empirically determining a value of each maturity dimension of the ESA and employing these estimates as predictors of enterprise performance. The overall maturity of the ESA is calculated as a weighted linear combination of each of dimensions of maturity and was evaluated as a predictor of enterprise performance (see Chapter 8). Our synthesis of the literature and practitioner techniques revealed that the concept ESA maturity is a novel approach that offers promise as a predictor of enterprise performance.

9.2 Research Contributions

We provided a complete treatment of enterprise growth as a continuum from development through business maturity. Consequently, this dissertation served as a useful resource for both researchers and practitioners concerned with understanding how enterprise performance might be enhanced in general, and ultimately predicted, in particular. A summary of contributions made by this dissertation is presented in Table 60, and each is briefly discussed as follows.

Table 60: Summary of Contributions to Theory and Practice

Contribution Domain	Intended Contribution
Theory	• Synthesis of literature from systems engineering, complexity theory, and information technology / information systems • Development of an ESA that creates separate layers for strategic and operational processes • Development of a conceptual model that identify four broad dimensions that contributes to and influence enterprise performance
Practice	• Evaluation of alternative architecture frameworks and models • Development of an enterprise maturity assessment framework • Demonstration of how enterprise performance can be predicted

9.2.1 Contributions to Theory

The theoretical contributions of the dissertation are multifold. First, we provided a thorough synthesis of several bodies of literature including enterprise studies, systems engineering, information systems, and information technology. Working from this theoretical base, we introduced a model depicting an enterprise growth continuum from development through maturity. Two unique aspects of this model include: (1) the delineation, per phase of growth, of specific tasks that executives need to complete in order to grow an enterprise and, (2) the characterization of these tasks as functions with associated uncertainties and underlying nonlinear dynamics. This model is both informed by and contributes to the theories of enterprise transformation, and the enterprise as a system, respectfully. A fundamental precept of our work is that flexible and adaptable enterprises --- those that understand the underlying dynamics of how they can change and are inclined to change --- have a better chance to grow into high performance organizations than those that do not understand and/or are not inclined. Our growth model stipulates elements from both the 'means' and 'scope' dimensions of the theory of enterprise transformation, and combines them in such a manner so as to help executives successfully effectuate sustained transition and/or transformation of the enterprise.

Next building on our growth model and further synthesis of the literature, we developed a different enterprise system architecture. In a novel, systems-based approach (see Chapter 2), our ESA includes separate layers to accommodate strategic and operational processes. We then identified and explored in significant depth the differences between these types of processes and various information technology-based systems used to support them. Again, from an enterprise transformation-theoretic perspective, ours is an innovative approach to combining elements from two dimensions of the framework, 'means' and 'scope', to show how the outcome, or 'ends', of a sustained transition and/or transformation might be predicted. Consequently, we furthered our understanding of how enterprises grow and, at the same time, provided a significant step in theoretical research in enterprise transformation in general, and enterprise performance prediction, in particular.

Finally, as an extension to our general ESA, we created a conceptual model that adds maturity dimensions to the ESA and investigated its applicability to the domain of enterprise performance prediction. By so doing, we were able to show the applicability of previous research and provide a theoretical foundation, particularly from a systems engineering perspective, to show how enterprise performance might be predicted.

9.2.2 Contributions to Practice

The primary function of executive leadership is to continue to build value in the enterprise as it faces a myriad of strategic and operational challenges. Such challenges range from transition issues related to phase-of-growth dynamics to enterprise transformation. Consequently, a major motivation of this dissertation was to impact practice by helping executives understand and 'navigate' these challenges. However, as we have emphasized throughout, understanding how to enhance enterprise performance and ultimately predict it is a highly complex and multi-dimensional problem.

While the limitations of our methodology are recognized (see section 9.3), we clearly demonstrate how enterprise performance might be predicted. This is a significant result with important practical implications (see section 9.4). First, using the results from our empirical analysis, we outlined an ESA maturity assessment framework. Similarly, we outlined, per phase of growth, tasks that executives need to complete in order to grow an emerging enterprise. Our method of dimensionalizing the ESA enables the executive of a more mature enterprise to understand the impact of each dimension on enterprise performance. Such a tool not only provides a means for enterprise self-assessment, but also provides a way for executives to focus their time on those dimensions that are not appropriately contributing to enterprise performance. A synopsis of some salient findings and an interpretation of their practical significance is presented in section 9.4

9.3 Research Limitations

When conducting research such as this, the possibility exists of omitting relevant theories from other domains, various models, and other methodological approaches to data analysis, among others. As such, research on this topic could be enhanced, improved, and expanded in scope by pursuing alternative approaches. Both the ESA and our conceptual framework that dimensionalizes it should be viewed as an initial, high-level approach to understanding enterprise performance predictability. However broad, our investigation of a typical enterprise growth continuum could not be comprehensive in scope. Put simply, the complexity of this topic is such that it cannot be a "one dissertation" study. Other limitations are discussed as follows.

Methodological

The conceptual framework and subsequent analysis is based on a broader architectural view of an enterprise as a system. The framework was designed to be broad in scope in order to both reflect the scale and complexity of an enterprise system, and provide a general understanding of existing relationships at the macro, enterprise level. The chosen method of analyzing each dimension of the ESA (see Chapter 8) was intended to provide high level guidance rather than a detailed assessment of the characteristics of enterprise processes, information systems, information technology, and enterprise architecture. This limits our methodological approach from providing detailed design-level guidance. However, the research was undertaken with the intent of conducting a macro-level analysis focused on relationships in and among complex, sometimes amorphous, and “messy” variables such as information technology, information systems, and enterprise processes, respectively. It was reasoned that such an approach could provide the appropriate context and groundwork for future theoretical work. Such efforts might entail a more in-depth analysis of discrete sub-components of each proposed relationship (see Chapter 5).

Enterprise Performance

While our research entailed an investigation of all phases of enterprise growth, we placed a particular emphasis on the prediction of enterprise performance for mature enterprises. The following limitations with how enterprise performance was derived are observed and noted. First, enterprise performance was ascertained based on a collective measure of seven questions asked in the web-based survey (see Appendix F). As such, our measure of performance was based solely on qualitative, subjective data, i.e., perceptions of executives. No attempt was made to collect quantitative, objective data about either (1) the respective company of each survey respondent or, (2) the aggregate performance of the aerospace and defense industry versus other industry sectors. Second, in the absence of quantitative data, respondent’s commentary on enterprise performance was based on perceived versus measured variables.

Interviewees, Respondents, and Industry Focus

Other limiting factors of this dissertation include the interviewees and survey respondents, respectfully, and our singular focus on the aerospace and defense industry. All interviewees and survey respondents were senior executives; we did not solicit input from individuals from other enterprise echelons. As a consequence, we perhaps missed potential insights concerning both the relevance and importance of lower-level enterprise dimensions to our approach to performance prediction. Similarly, our data collection efforts were focused exclusively on the aerospace and defense industry. Future studies might include senior managers and personnel from other industry sectors to facilitate comparisons not only between perceived and measured variables, but also between different industry sectors.

9.4 Synopsis of Key Results

While influenced by exogenous factors such as industry dynamics and associated risk/uncertainties, four broad dimensions of our ESA were hypothesized to contribute to and influence enterprise performance; enterprise processes; technology-based support of enterprise processes [denoted information systems]; technology structure and deployment [denoted information technology]; enterprise architecture. Building on findings previously discussed in Chapters 4 and 8, respectfully, we discuss practical implications in terms of how what was learned could be applied by executives and investors.

9.4.1 Dimensional Maturity Models

As context for the following discussion, each individual dimension of maturity and ESA maturity is reviewed. Each of the four ESA dimensions is defined as a maturity measure. We determined the value of each dimensional maturity and assessed its impact as a predictor of enterprise performance (see Chapter 8). A summary of the results for each dimension is depicted in Figure 86 (a-d) and discussed later in this section.

Enterprise Performance = 1.74 + 0.597 Process Maturity

Predictor	Coef	SE Coef	T	P
Constant	1.7434	0.2973	5.86	0.000
Process Maturity	0.59653	0.09035	6.6	0.000
S = 0.611593	R-Sq = 42.9%	R-Sq(adj) = 41.9%		

(a) Enterprise Performance From Process Maturity

Enterprise Performance = 0.990 + 0.875 IS Maturity

Predictor	Coef	SE Coef	T	P
Constant	0.9900	0.3759	2.63	0.011
IS Maturity	0.8755	0.1218	7.19	0.000
S = 0.588725	R-Sq = 47.1%	R-Sq(adj) = 46.2%		

(c) Enterprise Performance From IS Maturity

Enterprise Performance = 1.02 + 0.762 IT Maturity

Predictor	Coef	SE Coef	T	P
Constant	1.0174	0.4055	2.51	0.015
IT Maturity	0.7620	0.1158	6.58	0.000
S = 0.612393	R-Sq = 42.8%	R-Sq(adj) = 41.8%		

(b) Enterprise Performance From IT Maturity

Enterprise Performance = 2.85 + 0.280 EA Maturity

Predictor	Coef	SE Coef	T	P
Constant	2.8475	0.3063	9.30	0.000
EA Maturity	0.2803	0.1031	2.72	0.009
S = 0.762360	R-Sq = 11.3%	R-Sq(adj) = 9.8%		

(d) Enterprise Performance From EA Maturity

Figure 86 (a-d): Dimensional Maturities as Predictors of Enterprise Performance

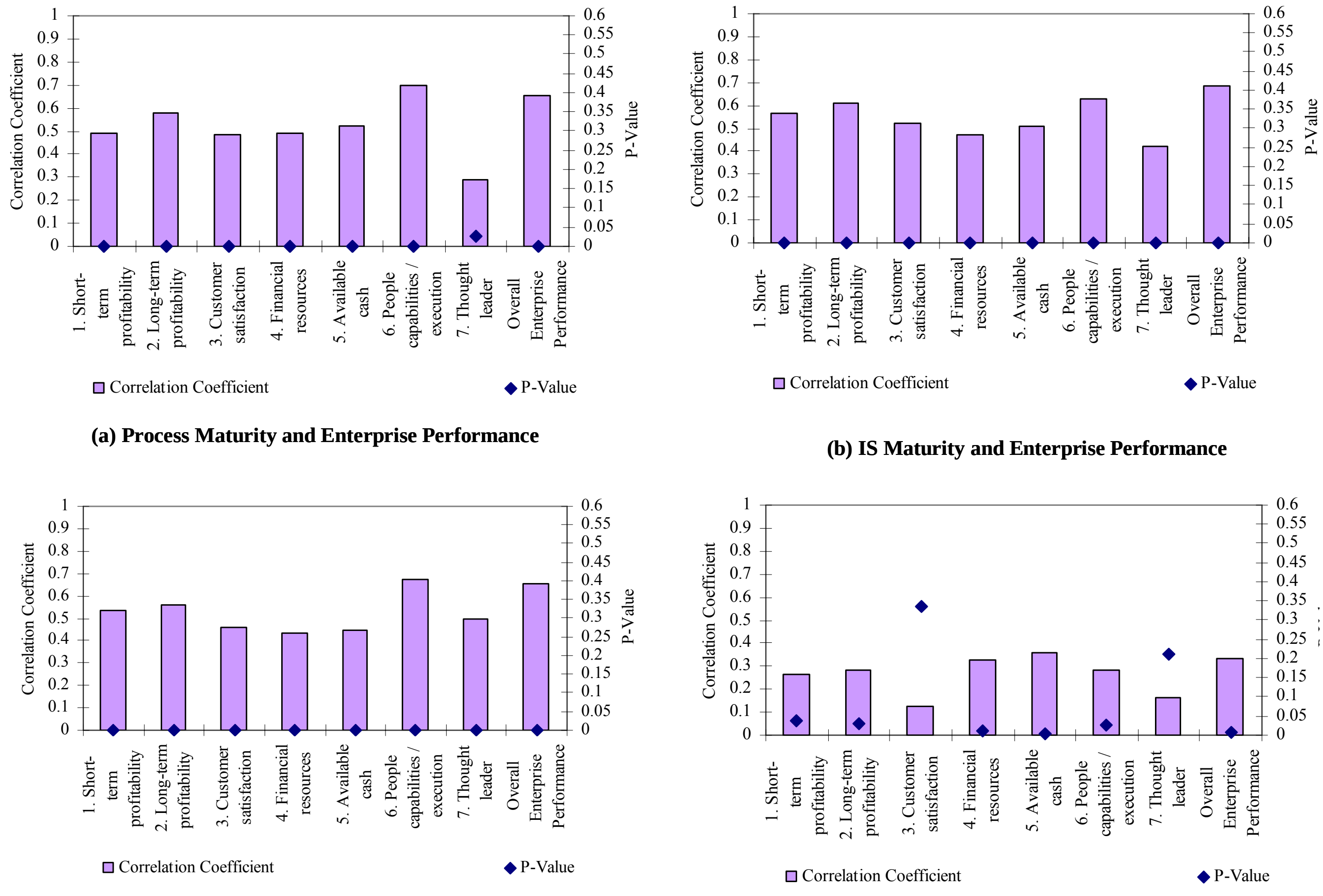
Given that each ESA dimension may influence and interact with each other, they were also aggregated and evaluated against enterprise performance. ESA maturity was constructed by first conducting a Principal Components Analysis (PCA) in order to extract the maximum variance from all four dimensional maturities. Then, ESA maturity was calculated as the weighted linear combination of each of the four dimensional maturities using the factors obtained from the PCA. We hypothesized that ESA maturity, determined in this way, would be a predictor of enterprise performance (see Chapter 8). Table 61 depicts the strength of ESA maturity as a predictor of enterprise performance compared to the other four dimensional maturity models.

Table 61: Dimensional Maturity Model Comparison

	Correlation Coefficient	Linear Regression adjusted R^2	GLM adjusted R^2	Mallows Cp	Slope of Fitted Line
Process Maturity	65.50%	41.90%	29.79%	22.1	0.597
IS Maturity	68.60%	46.20%	11.60%	16.4	0.875
IT Maturity	65.40%	41.80%	27.00%	22.3	0.762
EA Maturity	33.60%	9.80%	12.90%	65.4	0.280
ESA Maturity	69.60%	47.60%	24.38%	2.0	0.868

9.4.2 Practical Implications

Given how we defined enterprise performance, and each dimensional maturity in the context of our ESA, the analyses depicted in Table 61 confirms that ESA maturity is a better predictor of enterprise performance than any one of the dimensional maturities. Figure 87 (a-d) depicts both the correlation and significance of each element of each of dimensional maturity versus enterprise performance.



(a) Process Maturity and Enterprise Performance

(b) IS Maturity and Enterprise Performance

(c) IT Maturity and Enterprise Performance

(d) EA Maturity and Enterprise Performance

Figure 87: Each Dimensional Maturity Versus Enterprise Performance

Several practical insights gleaned from these results can be operationalized and applied by both executives and investors. While variability exists in terms of how executives and investors currently monitor the ‘health’ of an enterprise, the manner in which we dimensionalize the enterprise as a system has particular utility. For example, upon examining the results from both Table 61 and Figure 87, an executive might note that the most improvement in enterprise performance can be achieved through improvements in IS maturity, followed by IT maturity, then process maturity, respectively. This is supported by the fact that more than 80% of survey respondents agreed that information-based technologies are critical to aerospace and defense sector enterprises since technological change is rapidly shaping the industry sector.

Based on the results of our empirical analyses, executives should note the following vis a vis enterprise performance prediction:

Enterprise Architecture

In theory, enterprise architecture provides the context for the development of an enterprise's capabilities; practically, however, it is simply another piece of information about the internal environment of the organization. As part of an enterprise's architecture, we postulated that operational efficiencies and other enterprise performance enhancing synergies may emanate due to closer alignment / coupling between operational and strategic processes; results of our empirical analyses demonstrate that this is true. The following observations about enterprise architecture are noted: (1) However strong these synergies might be, when applied in the context of an enterprise architecture, this dimension of maturity is an especially weak predictor of enterprise performance compared to each of the other dimensions (see Figure 86) and, (2) No agreed upon definition of architecture exists, and 'architecture' often means different things to executives in different roles and with different backgrounds. The amalgam of these insights might suggest that executives carefully identify and consider those enterprise value deficiencies that an EA is designed to eradicate prior to investing the time and expense to implement one. All in all, considering the ambiguity with which executives view the concept of architecture, we have to conclude that "the jury is still out" with regard to the relationship between EA maturity and enterprise performance.

Support of Strategic Layer Processes

Perhaps the most interesting result from our empirical analyses involves the relationship between an enterprise's information systems, and how well they support its strategic processes. Our findings from the interviewee data were not entirely consistent with the survey data. Each interviewee (8 were queried) stated that current information systems do not support strategic level processes, and expressed great enthusiasm for a technology-based representation of strategic processes. Only approximately 8% of survey respondents stated that strategic process are not at all supported by current enterprise information systems (a score of 2 or less [see Chapter 8]); however, when respondents who scored 3 or less were considered, the number of respondents who felt that strategic processes are not supported by current information systems increased to

45%. These data might suggest that a large number of executives do not perceive that information systems support strategic processes since they only know what those systems tell them. Further, it may not be within the executives' purview to know or be concerned with the extent to which these processes are supported, or that the nature of how these processes either are or could be supported by current information systems is not clear to them.

The two sets of data, interviewee and survey, were aligned with regard to the strategic process, 'situational awareness'. The survey respondents indicated that acquiring and maintaining situational awareness is the most important of all the strategic processes; they also indicated that this strategic process would be the most valuable to be supported by an information system. Our empirical analysis shows that the two are highly correlated. These qualitative and quantitative data suggest that a strategic layer analysis / portrayal tool focused specifically on the representation of strategic layer processes might provide much utility in the context of executive decision making. A high-level description of such a tool is presented in the following Chapter.

9.5 Summary

From an enterprise performance perspective, executives need to understand how business processes, information technology, information systems, and enterprise architecture can and should be aligned. Several implications can be drawn from the findings of synthesis of the enterprise studies, systems engineering, information technology / information systems literature, and review of extant theories.

First, a multidisciplinary approach to the investigation of enterprise performance prediction is critical in order to have meaningful implications for practitioners. For example, enterprise studies from organizational theory, strategic management, and various other research streams that address the notion of 'right-sizing' enterprise organizational structure to "optimize" performance, should do so in the context of a dynamically complex enterprise system. In other words, a uni-dimensional focus on enterprise performance significantly limits the utility of any such approach. Second, our multi-disciplinary approach enables us to integrate and synthesize various theories, approaches, and methodologies into a holistic model such as the ESA. From this theoretical base, a novel approach to enterprise performance prediction is developed with potentially significant implications for practitioners.

Finally, the results presented in this dissertation provide an excellent foundation for future research. Based on our empirical results, we are of the opinion that the construction of a singular model or tool capable of predicting future enterprise performance is extraordinarily difficult. Taking an integrated, multi-dimensional approach, the following may lead to a more robust understanding of enterprise performance prediction: (1) development of an ESA maturity assessment framework, (2) development of a strategic layer analysis tool, and (3) enterprise system simulation. Each is briefly described in Chapter 10.

CHAPTER 10:
FUTURE RESERCH DIRECTIONS

In order to enhance the practical utility of our empirical results, we first outline an ESA maturity assessment framework. This framework could provide decision makers with a systematic view of various dimensions of their enterprise, and enable them to assess the relative maturity of each based on its contribution to overall enterprise performance. Insights about future enterprise performance might also be derived based on such an assessment. Two other extensions of our research results, the development of a strategic layer analysis tool, and enterprise system simulation, are briefly described as follows.

10.1 ESA Maturity Assessment Framework

As stated earlier (see Chapter 2), discontinuance rates can be as high as 70 % during the first five years of an enterprise's lifecycle; more mature enterprises lose time, resources, and money. Why is this so? At each phase of enterprise growth, executives may lack clarity and focus on those tasks that have the greatest potential impact on performance, thereby reducing the likelihood of achieving future growth. In addition, sufficient alignment may not exist between an enterprise's processes, information-based technologies, and its business strategy. We argue that the mode of operation for a growing, thriving enterprise is one of sustained transition. It might also be argued that the "health" of an enterprise is analogous to the health of a person in that, from the time an enterprise is created, it is dying. Action must be taken to keep it alive and growing; the natural tendency of a company is to fail. Consequently, it is incumbent upon executives to understand how each enterprise dimension is either positively contributing to performance, or inhibiting it.

Our ESA assessment framework moves the enterprise toward such an understanding. The motivation for the high number (13) of relationships that were tested in this dissertation is to collect enough data so as to be able to make some assertions about the construct of an enterprise maturity assessment framework. For example, executives may assert that a high maturity enterprise possesses the characteristics portrayed by some relationships, while a low maturity enterprise would have a strong correlation to other characteristics. A 'mid-maturity' enterprise might exhibit some kind of mix, etc. The basis for a representative ESA maturity assessment framework is depicted in Table 62 and is based on questions from our web-based survey.

Table 62: Foundation of an ESA Assessment Tool

	Level of ESA Maturity		
	Low	**Mid**	**High**
Enterprise Processes *(Process Maturity)*			
Q 11: Coupling between strategic / operational processes			
Q12: Balanced set of metrics used			
Q 13: Capability / process maturity models used			
Support of Processes *(IS Maturity)*			
Q15 - 19: support of strategic processes			
Q22-26: Support of operational processes			
Q28: Addresses the gap between IS capability and strategic decision making			
Q29: Addresses the gap between IS capability and strategic versus operational decision making			
Technology Deployment / Structure *(IT Maturity)*			
Q 31, 33: Executive-level involvement			
Q 32, 37-40: Support of business and strategic objectives			
Q 34-36: Executive-level understanding			
Q41: Systems interoperability			
EA Maturity			
Q43: Architecture supports the alignment of technology /business objectives/enterprise strategy			
Q 45: Use of an architecture framework			

Once the table has been completed, ESA maturity could be calculated for the enterprise. Such a high-level calculation might lead management toward a specific course of action such as increased investment into a specific dimension of the business, or suggest the need to alter a particular business unit strategy, for example. However, more data would need to be collected to increase the breadth, scope, and depth of the framework. Then, the framework would be better suited to provide more robust functionality such as suggesting the implementation of a specific process or procedure, a new acquisition strategy, etc. This raises the question of how to remediate deficiencies in an assessment using the above table. What shift from Low to Med, or Med to High, would most improve ESA maturity? Further research is needed to determine how to provide this kind of advice.

10.2 Strategic Layer Analysis / Portrayal Tool

Based on feedback from our interviews (see Chapter 8), executives liked the notion of a technology-based representation of strategic processes, beyond what is currently available to them. However, all interviewees queried stated that current information systems do not support strategic level processes. The survey respondents indicated that acquiring and maintaining situational awareness is the most important of all the strategic processes; they also indicated that this strategic process would be the most valuable to be supported by an information system. Our empirical analysis shows that the two are highly correlated. A high-level outline of a strategic layer analysis tool focused specifically on the representation of strategic layer processes can be described as follows:

1. <u>Premise of Such a Tool</u>:
    - A better representation of enterprise data and information should lead to a better understanding of the underlying dynamic complexities of an enterprise;
    - More robust understanding at multiple levels of abstraction can lead to better CXO decision-making capability;

- Better CXO decisions can lead to reduced enterprise failure rates and increased transformation success rates for both strategic initiatives and transition / transformation efforts;

Encapsulating a “top-down” enterprise view into a software-based tool may enhance the ability of executives to better understand and predict future enterprise growth and success based on both endogenous and exogenous data.

2. Focus and Characteristics:
   - The ability to present information (not data) at the level of abstraction of the decision-maker in a format that is more meaningful;
   - Provides a strategy-centric view of the enterprise, not a software-centric view. Essentially, current enterprise models ‘force’ the CXO to view the enterprise from the perspective of the software of the information systems. Consequently, there exists a tremendous gap in terms of how information is represented to the decision-maker, and the tools available to aid in such decisions; (it’s almost as if they are 180 degrees out of phase);
   - The format is a representation of both the context and ‘boundary conditions’ of the decision to be made --- at the decision-maker’s level of abstraction and aggregation;
   - While the model’s representation needs to be more hierarchical in nature, the underlying mechanisms for addressing higher levels of resolution would be transparent to the user-decision maker in order to reduce complexity to the user (Rouse, 2007)

An incremental step toward the development of such a tool would be to test its viability on one strategic process, perhaps the acquisition of situation awareness. Also included would be relationship maps for computer-based representation of an enterprise’s strategic situation, semantic querying to support the understanding of its strategic situation at any particular instance in time, and agent-based simulation (Bonabeau, 2001) to help predict its evolution over time. This is also a first step toward filling the information gap that currently exists in technology-centric support of strategic decision making.

10.3 Enterprise System Simulation

Finally, building on the work of Rouse and Boff (2005), Carley and Gasser (2000) and others, a simulation framework could be employed to augment our understanding of enterprise dynamics, its emergent behavior, and possible links to enterprise value creation and performance. Armed with this knowledge, and used in conjunction with currently available business systems and tools, executives may be able to make better tactical and strategic decisions regarding enterprise value creation. Unfortunately, current (traditional) analysis of business dynamics, and the information upon which executives currently base their decisions assumes that the path from one time period to the next is linear. Enterprise simulation can significantly broaden the executive's perspective of the enterprise since it embraces the notion that cause-effect relationships and their behavior patterns are rarely linear.

In particular, enterprise simulation has tremendous applicability to practice in general, and specifically, to the institutional investment community. For example, what if prospective investors could model and simulate not just one company operating within a given sector, but the behavior of an entire sector? Two benefits are noted as follows:

- Valuation Realization Model: This may enable investors to be more effective and efficient as they collectively target prospective acquisitions. One could model both the 'as is" value of a company, as well as its "to be" value in combination with prospective acquisition targets. Then, various combinations of enterprises could be entered into a simulation model to see how the various combinations behave within the context of a larger industry sector, perhaps the aerospace and defense sector;
- Post-Merger Integration and Performance Management: The creation of ROIC and economic profits that are accretive to shareholder value is a derivative of management systems that align people, financial, process and

technology opportunities. Investors and executives strive to increase enterprise performance and hence shareholder value. Such a simulation could further an understanding of the opportunities to produce M & A results in the aerospace and defense industry, as well as other industries, that exceed historical investment returns.

APPENDIX A:
GROWTH FACTOR VARIABLES

Representative GFVs

Corporate Level: People and Plan		
Realistic business plan	Adaptability to change	Performance management
Vision	Values integration	
Mission statement	Focused purpose of company	
Market economy	Developmental coaching	
Focused business strategy	Clear roles & responsibilities	
Experienced founding team/CEO	Organizational Communication	
Thorough competitive analysis	Empowerment	
Compelling value proposition	Incentive compensation plan	
Making good first hires	Continuous learning	
Board of Directors that add value	Informal communication	

Operations		
Operations Administration / HR	Operations: Facilities	Operations – IT
Processes	Location	Skills/Team
Controls	Size (sq/ft)	Disaster recovery
Admin to exec ratio	Sq/ft per employee	Inventory mgmt
Skills/team	Cost / sq/ft	Data mgmt
Tools	Appropriateness	User controls
Utilization	Legal	Security
Insurance	Contracts	Policies & Procedures
Compliance	Templates	
	Representation	

Product / Technology Development		
Documentation	Methodology	Features, functions and benefits specs
High –caliber development team	Clear product schedule	Architecture that supports multiple products
Efficiency Rate	Design	
Ability to build or buy	Creation of user manual	
Work with development partners	Budget for development	
"Patentable" IP	Availability of resources	
Design pro to budget	Availability of materials	
Willingness to invest in R & D	Development Capacity	
"Disruptiveness" of technology	Existence of functional specifications	
Clear product differentiation		

Cash, Finaceability and Fiscal Management	
Budget Process	Financing strategy
Accounting process in place	Sufficient working capital
A/P	Clear path to profitablity
A/R	Long term debt
General Accounting Practices	Create ROI plan for investors
Conduct regular audits	Monthly financial statements
Ability to pay founders	
Profit Margins	
Valuation	
Valuation Basis	

Customer-Facing: Sales and Marketing			
Sales	Sales	Marketing	Marketing
Incentive compensation plan	Channel strategy & partners	Strategic alliances	Information Resources
Support	Channel partners	Market size	Product Management
Production capacity	Accountability	Target Market	Functionality Fulfillment
Production utilization	High growth / large market	Market Fulfillment	Pricing
Efficiency ratio	Customer satisfaction	Competition	Accurate Forecasting
Logistics/transport	Sales cycle time	Branding	Defined rqmnts. for product
Geographic territory	Quota	Market Trends / trend analysis	Marketing plan in place
First customer acquisition	Quota obtainment ratio	Budget	Product rqmts. specifications
Budget	Lead Generation	Public Relations	
Territory coverage	Sales Process	Penetration/Position	

APPENDIX B (Part I):
GFV: PILOT SURVEY

Pilot Survey: Required Growth Factors For High Technology Ventures

Purpose of the Survey

As part of a joint industry / academia project, students at the Dupree College of Management at the Georgia Institute of Technology are investigating a framework that would allow both entrepreneurs and investors to judge the health of an enterprise at various phases of growth. The focus of the survey is to evaluate the resources and variables that are needed by entrepreneurs to achieve milestones and action items to progress their businesses to the next phase of growth. By investigating entrepreneurial experiences related to the growth of high technology product development ventures, we also hope to more fully understand entrepreneur preferences for the categorization, assessment, and prioritization of certain variables and resources to have access to as they pertain to each phase of growth in the typical lifecycle of the venture. This information will help us understand which variables and resources are the most significant to enable the company to successfully transition from one phase of growth to the next. These variables can pertain only to a phase of growth or can be important across the entire lifecycle of a technology enterprise.

Survey Structure

The survey consists of two parts and will take approximately 30 minutes to complete. For each section, a brief description and background is provided. Section A consists of questions concerning your role with the high technology company. In section B, you will be presented with a framework that breaks down the lifecycle of a high technology company into five specific phases of growth. We are interested in the first three stages for this survey. A list of resources and variables will be given for each phase and you will be asked to identify the ones you feel are critical or irrelevant in order to successfully complete that phase and transition to the next phase of growth.

Please remember that this is only a survey of your opinions and that there are no "correct" answers to these questions. All information provided will remain strictly confidential.

The Survey Team

The individuals conducting this survey are experienced entrepreneurs well versed in the creation of high technology ventures. We are available and very interested in your opinions. Please feel free to call or contact us at any time if you have questions regarding the survey or wish to discuss anything concerned with this project.

Faculty Representative:	Industry Representative:
Dr. Anindya Datta	Mark Mykityshyn
Georgia Institute of Technology	Five Paces Ventures
email: anindya@chutneytech.com	email: myk@fivepaces.com

<u>A. General Company Questions</u>

Your name (optional) __________________________________

1. What was / is the primary business of the enterprise?

    __ Software development
    __ Hardware development

2. When was the company founded (incorporated)?

3. What was / is you position in the company?

    __ CEO / Founder
    __ CTO / Founder
    __ VP of Marketing
    __ VP of Sales
    __ Early employee (within the first 10 hires)
    __ Other _____________

4. How long were you/have you been with the company?

__ One year
__ Two years
__ Three years
__ More than three years

Are you still there? ________

5. Do you / did you have previous entrepreneurial experience, prior to joining/founding your latest venture?

__ Yes
__ No

6. How many "rounds" of financing have been/were raised by the company?

__ None: self-financed or funded through company cashflow
__ One
__ Two
__ Three
__ More than three

7. Did the company liquidate? If so, How? (Please check all that apply)

__ Asset acquisition/merger?
__ Sale
__ IPO
__ Cease operations

B. Phase of Growth Analysis

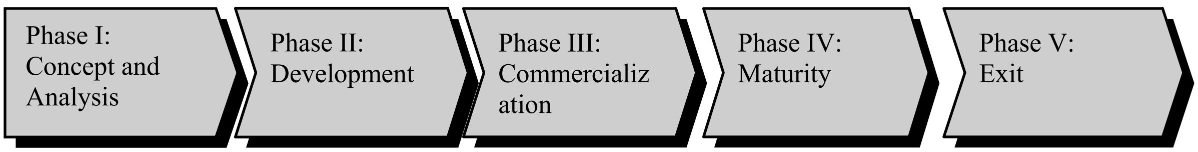
Purpose

Depending on background, experience, and position within the company, variability exists in terms of how entrepreneurs:

- Assess certain growth factor variables;
- Understand the importance of what resources they need to have access to and when (phase of growth);
- Utilize those resources that are available to them, and;
- Regard the collective importance of these variables and resources as a function of phase of growth in the company's lifecycle.

Based on your experience, we would like you to assess the criticality (or irrelevance) of certain growth factor variables and resources entrepreneurs need to have in order to successfully complete representative action items/milestones per phase of growth, thereby ensuring a successful transition to the next phase.

Researchers have subjectively divided the lifecycle of a high technology venture into five phases of growth that are outlined and briefly described below. Please note that phases of growth are not directly correlated to respective rounds of financing.



Phase I: Concept and Analysis: Here, the company begins and there are no barriers to entry.

Phase II: Development: In this phase of the company's development, the founders and current management team, which is probably pretty lean, actually plan the company's construct to a much more rigorous level of detail.

Phase III (a): Product / Technology Development: Product/technology development is progressing so that it can be scheduled and accurately budgeted for. This is the period of time during which needed improvements are made and the product is tested and proven to be commercially producible. Also, the team confirms that the product will perform as specified by constructing and testing engineering prototypes or pilot processes, resulting in a tested and proven engineering prototype or pilot process.

Phase III (b): Commercialization: (Note: For the purpose of this model, sales and business development are a subset of market development). This is the culmination point in the business cycle of all work done in the previous phases whereby the product is injected into the market. Although previous phases might portend success or failure of the enterprise, it is in this phase that success or failure becomes readily apparent.

The Following two phases are not part of the survey, but a brief definition is included for completeness:

Phase IV: Maturity: Generally, activities common to the business maturity phase pertain directly to investment options and business decisions that ensure enhanced competitiveness. Business maturity is the period of time during which the enterprise secures market position, reaches cash flow break even or profitability from business operations and, from a product perspective, explores diversification to pursue various markets. The company is on the way to creating a healthy and enduring organization. The objective of this phase of growth is to maximize profit potential of the enterprise.

Phase V: Exit: The company successfully exits via an IPO or a merger/acquisition, or it ceases operations. Without the requisite capital structure to sustain current operations, the company will be forced to pursue one of the following:

- Asset Acquisition/Merger: Since the company can no longer operate as a stand-alone entity, it agrees relinquish its assets to another company. These assets include intellectual property, technology, people (whomever either chooses to stay or is selected to stay with the new entity), products, capital equipment, etc.
- Liquidation: The Board of Directors of the entity might choose to liquidate the company by selling all non-cash assets while distributing all remaining cash back to the investors.

Directions for Completing the Survey

For this research, we are interested in the first three phases of growth. For each given phase of growth (Phase I-III), you will be presented with two things:

1. A framework that contains some representative action items/milestones that are typically undertaken while in that phase;
2. A two page list of certain variables and resources that is located directly behind the framework. It is important to note that the same variables and resources will be presented for each phase;

You will be asked to evaluate the variables and resources as they pertain to each respective phase of growth in the following manner:

- Please place a "C" next to only those variables and resources that you feel are critical to the successful completion of the action items/milestones for each phase, thereby enabling the company to progress to the next phase of growth. For example, if you feel that a vision of the company is a critical success factor for Phase I, place a "C" next to it.
- Please place a "X" next to only those variables and resources that you feel are irrelevant, or do not pertain, to the successful completion of the action items/milestones for each phase.

If there are certain variables or resources that have not been included and you feel are either critical or irrelevant, please feel free to write them on the sheet next to the category in which you feel they belong.

PLEASE NOTE: It is not necessary to place either a "C" or an "X" next to each variable, only those variables that you consider to be critical or irrelevant, respectively.

Phase I: Concept and Analysis

1. Description of Phase I: Here, the company begins and there are no barriers to entry. The fledgling company begins as purely an idea surrounded by some tangible yet unrefined thoughts about how the product might be built, marketed, and sold. At this point, the founder (s) are serious enough to conduct some preliminary due diligence and investigation in order to seek exogenous validation for the concept.
2. Some Representative Action Items / Milestones to be Achieved During Phase I:

Technical Concept Analysis	
Purpose	Determine that the physical features of the product concept are potentially achievable
Objective	Succinctly define the concept and establish its technical uniqueness

Market and Sales (Concept) Analysis	
Purpose	Determine that the concept demonstrates superior ability over current solutions to either meet a market need, capture a niche of a current market, or capture a newly emerged market
Objective	Succinctly define the concept and establish the technical uniqueness of the product offering

Financeability: General Company Assessment	
Purpose	Determine whether or not the business opportunity can generate revenue
Objective	If concept is determined to be compelling enough, position company for Series "A" financing

Financials and Cash Analysis	
Purpose	Determine cash requirements for all assets and product development
Objective	Successfully procure required cash to achieve seed stage milestones

Directions:

Using the "Variables, Growth Factors and Resource Preferences" for Phase I located on the following two pages:

- Please place a "C" next to only those variables and resources that you feel are critical to the successful completion of the action items/milestones for each phase, thereby enabling the company to progress to the next phase of growth. For example, if you feel that a vision of the company is a critical success factor for Phase I, place a "C" next to it
- Please place a "X" next to only those variables and resources that you feel are irrelevant, or do not pertain, to the successful completion of the action items/milestones for each phase.

If there are certain variables or resources that have not been included and you feel are either critical or irrelevant, please feel free to write them on the sheet next to the category in which you feel they belong.

PLEASE NOTE: It is not necessary to place either a “C” or an “X” next to each variable, only those variables that you consider to be critical or irrelevant, respectively.

Phase II: Development

1. Description of Phase II: In this phase of the company’s development, the founders and current management team, which is probably pretty lean, actually plan the company’s construct to a much more rigorous level of detail
2. Some Representative Action Items / Milestones to be Achieved During Phase II:

Technology / Product	
Purpose	Develop initial construct for building a product model
Objective	Produce a viable product that fulfills the technical uniqueness as described by work in Phase I

Market and Sales	
Purpose	Develop an initial marketing and sales model
Objective	Objective: Identify who will buy the product, how many units they will buy, and how much they will pay

Financial ‘Health’	
Purpose	Determine cash requirements for all assets and product development
Objective	Develop a break-even financial model based on 'all in costs' to take product from idea to market

Directions

Using the “Variables, Growth Factors and Resource Preferences” for Phase II located on the following two pages:

- Please place a “C” next to only those variables and resources that you feel are critical to the successful completion of the action items/milestones for each phase, thereby enabling the company to progress to the next phase of growth. For example, if you feel that a vision of the company is a critical success factor for Phase I, place a “C” next to it.
- Please place a “X” next to only those variables and resources that you feel are irrelevant, or do not pertain, to the successful completion of the action items/milestones for each phase.

If there are certain variables or resources that have not been included and you feel are either critical or irrelevant, please feel free to write them on the sheet next to the category in which you feel they belong.

PLEASE NOTE: It is not necessary to place either a “C” or an “X” next to each variable, only those variables that you consider to be critical or irrelevant, respectively.

Phase III (a): Expansion

1. Description of Phase III (a): Product/product development is under control and progressing so that product development can be scheduled and accurately budgeted for. Also, this is the period during which the needed improvements are made and during which the product is tested and proven to be commercially producible
2. Some Representative Action Items / Milestones to be Achieved During Phase III (a):

Phase III Development III (a) Product / Technology Development	
Phase III (a) 1. Specifications, Hiring Plan, Basic R & D	
Purpose	Create detailed design specifications (refer to "Techincal Questions" handout)
Objective	'Final' project plan, Preliminary Design Review (PDR), Critical Design Review (CDR)
Phase III (a) 2. Design / Build / Evaluate	
Purpose	Identify the materials, processes, and designs suitable for commercial production to be incorporated into the product
Objective	Produce the first functional product from tested and integrated components
Phase III (a) 3. Alpha Test: Internal System Test	
Purpose	Develop the manufacturing processes and techniques
Objective	Produce the first operational product and validate via internal use
Phase III (a) 4. Beta Test: "Launch" Customer / Acceptance	
Purpose	Prepare the product for introduction to the marketplace
Objective	Customer-driven modification/adaptation of product for use in their working environment

Directions

Using the "Variables, Growth Factors and Resource Preferences" for Phase III(a) located on the following two pages:

- Please place a "C" next to only those variables and resources that you feel are critical to the successful completion of the action items/milestones for each phase, thereby enabling the company to progress to the next phase of growth. For example, if you feel that a vision of the company is a critical success factor for Phase I, place a "C" next to it.
- Please place a "X" next to only those variables and resources that you feel are irrelevant, or do not pertain, to the successful completion of the action items/milestones for each phase.

If there are certain variables or resources that have not been included and you feel are either critical or irrelevant, please feel free to write them on the sheet next to the category in which you feel they belong.

PLEASE NOTE: It is not necessary to place either a “C” or an “X” next to each variable, only those variables that you consider to be critical or irrelevant, respectively.

Phase III (b): Commercialization

1. Description of Phase III (b): This is the culmination point in the business cycle of all work done in the previous phases whereby is internally tested and then injected into the market. Although previous phases might portend success or failure of the enterprise, it is in this phase that success or failure becomes readily apparent.
2. Some Representative Action Items / Milestones to be Achieved During Phase III (b):

Phase III Development III (b) Market Development	
(Note: For this model, sales and business development are a subset of market development)	
Calibration of Existing Market Model / Market Acceptance	
Purpose	Introduce the product to the market
Objective	Based on market feedback, revise product, modify pricing, and sales plan to ensure that the company has a plan that gets it to profitable operations
Financial Controls	
Purpose	Adjust fixed spending to meet unit variable and product and sales costs
Objective	Ensure that the company is progressing toward 'break-even' point in operations
Market Expansion	
Purpose	Achieve further market penetration with product, according to plan
Objective	Achieve first break-even quarter of operations
Market Diversification	
Purpose	The product is modified to meet new opportunities, or new products are developed to meet existing market demand
Objective	Effectively address changing market conditions

Directions

Using the “Variables, Growth Factors and Resource Preferences” for Phase III(b) located on the following two pages:

- Please place a “C” next to only those variables and resources that you feel are critical to the successful completion of the action items/milestones for each phase, thereby enabling the company to progress to the next phase of growth. For example, if you feel that a vision of the company is a critical success factor for Phase I, place a “C” next to it.
- Please place a “X” next to only those variables and resources that you feel are irrelevant, or do not pertain, to the successful completion of the action items/milestones for each phase.

If there are certain variables or resources that have not been included and you feel are either critical or irrelevant, please feel free to write them on the sheet next to the category in which you feel they belong.

PLEASE NOTE: It is not necessary to place either a “C” or an “X” next to each variable, only those variables that you consider to be critical or irrelevant, respectively.

Post-Survey Questions

1. Did you feel that the categorization of variables was appropriate? If not, what would you change?

2. Across all three Phases of growth, what are, in your opinion, the top ten variables and/or resources that determine the success of a high technology product development venture?

#1: ___________________________
#2: ___________________________
#3: ___________________________
#4: ___________________________
#5: ___________________________
#6: ___________________________
#7: ___________________________
#8: ___________________________
#9: ___________________________
#10: __________________________

APPENDIX B (Part II):
GFV: EXPLORATORY SURVEY RESULTS

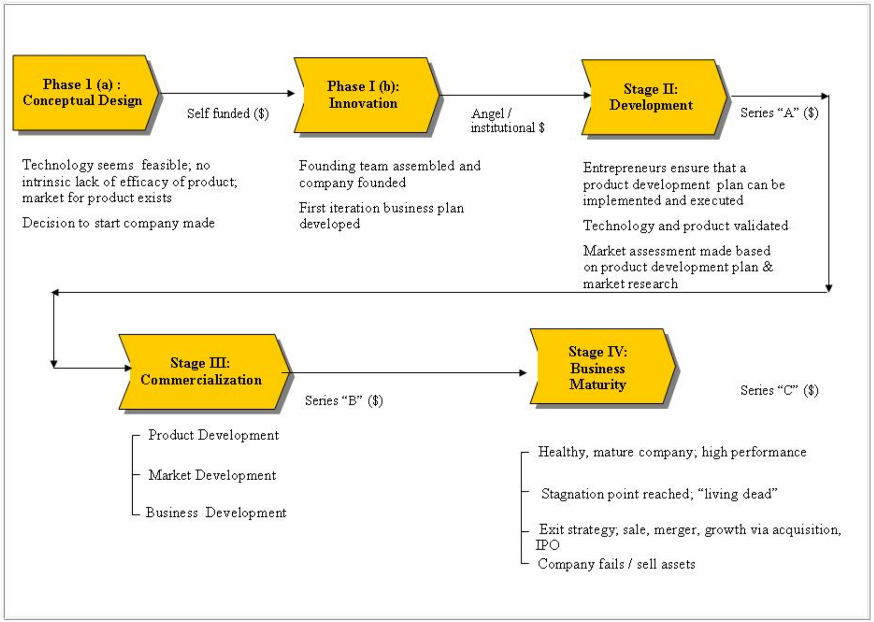


Figure 88: Phases of Growth Framework

- Analysis conformed with the survey construct
- Significance test (MANOVA) in order to test the validity of the data obtained to date *(average Phase p value ~ 5.0E-24)*
- Factor Analysis (FA) with Varimax rotation was performed. Multidimensional Scaling (MDS) was also performed as a cross check
  - Reduce the 24 Growth Factor Variables (GFV) to smaller components or dimensions
  - Considered cluster analysis as a check if the results from MDS and FA had yielded markedly different results, but they didn't
- Studied the eigenvalues and correlations
  - Yielded three major components, around which the 24 GFV's could be grouped
  - Strategy / strategic vision, finance / financeability, and product / product development
- Evaluated and unit-weighted correlation coefficients that were obtained from FA to calculate weights of individual variables and dimensions
  - Based on this analysis, were able to construct a 3-D view of the data
  - In future work, this will be used for trajectory analysis of an individual company relative to others in the same sector; i.e., software/hardware development

Figure 89: Overarching Statistical Plan

- Grouped variables per dimension, based on the correlations component matrix, based on the individual correlation of the GFV to dimension
- Subjective analysis done for factors of equal correlations

Strategy / Strategic Vision	Product Development	Finance/Finanecibiltiy
Compelling Vision	Team Skills Talent	Compelling ROI
Communication of Vision	Competitive Analysis	Attract Smart Investors
Founder's Ability to Cultivate the Opportunity	Innovative Eng Team	Accurate Product Docs
Convert Assumptions	Product Differentiation	Technology Disruptiveness
Corporate Culture	Invest R&D	Strategic Alliances
Focused Business Strategy	Patentable IP	Profitable Business Model
Prospective Customer Identification	Sufficient Capital	
Translation Of Customer Needs	Cost Controls	
Effective Sales Process	Secure First Customer	

Figure 90: GFV Dimensionalization

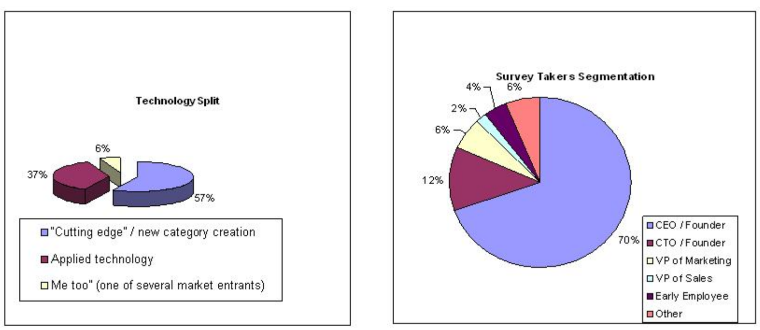


Figure 91: Summary Statistics General Information Questions

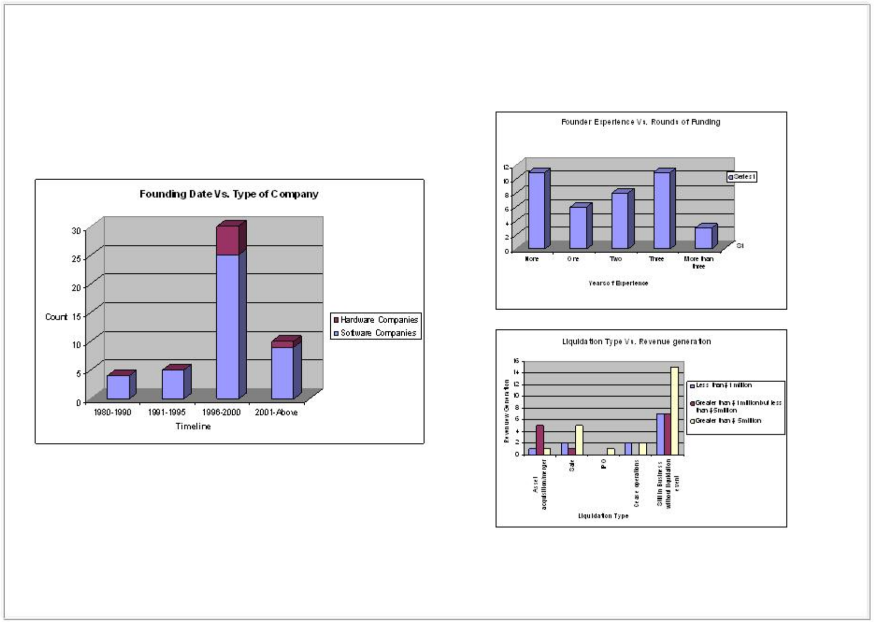


Figure 92: Summary Statistics: General Information Questions (continued)

		Ranking	
	Phase1	Phase2	Phase3
Compelling Vision	2	2	11
Communication of Vision	3	3	13
Founder Cultivate Opportunity	1	1	4
Team Skills Talent	6	5	5
Convert Assumptions	15	14	19
Competitive Analysis	17	19	14
Corporate Culture	20	20	17
Focused Business Strategy	12	10	10
Compelling ROI	14	16	15
Innovative Eng Team	9	13	21
Attract Smart Investors	16	15	16
Accurate Product Docs	24	23	22
Technology Disruptiveness	22	22	23
Product Differentiation	10	9	9
Invest R&D	11	18	20
Patentable IP	21	24	24
Sufficient Capital	8	8	6
Cost Controls	13	11	8
Prospective Customer Identification	5	4	3
Translation Of Customer Needs	4	6	7
Effective Sales Process	18	12	1
Secure First Cust	7	7	2
Strategic Alliances	23	21	18
Profitable Business Model	19	17	12

Figure 93: Summary Statistics: Variable Rankings

Phase1		Phase2		Phase3	
Founder Cultivate Opportunity	1	Founder Cultivate Opportunity	1	Effective Sales Process	1
Compelling Vision	2	Compelling Vision	2	Secure First Customer	2
Communication of Vision	3	Communication of Vision	3	Prospective Customer Identification	3
Translation Of Customer Needs	4	Prospective Customer Identification	4	Founder Cultivate Opportunity	4
Prospective Customer Identification	5	Team Skills Talent	5	Team Skills Talent	5
Team Skills Talent	6	Translation Of Customer Needs	6	Sufficient Capital	6
Secure First Customer	7	Secure First Customer	7	Translation Of Customer Needs	7
Sufficient Capital	8	Sufficient Capital	8	Cost Controls	8
Innovative Eng Team	9	Product Differentiation	9	Product Differentiation	9
Product Differentiation	10	Focused Business Strategy	10	Focused Business Strategy	10
Invest R&D	11	Cost Controls	11	Compelling Vision	11
Focused Business Strategy	12	Effective Sales Process	12	Profitable Business Model	12
Cost Controls	13	Innovative Eng Team	13	Communication of Vision	13
Compelling ROI	14	Convert Assumptions	14	Competitive Analysis	14
Convert Assumptions	15	Attract Smart Investors	15	Compelling ROI	15
Attract Smart Investors	16	Compelling ROI	16	Attract Smart Investors	16
Competitive Analysis	17	Profitable Business Model	17	Corporate Culture	17
Effective Sales Process	18	Invest R&D	18	Strategic Alliances	18
Profitable Business Model	19	Competitive Analysis	19	Convert Assumptions	19
Corporate Culture	20	Corporate Culture	20	Invest R&D	20
Patentable IP	21	Strategic Alliances	21	Innovative Eng Team	21
Technology Disruptiveness	22	Technology Disruptiveness	22	Accurate Product Docs	22
Strategic Alliances	23	Accurate Product Docs	23	Technology Disruptiveness	23
Accurate Product Docs	24	Patentable IP	24	Patentable IP	24

Figure 94: Summary Statistics: Variable Rankings (continued)

- Based on experiences as a VC and entrepreneur, it was hypothesized that:
  - ➢ Entrepreneurs would state that the relative importance of certain GFV would significantly change from Phase II to Phase III (Phase IV, Maturity, was not studied as this analysis was concerned only with the very nascent phases of growth)
  - ➢ Statistically, it could be shown that the GFV's could be 'dimentionalized' around strategy, product development, and matters relating to corporate finance / "financeability" (Current performance metrics are based exclusively on financial performance; i.e., is the company profitable)
- In the absence sales / financial data, it is possible to create a 3-D map of a company's development, particularly at the early stages of growth -- before profitability

Figure 95: Summary Statistics / Hypotheses

➢ Statistical Objectives (first approximation):

- Importance: In general, the biggest thing from this section that we're testing is the hypothesis that the importance of GFV change as a function of phase of growth.
- Correlation of Each Factor: How does each factor contribute to each phase?
- Deviation from the Relative Correlations: If the deviation was large then we would want to evaluate the factor in depth to find out the reason for such high deviation.
- Even thought deviations were found to be small, the following techniques were used to find correlations within the GFV's to obtain the factors:
  - Multi-Variate ANOVA
  - Mean-median
  - Factor Analysis
  - Multi-dimensional Scaling
- Relative Weights of Each Factor: Once correlation of each factor was identified, unit weights and individual correlations with the 3 dimensions were analyzed to evaluate the individual weights of each GFV within that dimension

Figure 96: Statistical Protocol: Growth Phases I - III

Components Versus Phases (Time Line)

	Strategy / Vision	Product Dev	Finance / Financeability
Phase 1	0.265	0.341	0.394
Phase 2	0.378	0.364	0.259
Phase 3	0.098	-0.181	1.083

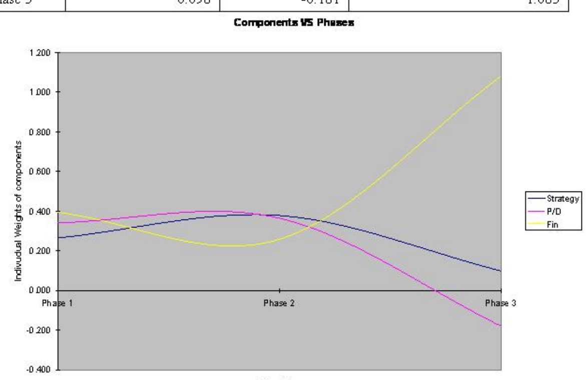


Figure 97: General Results: Growth Phases I - III

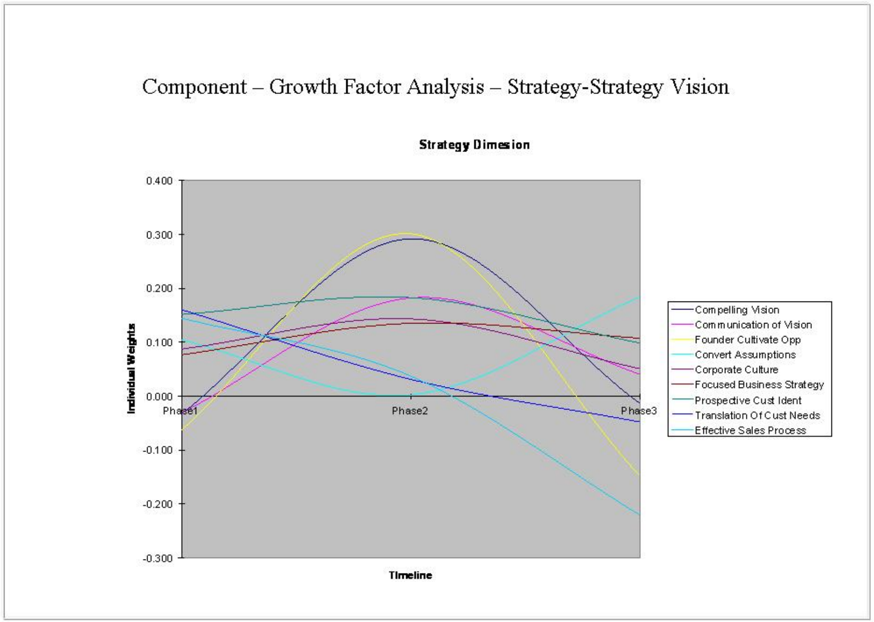


Figure 98: General Results: Growth Phases I – III (continued)

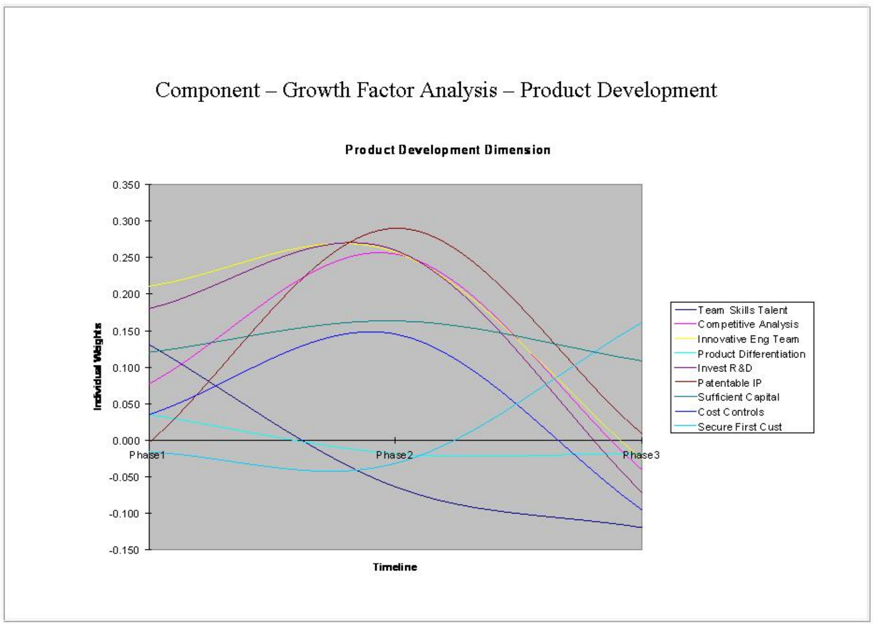


Figure 99: General Results: Growth Phases I – III (continued)

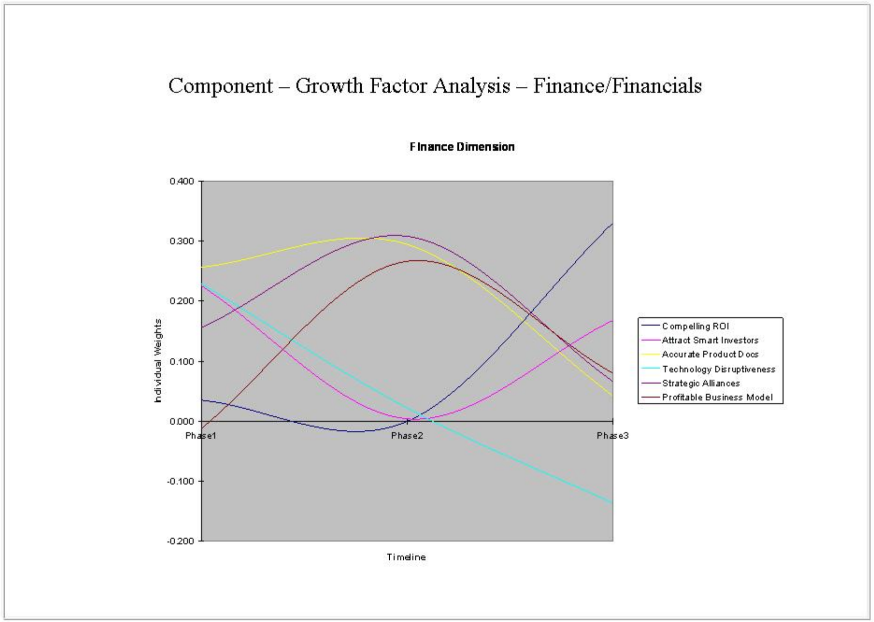


Figure 100: General Results: Growth Phases I – III (continued)

Metric	Phases I & II	Phase III
Culture	Entrepreneurial	Professional business system
"Policies" that guide decision making	Based on untested assumptions	Based on acquired knowledge to make more informed decisions
System (phase) construct	Linearly independent	Interrelated
System behavior	Nonlinear/modular---neutrally stable at best	Dynamically complex, unstable
Formulating the construct	Define/specify the business model	Execution focused
Planning	Ad hoc, more spontaneous, sensitive dependence on initial conditions	More formalized, disciplined approach
Management style	Identify critical task structure	Managing to milestones
Profit	"Just happens"	Set and manage to targets
Roles/responsibilities	Largely undefined, wear many hats	Defined and mutually exclusive
Uncertainty	Untested assumptions	Based on benchmarked data
Outcome of phase	Deterministic/probabilistic	probabilistic

Figure 101: Distinguishing Characteristics: Growth Phases I - III

- The relative importance of certain GFV changed significantly from Phase II to Phase III
- Statistically, was shown that the GFV's could be 'dimentionalized' around strategy, product development, and matters relating to corporate finance / "financeability"
- In the absence sales / financial data, it is possible to create a 3-D map of a company's developmental profile, particularly at the early stages of growth -- before profitability
  - Predictive capability vs. screening tool
- Validated the presence on nonlinear dynamical growth patterns
- Higher sample size desired (still collecting data..)
- More granularity per dimension
- Selection bias yet to come..

Figure 102: Conclusions

Phase I Objectives:

- *Develop a stable & objective methodology for determining the probability of success for a new venture*
  - Articulate / develop an explicit, organizational framework of early stage company formation
  - Cultivate a broad understanding of the fundamental tenants of VC / private equity investment decision making
  - Validate dynamic complexity at the nascent stages of growth

Phase II Objectives:

- *Develop framework & model for complex problem solving/decision making*
  - Agent-based hybrid intelligent system

Phase II Objectives:

- *Develop an analysis tool for both the investment professional and the entrepreneur*
  - Stochastic analysis capability
  - Help shape overarching investment strategy/ increased confidence
  - Check the accuracy of the due diligence process
  - Legal / regulatory compliance / fiduciary responsibilities

Figure 103: Implications and Next Steps

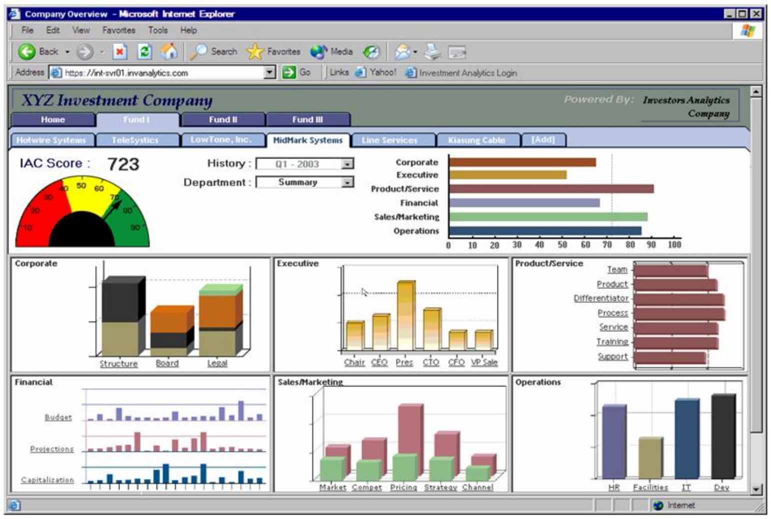


Figure 104: Prototype User Interface

APPENDIX C:
ANALYSIS OF FINANCIAL METRICS AND VARIABLES

Introduction

It was hypothesized that some key financial metrics would consistently predict enterprise performance over a sample of enterprises in the satellite-based communication industry serving the aerospace and defense sector. In order to show this, data were gathered for a group of small to medium-sized publicly held enterprises in this sector. Multiple regression analysis were performed on the data with enterprise performance as the dependent variable. Return on invested capital (ROIC) was used as a proxy metric for enterprise performance. It was hypothesized that some or all of the following metrics would predict enterprise performance: gross margin, EBITDA, gross revenue, working capital turns, cash balance, free cash flow, headcount, revenue per employee.

I. Methodological Overview

The analysis was conducted in order to investigate the following:

1. Defend why ROIC versus other output variables such as Earnings Per share (EPS) and stock price should be used as a proxy for enterprise value;
2. Identify those performance metrics; i.e., "factors", that most influence ROIC;
3. Identify the executive-level tasks and activities; i.e., "workflow", associated with strategic plan implementation that could most influence those factors;
4. Correlate executive-level workflow to enterprise performance;
5. Applications & future research (toward performance predictability)

The analysis entailed five major objectives:

1. Objective: Defend why ROIC versus other output variables such as EPS and stock price should be used as a proxy for enterprise value

A measure of how effectively a company uses the money (borrowed or owned) invested in its operations.

2. Objective: Identify those performance metrics; i.e., "factors", that most influence ROIC

The methodology is top-down, taking its source data from publicly reported financial statements. Since generic public filings such as 10k's and 10Q's do not report 'people' data, underlying dynamics and intangibles of performance are greatly simplified. This allows for reliable comparisons among other companies in both the Department of Defense (DoD) satellite communications sector, as well as DoD-wide. By contrast, bottom-up methodologies do not easily lend themselves to 'peer' comparisons as they require many more factors and comparisons, making them more difficult, time consuming, and expensive to conduct. Preparatory analysis included the following:

a) Database Development: The creation of a database of ~300 DoD Satcom companies. After applying some filters, the number was reduced to 23 companies between $75M and $1B in sales;

b) Selection of Predictors / "Factors": The following 10 predictors/factors were narrowed from approximately 30 based on our research and discussions with various investment banking and hedge fund analysts. At least 12 quarters of data have been collected on the aforementioned companies according to 10 predictors/factors listed below:
   - ROIC
   - Gross revenue
   - Gross margin
   - EBITDA
   - Booking /backlog
   - Working capital turns
   - Cash balance
   - Cash flow
   - Headcount
   - Revenue per employee

c) Arriving at the Factors: Among others, three measurable outcomes are an artifact of a good strategic plan and its implementation. Each of these metrics, efficiency, growth, and profitability, is a derivative of ROIC. As will be discussed in more detail at a later point, ROIC was chosen to regress against since we believe that the strength of the enterprise is best represented by ROIC which is driven by profitability and capital efficiency. ROIC and each derivative are briefly discussed below:

d) 1st Order Metric: ROIC[12]

The ultimate focus is on real and/or perceived enterprise value. Other measures of enterprise value that may be considered include NOPAT[13] and invested capital turnover[14]. These are outcomes. From an executive workflow perspective, what can/should be done to influence the aforementioned outcomes? Some associated questions might include the following:

- Is ROIC a value differentiator for enterprises in the lower middle market as it is for the larger prime contractors? If so, what are those value differentiators?
- Does the analysis 'hold' for smaller, lower middle market public companies?
    a) From our collected data
    b) Across all DoD-centric companies
- Even smaller companies in the sub-$50M range

e) Suggested Analyses Protocol:

Typically, enterprises in the aerospace and defense industry use a range of metrics to measure enterprise performance; some are available via public filings, and some are not. Measurable metrics include traditional financial factors such as growth, profitability, and capital efficiency. Those metrics for which data are not publicly available include contract performance (e.g., internal), and new contract captures (e.g., external). While

12 ROIC Defined as NOPAT / (Total assets – excess cash – NIBCL)
13 NOPAT (Net Operating Profits After Tax) Defined as Sales – Operating Expenses - Taxes
14 Invested Capital turnover defined as Revenue / Avg. Book Capital

the measurement metrics that we've chosen to focus on may not, in the aggregate, provide as robust a picture of company performance as possible, we are limited to only those metrics for which public data exists.

1. For the 23 public DoDsatellite-based communication companies in our database:
2. Validate that the data collected are accurate;
3. Rank each of the 23 companies in the database in order from the lowest ROIC to the highest, and separate into quartiles. As previously noted, ROIC was chosen to regress against since we believe that strength of the enterprise is best represented by ROIC which is driven by profitability and capital efficiency. This yielded a 10 x 23 matrix of R2 values;
4. Per company, conduct a single variable regression analysis on of each the 10 factors against ROIC;
5. Use this analysis to 'down-select' to a handful of predictors/factors;
6. Conduct multiple factor MV regression analysis to determine the relationship between predictors/variables;
7. Compute the average the R2 values for the top quartile and compare to the average R2 values of the bottom quartile and test for significance;
8. Perform MV regression analysis to ascertain the extent to which the factors themselves interact;
9. Monte Carlo Simulation (future work): Construct a continuous time, dynamic simulation incorporating exogenous variables
    - Show interrelationships
    - Discuss how the metrics shown to most influence ROIC might be isolated from exogenous variability. Such variability includes, but is not limited to, GDP trends, short time constant financial data (quarter-to-quarter), as well as long time constant financial data (year-over-year), the shape of the budget curve (DoD), and unemployment, etc.

3. Objective: Identify the executive-level tasks and activities; i.e., “workflow”, associated with strategic plan implementation that could most influence those factors

Part of the outcome of this analysis might be used to provide a CEO with some actionable recommendations concerning those tasks and activities that executives should be focused on in order to have the highest likelihood of increasing company performance. Based on the data, it is left to future work to determine what processes should be implemented / pursued in order to increase value, gain more competitive advantage, and operate the enterprise more efficiently.

4. Objective: Correlate executive-level workflow to enterprise performance
   - Ascertain the extent to which executive workflow conducted to implement a company’s strategic plan correlates to company performance as measured by several financial metrics, and corroborated by interview data.
   - Through an in-depth investigation of a company (or two), one could cultivate an understanding of those tasks and activities associated with each factor and collect data over time to see if increases (or decreases) in performance correlate to those tasks and activities.

For example, for an enterprise that has completed its strategic planning process and is beginning the implementation phase, each executive; i.e., sales, operations, etc., could be tasked to complete a plan for his unit that contributes to the accomplishment of the enterprise’s overarching plan. So, once the plan has been completed and implementation has begun, how does the company know that it’s achieving the plan? What are the feedback and control loops, etc.? An analyis such as this creates an opportunity to collect data to ascertain whether or not the results are broadly applicable to other DoD satellite communications-focused enterprise and, perhaps, all enterprises in the aerospace and defense sector. These data might also be used by both management and investors to help assess and predict future enterprise performance.

5. Objective: Applications and Future Research: Toward Performance Predictability
   - Will not be able to predict based on generic public data; need ‘people’ data
   - Lessons learned for those who aspire to manage an enterprise

II. Data Analysis and Results

We originally hypothesized that some key financial metrics would consistently predict enterprise performance over a sample of enterprises in the satellite-based communication industry serving the aerospace and defense sector. In order to show this, data were gathered for a group of small to medium-sized publicly held enterprises in this sector. Multiple regression analysis were performed on the data with enterprise performance as the dependent variable. Return on invested capital (ROIC) was used as a proxy metric for enterprise performance. It was hypothesized that some or all of the following metrics would predict enterprise performance: gross margin, EBITDA, gross revenue, working capital turns, cash balance, free cash flow, headcount, revenue per employee.

Results show that EBITDA and cash flow are the only two significant predictors of ROIC, with cash flow having a negative impact on ROIC. We see the greatest prediction rate for enterprises with gross revenue ranging from $70 million to $1 billion and with -50% < ROIC < 50%. Although we can ROIC to some extent with our model, enterprise performance can not solely be predicted through financial measures, but other qualitative aspects of the enterprise must be considered when predicting performance.

Three data sets were used, referred to as A, B, and C. Each data set consists of enterprises in that portion of the satellite communication industry that serves the defense sector. The financial data within these data sets are overlapping, so it is important to remember that A, B, and C are not independent data sets. Descriptive characteristics of the data sets are found in the Table 1:

Data Set	**Number of enterprises (n)**	**Range of Avg Revenue**	**ROIC Range**	**R2 (All 8 predictors)**
A	18	$7M - $1.2B	-15% - 28%	60.4%
B (original)	56	$467K - $12B	-367% - 1730%	3%
B (modified)	49	$3.7M - $12B	-36% - 38%	26%
C	32	$72M - $1B	-23% - 36%	47.2%

Table 1: Multiple Data Set Characteristics

It is shown that data set A has a very small sample size (18 enterprises), and so it is difficult to draw conclusions with conviction. Using all eight predictor variables, we found a R2 of 60.4%, and only one significant predictor variable: EBITDA. The results

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.777[a]	.604	.251	10.30069

a. Predictors: (Constant), GrossRev, GrossMar, RevPerEm, Balance, WorkCap, EBITDA, Headcnt, Flow

from this initial regression are shown in Table 2.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-4.208	22.607		-.186	.856
	EBITDA	.340	.155	1.125	2.196	.056
	GrossMar	.429	.444	.340	.965	.360
	RevPerEm	4.11E-006	.000	.041	.115	.911
	WorkCap	-4.057	10.102	-.135	-.402	.697
	Balance	.008	.070	.034	.120	.907
	Flow	-.022	.297	-.069	-.074	.943
	Headcnt	-.001	.004	-.175	-.219	.832
	GrossRev	-.024	.045	-.671	-.543	.601

a. Dependent Variable: ROIC

Table 2: All Predictors / Factors

Another regression was run using only EBITDA as a predictor variable. This regression resulted in an R2 = 19.0%. In other words, 19% of the variance of ROIC is due to the EBITDA of the 18 enterprises. If this holds true across a larger sample size, then EBITDA alone will predict almost 20% of an enterprise's performance. Table 2 depicts the result of this analysis

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.436[a]	.190	.139	11.04470

a. Predictors: (Constant), EBITDA

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	2.778	3.057		.909	.377
	EBITDA	.132	.068	.436	1.938	.071

a. Dependent Variable: ROIC

Table 3: EBITDA as a Predictor Variable

Next, we obtained a larger sample size (56 enterprises), data set B, and ran a regression using all 8 predictor variables. The results showed an R2 of 3%, meaning that the 8 predictor variables did not account for much of the variance in ROIC. If this is true, the predictor variables are not good predictor variables for enterprise performance. However, looking at the ROIC range, there is a very large spread in the data, and models do not typically work well in extreme ends of a range. We removed all enterprises whose ROIC < -50% or ROIC >50%, leaving us with 49 enterprises – this is called the modified data set B.

Running a regression with all 8 predictor variables on modified data set B, we find an R2 = 26%, with EBITDA and Cash Flow as significant predictors and gross margin as an almost significant predictor. These data are depicted in Table (See tables below.)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.519[a]	.269	.123	14.53212

a. Predictors: (Constant), RevPerEM, Balance, EBITDA, WorkCap, GrossMar, Headcnt, Flow, GrossREv

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-4.513	6.890		-.655	.516
	GrossREv	.009	.028	1.068	.336	.739
	GrossMar	.262	.174	.263	1.511	.139
	EBITDA	.186	.076	2.792	2.444	.019
	WorkCap	-4.035	4.522	-.138	-.892	.377
	Balance	.014	.013	.184	1.034	.307
	Flow	-.202	.081	-3.912	-2.514	.016
	Headcnt	.000	.004	.167	.063	.950
	RevPerEM	.043	.455	.016	.094	.926

a. Dependent Variable: ROIC

Table 4: Predictor Variables for Larger Sample Size

Another regression was run, with only EBITDA, cash flow, and gross margin as predictor variables. This regression resulted in an R2 = 18.2%. In other words, 18% of the variance of ROIC is due to the EBITDA, gross margin, and cash flow of the 49 enterprises. Only cash flow and EBITDA are significant. Notice that cashflow has a negative impact on the predicted ROIC. The resulting equation is

ROIC = -2.69 + .135* Grossmargin + .1292*EBITDA - .095*Cashflow

Results are depicted in Table 5.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.426[a]	.182	.127	14.49502

a. Predictors: (Constant), Flow, GrossMar, EBITDA

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-.269	4.682		-.057	.954
	GrossMar	.135	.153	.136	.884	.381
	EBITDA	.129	.059	1.940	2.204	.033
	Flow	-.095	.046	-1.827	-2.070	.044

a. Dependent Variable: ROIC

Table 5: EBITDA, Cash Flow, and Gross Margin as Predictor Variables.

However, we felt the revenue range in modified data set B was too wide. We feel that very large enterprises and very small enterprises operate differently than medium-sized enterprises. So, we reduced the data set to data set C. We eliminated all enterprises from original data set B that had gross revenue < \$70 million or gross revenue > \$1 Billion. Then, we eliminated all enterprises with ROIC < 50 % or ROIC > 50%. Only one enterprise had an extreme ROIC after we eliminated the very small and very large enterprises. This resulted in a data set with 32 enterprises.

Running a regression with all 8 predictor variables on modified data set B, we find an R2 = 47%, with EBITDA, Cash Flow, and gross margin as significant predictors. Results of this analysis are depicted in Table 6.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.687[a]	.472	.289	10.96593

a. Predictors: (Constant), RevPerEm, Balance, GrossRev, Grossmar, flow, WorkCap, Headcnt, EBITDA

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-1.140	7.957		-.143	.887
	GrossRev	-.001	.026	-.028	-.049	.961
	Grossmar	.383	.185	.462	2.067	.050
	EBITDA	.275	.100	2.399	2.755	.011
	WorkCap	-3.622	8.781	-.111	-.412	.684
	Balance	.031	.022	.584	1.411	.172
	flow	-.321	.113	-2.420	-2.831	.009
	Headcnt	.000	.003	-.018	-.037	.971
	RevPerEm	.128	.358	.072	.356	.725

a. Dependent Variable: ROIC

Table 6: Regression Analysis: Eight Predictor Variables on Modified Data Set B

Another regression analysis was conducted, this time using only EBITDA, cash flow, and gross margin as predictor variables. This regression resulted in an R2 = 39.7%. In other words, 40% of the variance of ROIC is due to the EBITDA, cash flow, and gross margin of the 32 enterprises. Only EBITDA and cash flow are statistically significant as predictors. Table results are shown below. The resulting equation is

ROIC = 2.649 + .231* Grossmargin + .162*EBITDA - .174*Cashflow

This equation should hold true for satellite/ communication enterprises in the defense sector with a gross revenue ranging from $70 million - $1 billion dollars and -50% < ROIC < 50%. This equation will account for 40% of the variance found in ROIC.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.630[a]	.397	.333	10.62187

a. Predictors: (Constant), flow, Grossmar, EBITDA

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.649	4.180		.634	.531
	Grossmar	.231	.152	.279	1.523	.139
	EBITDA	.162	.058	1.413	2.775	.010
	flow	-.174	.063	-1.311	-2.763	.010

a. Dependent Variable: ROIC

Table 7: EBITDA, Cash Flow, and Gross Margin as Predictor Variables

Financial Analysis Observations:

Consistently through this exercise, EBITDA and Cash Flow are depicted as significant predictors of ROIC, which was taken as a proxy for enterprise performance. It is interesting to note that cash flow consistently has a negative impact on ROIC. Using our derived formula, one can conclude that EBITDA and cash flow can predict part of the variation in ROIC. It should be noted that this formula only works for enterprises with gross revenue ranging from $70 million to $1 billion and with -50% < ROIC < 50%. Even though EBITDA and cash flow can predict 40% of the variance in ROIC, that means that 60% of the variance is unaccounted for. We believe that enterprise performance can not solely be predicted through financial measures, but other qualitative and quantitative aspects of the enterprise must be considered when predicting performance.

Other Observations

Most traditional enterprise financial performance metrics are “as was” focused; consequently, they are of little correlation to the prediction of Enterprise Value (In the context of the analyses, ROIC is taken as a proxy for enterprise value);

- Most (80% [+]) M&A transactions fail to meet/produce stated expectations for the resulting enterprises' performance and/or value. Consequently, one can assert that most M&A transactions destroy enterprise value;
- EBITDA has, traditionally, been used as a proxy for enterprise value; however, EBITDA is not a tightly correlated predictor of enterprise value;
- EBITDA per Employee is significantly correlated with the prediction of enterprise value;
- EBITDA per Employee could be a "Dashboard Metric" for "enterprise effectiveness and efficiency", should we choose to develop a prototype;
- Decoding how "employee effectiveness and efficiency" can be measured, predicted and influenced is the key to creating enterprise value and not destroying enterprise value in M&As;
- This could enable an enterprise to identify targets with both "as is" enterprise value and truly unrealized "to be" enterprise value that can be unlocked after an M&A transaction, through improving "people effectiveness"
- Traditionally, *return on Average Assets* was viewed as a proxy for "enterprise efficiency"
    - Assets, in this metric, dealt typically with more "tangible assets" (e.g., plant and equipment, real estate, financial investments)
    - Today, most annual reports parrot the phrase "People are our most valuable asset"; and they may be right in a real and tangible way
    - In technology and service focused enterprises, plant and equipment are a relatively small component of Total Assets; therefore, Return on Average Assets does not represent a meaningful measure of "enterprise efficiency"
- Therefore, *EBITDA per Employee* is a more accurate representation of "enterprise efficiency"
- Increasing unrealized "people effectiveness and efficiency" unlocks unrealized "enterprise value"
- Keys to "people effectiveness and efficiency" might include:

- Effective and efficient work flows that are tightly aligned with the enterprise's business strategy
  - A business strategy is not valuable for strategic business positioning unless it can be:
    - Communicated, understood and made relevant to people at all levels of the enterprise
    - Made actionable at all levels of the enterprise
- People communication is a business proxy for the satisfaction of a "hierarchy of needs" that is just above "sustenance";
- Compensation programs that influence valuable behavior; i.e. prospective in focus rather than retrospective in focus;
- Metrics that measure "value creation" and that are linked to tools that influence "as is" and "to be" results;
- Creation/maintenance of culture/values that have a "strategic fit" and that provide a context for assessing "people fit" in both people recruiting and people retention/reward

INDEX OF COMMON OUTPUT VARIABLES

Measuring The Performance of Public Companies

Common Ratios & What They Mean

The following terms and ratios are in common use by securities analysts, brokers, institutional investors and others in the investment community, and by companies, public and private, to make general comparisons of financial performance.

CF/S - Cash Flow Per Share

EPS - Earnings per share

E/P - Earnings-Price Ratio

EBIT - Earnings Before Interest and Taxes

EBITD - Earnings Before Interest, Depreciation and Taxes

EBITDA - Earnings before Interest, Taxes, Depreciation and Amortization

P/CF - Price to Cash Flow (or CF/S - some prefer Cash Flow per Share)

P/E - Price to earnings

P/S: Price to Sales

P/BV: Price to Book Value

CF/Debt: Cash Flow to Debt

ROIC: Return on Invested Capital

GPM or Gross PM: Gross Profit Margin

NWC: Net Working Capital

T/V or TVol: Trading Volumes

Definitions of Terms and Ratios

CF/S: Cash flow per share. Divide the company's annual cash flow by the number of shares outstanding at fiscal year end. Investors expect this number to be on a fully diluted basis, i.e., including all warrants and options.

EBIT/S: Earnings before interest and taxes per share.

EBITD: Earnings before interest, taxes and depreciation

EBITDA: Earnings before interest, taxes, depreciation and amortization

E/P: Earnings-price ratio - the relationship of earnings per share to the current stock price. Also referred to as earnings yield. E/P is used to compare the relative attractiveness of stocks, bonds and money market instruments. It is the inverse of the price-earnings ratio.

EP/S: Earnings per share. Net Earnings divided by the number of shares outstanding. Usually expressed both as a gross EP/S and as fully diluted, i.e., including outstanding options and warrants.

P/CF: Price to cash flow. Divide the latest share price by the company's cash flow per share for the most recent 12-month period. (The lowest number is the best ratio.) Cash flow measures a company's ability to grow, without feeding upon itself by selling assets. It includes non-cash charges like depreciation, which can be large at times, thus cash flow is considered by many as a better indicator than earnings. Cash flow is an important indicator for capital intensive companies which invest heavily during start-up, then will have smaller outlays as the business grows -- oil and gas, real estate, cable television.

P/BV: Price to book value. The ratio between a company's latest closing share price divided by its most recent book value, usually a fiscal year end or the end of a quarter. Book value is net worth per share, and calculated by totaling up all assets recognized for accounting purposes and subtracting all liabilities.

P/S: Price to sales. The latest closing price divided by the company's revenues per share for the latest 12 months. (The lowest number is the best ratio.) Sales is more strictly-defined than earnings, thus P/S ratios are more constant and reliable than price-earnings ratios. Note: Industries with higher profit margins like oil and gas, and information technology, generally have higher P/S ratios than those with thinner margins, like the retail sector. Regardless, any stock with a P/S ratio of more than two will be considered high risk.

P/E: Price to earnings. The latest closing price divided by earnings per share, fully diluted (all warrants and options included), for the most recent four quarters. Financial markets consider P/E a measurement of investor popularity, i.e., their enthusiasm about/confidence in the company's potential for future earnings. Some investors believe a low P/E is an indicator of an undervalued stock. Some companies have low P/E ratios as a result of performance; some have earned high P/Es through rapid growth.

Other Ratios

CF/Debt: Ratio of cash flow to debt -- the ability to repay debt. For example, a Figure of 0.82 would mean the company's cash flow covers its total debt 0.82 times. Thus the higher the number the better. The markets expect utilities to show cash flow of 0.20 or hither, industrials should be 0.30 or higher.

ROIC: Return on invested capital. The Figure shows how well a company's managers have employed its assets, regardless of the source of the capital -- debt or stock. The ratio is expressed as a percentage. The higher the percentage the better; a negative number means a negative return.

NWC: Net working capital. This ratio is similar to a company's current ratio, a comparison of the value of current assets against current liabilities. Net Working Capital also takes into account both short and long term liabilities. The higher the number the more assets a company has to cover its liabilities.

Vol: Trading volume. The number of shares traded over the last 52 weeks. Usually expressed in thousands of shares traded per day or per week. Trading volume compared with shares outstanding and the public float helps measure investor interest. Trading volumes are usually graphed with stock prices and indicate how the market has responded to company performance and announcements.

Hi/Lo: The share price high and low for the past 52 weeks. One indicator of investor interest and confidence.

APPENDIX D:
SUMMARY OF HYPOTHESIS TESTING: AEROSPACE AND DEFENSE INDUSTRY ENTERPRISES

Table 63: Enterprise Processes

	Proposed Relationship	Analyses Conducted	Outcome
Enterprise Processes (Measurement of Process Maturity)			
H1 (a)	Strategic layer processes and operational layer processes are different.	• Hypothesis testing using Binomial Distribution	Accepted
H1 (b)	Strategic and operational processes that are tightly coupled will have a positive relationship with enterprise performance.	• Correlation Coefficient and P-Value • Linear Regression • ANOVA using General Linear Model (GLM)	Accepted
H1 (c)	The use of capability / process maturity models will not have a positive relationship with enterprise performance.	• Correlation Coefficient and P-Value • Linear Regression • ANOVA using GLM	Rejected
H1 (d)	The use of capability / process maturity models will not have a positive relationship with the use of mechanisms to link business operations to strategy.	• Correlation Coefficient and P-Value • Linear Regression • ANOVA using GLM	Rejected
H1 (e)	The level of process maturity will be greater among high performing enterprises than among low performing enterprises.	• Correlation Coefficient and P-Value • Linear Regression • ANOVA using GLM	Accepted

Table 64: Support of Enterprise Processes

	Proposed Relationship	Analyses Conducted	Outcome
Technology-Based Support of Enterprise Processes (Measurement of IS Maturity)			
H2 (a)	IS and support of strategic layer processes will have a negative relationship with each other.	• Hypothesis testing using Binomial Distribution	Rejected
H2 (b)	IS and support of operational layer processes will have a positive relationship with each other.	• Hypothesis testing using Binomial Distribution	Rejected
H2 (c)	IS support of operational layer processes will be greater among high performing enterprises than among low performing enterprises.	• Correlation Coefficient and P-Value • Linear Regression • ANOVA using GLM	Accepted

Table 65: Technology Structure / Deployment

	Proposed Relationship	Analyses Conducted	Outcome
Technology Structure / Deployment (Measurement of IT Maturity)			
H3 (a)	The level of IS maturity will be greater among high performing enterprises than among low performing enterprises.	• Correlation Coefficient and P-Value • Linear Regression • ANOVA using GLM	Accepted
H3 (b)	The level of IT maturity will be greater among high performing enterprises than among low performing enterprises.	• Correlation Coefficient and P-Value • Linear Regression • ANOVA using GLM	Accepted
H3 (c)	Enterprise technology deployment / structure and information system maturity will be greater among high performing enterprises than among low performing enterprises.	• Correlation Coefficient and P-Value • Linear Regression • ANOVA using GLM	Accepted
Enterprise Architecture (Measurement of EA Maturity			
H3 (d)	The level of EA maturity will be greater among high performing enterprises than among low performing enterprises.	• Correlation Coefficient and P-Value • Linear Regression • ANOVA using GLM|	Accepted

Table 66: ESA Maturity

	Proposed Relationship	Analyses Conducted	Outcome
ESA Maturity			
H4	The level of ESA maturity will be greater among high performing enterprises than among low performing enterprises.	• Correlation Coefficient and P-Value • Linear Regression • ANOVA using GLM • Best Subsets Regression	Accepted

APPENDIX E:
EXPERT INTERVIEW PROTOCOL: AEROSPACE AND DEFENSE INDUSTRY EXECUTIVES

Overview of What We'll be Discussing Today:

Interviews will be conducted with CXO-level executives from the DoD, federal government, and private sector technology industry. Each interview will last approximately 45-60 minutes. The context of the interview is the enterprise as a dynamically complex system. The goal of the interview is to gain insights concerning how leaders think about two elements of the enterprises, strategic and operational business processes, how they interrelate, and the extent to which they are supported by, or are capable of being supported, by the enterprise.

How the Information Will be Used

- Strictly confidential
- To inform the survey
- Would like for them to test the survey

Background Information Questions:

Company Industry
Size (# of people)
Company revenue
Job title
Highest degree earned
Total years experience
Involved in IT budget?

Decentralization of the Enterprise

Very Centralized ◄────────────► Very Decentralized

1 2 3 4 5

How do you think about strategic processes vs. operational processes?

Strategic vs. Operational Processes:

Look at the strategic process chart:

- Have I adequately captured the essence of strategic processes? If not, what have I left out?
- Does your organization's strategy development process involve individuals from operations and IT?

Look at the operational process chart:

- Have I adequately captured the essence of operational processes? If not, what have I left out?
- Executive-level time apportioned between strategic and operational processes

2. Coupling Between Strategic and Operational Processes

- In your enterprise, and in your experience, on a scale of 1 – 5 (5 being tightly coupled/seamlessly integrated)
- How would you assess the extent to which the respective processes are coupled?
- Is this coupling portrayed by your IT and/or Information systems? What is the extent to which coupling is facilitated or decoupling exacerbated?
- Who determines/controls the extent to which they are/are not coupled?
- To what extent does your organization employ and balanced scorecard or a similar tool to attempt to align business operations to strategy?
- To what extent does your organization employ process maturity models?

3. Support of Processes: (Refer back to the tables)

Think about Strategic Processes:

- What is the extent to which your enterprise has an IT /IS that supports any one of the processes?
- What is the extent to they are supported manually? (social networks). Who do you talk to in making these decisions, and how do you communicate? (email / face-to-face / phone)
- Extent to which they can be supported
- What is the extent to which applications and business needs for information are integrate across the enterprise?

Think about Operational Processes:

- What is the extent to which your enterprise has the IT infrastructure / information system capability to support any one of the processes?
- What is the extent to they are supported manually? (social networks). Who do you talk to in making these decisions, and how do you communicate? (email / face-to-face / phone)
- Extent to which they can be supported

4. Strategic Layer Meta Model

a. (Validity): To what extent would you value a technology-based representation of strategic processes that could help you better visualize and understand problems and /or issues germane to such processes?

What would you like for it to do for you?”

b. (Acceptability) What is the most salient strategic process-related problem that might be better solved with explicit process modeling (and analysis?) tools What's the most likely candidate?

What might be some factors that affect adoption of such a solution?

c. (Viability) Assuming that such a representation is deemed to be valid, and technically and economically feasible, what is the extent to which executives would actually use it?

5. Enterprise Architecture (by induction):

- How big a role does IT infrastructure play in your organizational structure/operations? Please access on a sale from 1-5 (1= critical; 5= Not very important), assess the interplay between and IT infrastructure and your organizational structure/operations
- When making a decision to purchase a new information system or piece of information technology, who is involved in the decision?
- Is EA established in the organization?
- Extent to which your enterprise uses an EAF?
- To what extent does your EA think about both sets of processes?

APPENDIX F:
WEB-BASED EXPERT SURVEY OF AEROSPACE AND DEFENSE INDUSTRY EXECUTIVES

Section 1: Background Information Questions:

Company Industry
Size (# of people)
Company revenue (approximate
Job title
Highest degree earned
Total years experience

7. To what extent are your current information systems centralized?

Very Centralized ◄			►	Very Decentralized
1	2	3	4	5

Section 2: General Process Questions:

This section of the survey, questions 8 - 13, asks you to comment on both strategic and operational processes.

8. Please rank the importance of each strategic process using the following scale (Please use each number only once)

Least Critical ◄			►	Most Critical
1	2	3	4	5

__ Acquiring situation awareness: (That is, knowing what is happening around you via market sector trend information, understanding your market position relative to competitors, current state of your firm's operations, etc.)
__ Enterprise strategy development
__ Strategic decision making
__ Communication of intent: (That is, vision, mission, etc.)
__ People strategy (recruiting, incentive and rewards, work environment)

9. Please rank the importance of each operational process using the following scale (Please use each number only once)

Least Critical	◄	———	►	Most Critical
1	2	3	4	5

__ Project and program management
__ Supply chain management
__ Finance / financial management
__ Customer service / quality assessment
__ Human capital management

10. To what extent do you agree that strategic processes are different than operational processes?

Strongly Disagree	◄	———	►	Strongly Agree
1	2	3	4	5

11. To what extent do you agree that strategic and operational processes are coupled / integrated in your firm?

Strongly Disagree	◄	———	►	Strongly Agree
1	2	3	4	5

12. To what extent do you agree that your firm uses a balanced set of metrics to translate your firm's mission statement into quantifiable measures to gauge whether or not the desired result is being achieved?

Strongly Disagree	◄	———	►	Strongly Agree
1	2	3	4	5

13. To what extent do you agree that your firm uses capability / process maturity models that describe the characteristics of effective processes?

Strongly Disagree	◄	———	►	Strongly Agree
1	2	3	4	5

14. Additional comments for Section 2: ______________________________________

Section 3: Technology-Based Support of Enterprise Processes:

In the preceding section, you commented on both strategic and operational processes. The questions in this section ask you to comment on the extent to which these processes are, or are not, currently supported by your firm's information systems. In Part A, the questions are directed towards strategic processes; in Part B, these same questions are directed towards operational processes.

Part A:

To what extent do your firm’s current information systems support / enable the execution of strategic processes?

Not At All	←		→	Completely
1	2	3	4	5

15. __ Acquiring situation awareness: (That is, knowing what is happening around you via market sector trend information, understanding your market position relative to competitors, current state of your firm’s operations, etc.)

16. __ Enterprise strategy development

17. __ Strategic decision making

18. __ Communication of intent: (That is, vision, mission, etc.)

19. __ People strategy (recruiting, incentive and rewards, work environment)

20. For those strategic processes in questions 15 to 19 that are not well supported by your current information systems; i.e., for those that you scored either 1 or 2, why is that the situation? (Please place a check mark beside those that apply)

__ The firm did not buy or build an information system for that specific application
` __ The firm did buy or build an information system for that specific application, but the system is not capable of performing the task
__ The need and/or requirement for such an information system is ill-defined
__ Such an information system simply does not exist or cannot be built to support the process
__ Other (please specify): ____

21. On a scale of 1 (Least Valuable) to 5 (Most Valuable), which strategic process would be the most valuable to have supported by an information system? (Please use each number only once)

Least Valuable				Most Valuable
1	2	3	4	5

__ Acquiring situation awareness: (That is, knowing what is happening around you via market sector trend information, understanding your market position relative to competitors, current state of your firm’s operations, etc.)
__ Enterprise strategy development
__ Strategic decision making
__ Communication of intent: (That is, vision, mission, etc.)
__ People strategy (recruiting, incentive and rewards, work environment)

Part B:

For questions 22 to 26, please indicate the extent to which your firm's current information systems support / enable the execution of the following operational processes. (Please place a number beside each process)

Not At All				Completely
1	2	3	4	5

22. __ Project and program management

23. __ Supply chain management

24. __ Finance / financial management

25. __ Customer service / quality assessment

26. __ Human capital management

27. For those operational processes in # 10 that are not well supported by your current information systems; i.e., for those that you scored either 1 or 2, why is that the situation? (Please place a check mark beside those that apply)

__ The firm did not buy or build an information system for that specific application
__ The firm did buy or build an information system for that specific application, but the system is not capable of performing the task
__ The need and/or requirement for such an information system is ill-defined
__ Such an information system simply does not exist or cannot be built to support the process

__ Other (please describe): ____

28. To what extent do you agree that a gap exists between the information you have access to via your current information systems, versus the information you feel you need to have or would like to have to make better strategic decisions?

Strongly Disagree ←				→ Strongly Agree
1	2	3	4	5

29. To what extent do you agree that a gap exists between the information needed to make strategic versus operational decisions?

Strongly Disagree ←				→ Strongly Agree
1	2	3	4	5

30. Additional Comments for Section 3:

____

Section 4: Technology Deployment

Thus far in the survey you have commented on enterprise processes, and how well those processes are / are not supported by your current information systems. The questions in this section ask you to comment on how those systems are deployed and structured throughout your firm.

Note: For the following questions, the term 'IT" (Information Technology) is taken as the technology / technology infrastructure itself, not a firm's IT department or people who work in that department.

31. To what extent do you agree that executives are willing to invest resources and themselves to fill your firm's information technology needs?

Strongly Disagree ←				→ Strongly Agree
1	2	3	4	5

32. To what extent do you agree that information technology is selected so as to be consistent with and supportive of the firm's business objectives?

Strongly Disagree ←				→ Strongly Agree
1	2	3	4	5

33. To what extent do agree that executives choose to be involved in the process of evaluating the business impact of your firm's information technology?

Strongly Disagree				Strongly Agree
1	2	3	4	5

34. To what extent do agree that the role of your firm's information technology is effectively communicated throughout the enterprise?

Strongly Disagree				Strongly Agree
1	2	3	4	5

35. To what extent do agree that you understand how information technology supports your firm?

Strongly Disagree				Strongly Agree
1	2	3	4	5

36. To what extent do agree that other executives have an understanding of how information technology supports your firm?

Strongly Disagree				Strongly Agree
1	2	3	4	5

In questions 37 - 40, please comment on the extent to which you agree that your firm's technology structure:

37. Hinders the execution of business strategies?

Strongly Disagree				Strongly Agree
1	2	3	4	5

38. Informs the formulation of business strategies?

Strongly Disagree				Strongly Agree
1	2	3	4	5

39. Hinders the firm's ability to attain a stronger competitive position within your market sector?

Strongly Disagree				Strongly Agree
1	2	3	4	5

40. Has a significant level of importance in your organization / design?

Strongly Disagree ←——→ Strongly Agree

1 2 3 4 5

41. To what extent do you agree that your firm's computer-based systems do not exchange information with each other internally, and with external applications?

Strongly Disagree ←——→ Strongly Agree

1 2 3 4 5

42. Additional comments for Section 4: ____

Section 5: Enterprise Architecture-Related

Thus far in the survey you have commented on 3 elements of your firm:

1. Strategic and operational processes
2. The extent to which those processes are supported by your current information systems
3. How those technologies are structured and deployed in your firm.

The questions in this section ask you to comment on the extent to which these elements are related.

For the following questions, "enterprise architecture" simply refers to the elements and relationships, often organized in layers, of an enterprise such as roles, processes, etc., as well as information technology and associated systems. Consequently, an enterprise architecture explains how these elements are related.

43. To what extent do you agree that your enterprise architecture or design plays a critical role in helping to align strategic processes with operational processes?

Strongly Disagree ←——→ Strongly Agree

1 2 3 4 5

44. What is the extent to which you agree that true integration can only be effective and successful when a convergence exists between technology, enterprise strategy, and business objectives?

Strongly Disagree ←——→ Strongly Agree

1 2 3 4 5

45. To what extent do you agree that your firm uses an architecture framework, such as the Federal Enterprise Architecture Framework (FEAF), etc.?

Strongly Disagree ◄────────────► Strongly Agree

1 2 3 4 5

46. To what extent do you believe that your firm has a mature enterprise architecture?

Strongly Disagree ◄────────────► Strongly Agree

1 2 3 4 5

47. Additional comments for Section 5: ________________________________

Section 6: Environmental Complexity

The questions in this section ask you to comment on the nature of the industry sector within which your firm competes.

48. To what extent do you agree that the actions of your competitors are not predictable?

Strongly Disagree ◄────────────► Strongly Agree

1 2 3 4 5

49. To what extent do you agree that demand for your firm's products / solutions / services are not predictable?

Strongly Disagree ◄────────────► Strongly Agree

1 2 3 4 5

50. To remain competitive, what is the extent to which you agree that your firm must improve its work processes on a regular basis?

Strongly Disagree ◄────────────► Strongly Agree

1 2 3 4 5

51. To what extent do agree that the rate of technological change is shaping your industry sector?

Strongly Disagree ◄────────────► Strongly Agree

1 2 3 4 5

52. Additional comments for Section 6:

____

Section 7: Performance-Related Questions

Thus far in the survey you have commented on your firm's strategic and operational processes, the extent to which those processes are supported by your current information systems, how those technologies are structured and deployed in your firm, and the extent to which these 3 elements are related through an enterprise architecture. You then commented on the complexity of your market sector.

The questions in this final section ask you to comment on how well your firm has performed / is performing.

53. Relative to your industry sector average or to comparable organizations and / or competitors, what is the performance of your firm with regard to the following criteria:

	Very Weak 1	2	3	4	Very Strong 5
Short-term profitability	1	2	3	4	5
Long-term profitability	1	2	3	4	5
Customer satisfaction / loyalty	1	2	3	4	5
Financial resources / liquidity	1	2	3	4	5
Available cash / investment capacity	1	2	3	4	5
People capabilities / execution	1	2	3	4	5
Industry perception of your firm as a "thought leader"	1	2	3	4	5

54. Additional comments for Section 7:

____

APPENDIX G
STATISTICAL AND COMPUTATIONAL RESULTS

Table 67: Principal Component Analysis: Questions 11 - 13

Eigenanalysis of the Correlation Matrix

Eigenvalue	1.8274	0.7695	0.4031
Proportion	0.609	0.257	0.134
Cumulative	0.609	0.866	1.000

Variable	PC1	PC2	PC3
Question 11: To what extent do	0.503	0.804	0.317
Question 12: To what extent do	0.645	-0.105	-0.757
Question 13: To what extent do	0.575	-0.585	0.571

Table 68: Principal Component Analysis: Questions 15 - 19

Eigenanalysis of the Correlation Matrix

Eigenvalue	2.6318	0.8528	0.6706	0.5309	0.3139
Proportion	0.526	0.171	0.134	0.106	0.063
Cumulative	0.526	0.697	0.831	0.937	1.000

Variable	PC1	PC2	PC3	PC4	PC5
Question 15: Acquiring situatio	0.345	-0.809	-0.354	0.244	0.205
Question 16: Enterprise strateg	0.458	0.316	-0.454	-0.580	0.385
Question 17: Strategic decision	0.542	0.049	-0.086	-0.031	-0.834
Question 18: Communication of i	0.448	0.444	0.083	0.718	0.283
Question 19: People strategy: (	0.420	-0.217	0.809	-0.295	0.188

Table 69: Principal Component Analysis: Questions 22 - 26

Eigenanalysis of the Correlation Matrix

Eigenvalue 2.4174 0.9223 0.7047 0.5555 0.4000
Proportion 0.483 0.184 0.141 0.111 0.080
Cumulative 0.483 0.668 0.809 0.920 1.000

Variable PC1 PC2 PC3 PC4 PC5
Question 22: Project and progra 0.461 -0.528 0.199 -0.300 -
0.616
Question 23: Supply chain manag 0.489 0.156 0.527 -0.356
0.576
Question 24: Finance / financia 0.434 -0.137 -0.816 -0.215 0.283
Question 25: Customer service / 0.485 -0.125 0.081 0.858 0.079
Question 26: Human capital mana 0.353 0.814 -0.097 -0.031 -
0.451

Table 70: Principal Component Analysis: Questions 15, 16, 17, 18, 19, 22, 23, 24, 25, 26, 28, 29

Eigenanalysis of the Correlation Matrix

Eigenvalue 4.7184 1.5134 1.3108 1.0521 0.7470 0.5793 0.5487
0.4785
Proportion 0.393 0.126 0.109 0.088 0.062 0.048 0.046 0.040
Cumulative 0.393 0.519 0.629 0.716 0.778 0.827 0.872 0.912

Variable PC1 PC2 PC3 PC4 PC5 PC6
Question 15: Acquiring situatio 0.216 -0.042 0.612 -0.042 -
0.289 -0.206
Question 16: Enterprise strateg 0.265 0.305 0.052 -0.432 -0.158
-0.433
Question 17: Strategic decision 0.353 0.294 0.161 -0.215 0.082
0.128
Question 18: Communication of i 0.300 0.244 -0.116 -0.301
0.131 0.391
Question 19: People strategy: (0.277 0.372 0.059 0.429 -0.006 -
0.251
Question 22: Project and progra 0.253 -0.463 -0.196 -0.143 -
0.361 -0.336
Question 23: Supply chain manag 0.280 -0.143 -0.235 0.301 -
0.603 0.317
Question 24: Finance / financia 0.220 -0.092 -0.586 -0.108 0.281
-0.369
Question 25: Customer service / 0.345 -0.089 -0.092 -0.263 -
0.024 0.422
Question 26: Human capital mana 0.264 0.335 -0.191 0.495
0.045 -0.046
Question 28: To what extent do -0.335 0.337 -0.257 -0.189 -
0.235 -0.076
Question 29: To what extent do -0.315 0.378 -0.177 -0.136 -
0.486 0.049

Table 71: Principal Component Analysis: Questions 31 -41

Eigenanalysis of the Correlation Matrix

Eigenvalue 5.2295 1.2673 1.0232 0.7097 0.6594 0.5518 0.5050 0.3620
Proportion 0.475 0.115 0.093 0.065 0.060 0.050 0.046 0.033
Cumulative 0.475 0.591 0.684 0.748 0.808 0.858 0.904 0.937

Variable PC1 PC2 PC3 PC4 PC5 PC6
Question 31: To what extent do 0.353 0.181 0.250 0.109 -0.284 -0.045
Question 32: To what extent do 0.343 0.234 0.133 0.289 0.064 -0.271
Question 33: To what extent do 0.337 0.183 0.303 0.146 0.355 0.014
Question 34: To what extent do 0.330 0.223 -0.074 -0.123 0.007 -0.553
Question 35: To what extent do 0.257 0.064 -0.531 -0.591 -0.121 -0.211
Question 36: To what extent do 0.267 0.234 -0.467 0.157 0.073 0.541
Question 37: Hinders the execut -0.311 0.497 -0.231 0.106 0.014 0.003
Question 38: Informs the formul 0.283 -0.292 -0.137 -0.065 0.720 0.111
Question 39: Hinders the firm?s -0.294 0.482 -0.193 0.223 0.299 -0.156
Question 40: Has a significant 0.283 0.332 0.200 -0.222 -0.243 0.488
Question 41: To what extent do -0.234 0.310 0.416 -0.616 0.321 0.075

Table 72: Principal Component Analysis: Questions 43, 45, 46

Eigenanalysis of the Correlation Matrix

Eigenvalue 2.0799 0.6091 0.3110
Proportion 0.693 0.203 0.104
Cumulative 0.693 0.896 1.000

Variable PC1 PC2 PC3
Question 43: To what extent do 0.516 -0.857 0.011
Question 45: To what extent do 0.607 0.356 -0.711
Question 46: To what extent do 0.605 0.373 0.703

Table 73: Principal Component Analysis: Question 53

Eigenanalysis of the Correlation Matrix

Eigenvalue 4.2289 1.0645 0.5963 0.4847 0.3667 0.1596 0.0993
Proportion 0.604 0.152 0.085 0.069 0.052 0.023 0.014
Cumulative 0.604 0.756 0.841 0.911 0.963 0.986 1.000

Variable PC1 PC2 PC3 PC4 PC5 PC6
Question 53: Short-term profita 0.428 -0.059 -0.365 0.354 -0.283 0.225
Question 53:
Long-term prof 0.426 -0.073 -0.491 0.259 -0.013 0.002
Question 53:
Customer satis 0.365 0.372 -0.238 -0.403 0.689 -0.017
Question 53:
Financial reso 0.380 -0.510 0.188 -0.071 0.047 -0.733
Question 53:
Available cash 0.367 -0.468 0.412 -0.230 0.108 0.634
Question 53:
People capabil 0.354 0.413 0.130 -0.512 -0.640 -0.077
Question 53:
Industry perce 0.312 0.452 0.589 0.570 0.143 -0.058

Table 74: Principal Component Analysis: IS Maturity, IT Maturity

Eigenanalysis of the Correlation Matrix

Eigenvalue	1.7331	0.2669
Proportion	0.867	0.133
Cumulative	0.867	1.000

Variable	PC1	PC2
IS Maturity	0.707	-0.707
IT Maturity	0.707	0.707

Table 75: Principal Component Analysis: Process Maturity, IS Maturity, IT Maturity, EA Maturity

Eigenanalysis of the Correlation Matrix

Eigenvalue	2.7347	0.5703	0.4477	0.2473
Proportion	0.684	0.143	0.112	0.062
Cumulative	0.684	0.826	0.938	1.000

Variable	PC1	PC2	PC3	PC4
Process Maturity	0.491	0.233	-0.821	-0.173
IS Maturity_1	0.523	0.420	0.288	0.684
IT Maturity_1	0.531	0.112	0.492	-0.681
EA Maturity	0.452	-0.870	-0.018	0.196

Table 76: Correlations: Question 11; Question 53

Question 11: To Question 53: Sho Question 53: <br
Question 53: Sho 0.328
0.010

Question 53: <br 0.354 0.884
0.006 0.000

Question 53: <br 0.307 0.560 0.631
0.017 0.000 0.000

Question 53: <br 0.177 0.645 0.652
0.176 0.000 0.000

Question 53: <br 0.216 0.571 0.556
0.098 0.000 0.000

Question 53: <br 0.602 0.556 0.513
0.000 0.000 0.000

Question 53: <br 0.374 0.485 0.429
0.003 0.000 0.001

Enterprise Perfo 0.421 0.888 0.885
0.001 0.000 0.000

Table 77: Correlations: Question 13; Question 53

Question 13: To Question 53: Sho Question 53: <br
Question 53: Sho 0.350
0.006

Question 53: <br 0.450 0.884
0.000 0.000

Question 53: <br 0.357 0.560 0.631
0.005 0.000 0.000

Question 53: <br 0.414 0.645 0.652
0.001 0.000 0.000

Question 53: <br 0.408 0.571 0.556
0.001 0.000 0.000

Question 53: <br 0.519 0.556 0.513
0.000 0.000 0.000

Question 53: <br 0.092 0.485 0.429
0.483 0.000 0.001

Enterprise Perfo 0.484 0.888 0.885
0.000 0.000 0.000

Table 78: Correlations: Question 13; Question 12

Pearson correlation of Question 13: To what extent do and
Question 12: To what
extent do = 0.551
P-Value = 0.000

Table 79: Correlations: Process Maturity, Question 53

Process Maturity Question 53: Sho Question 53: <br
Question 53: Sho 0.493
0.000

Question 53: <br 0.580 0.884
0.000 0.000

Question 53: <br 0.485 0.560 0.631
0.000 0.000 0.000

Question 53: <br 0.492 0.645 0.652
0.000 0.000 0.000

Question 53: <br 0.519 0.571 0.556
0.000 0.000 0.000

Question 53: <br 0.697 0.556 0.513
0.000 0.000 0.000

Question 53: <br 0.289 0.485 0.429
0.025 0.000 0.001

Enterprise Perfo 0.655 0.888 0.885
0.000 0.000 0.000

Table 80: Correlations: IS Maturity, Question 53

	IS Maturity	Question 53: Sho	Question 53: <br
Question 53: Sho	0.567		
	0.000		
Question 53: <br	0.611	0.884	
	0.000	0.000	
Question 53: <br	0.523	0.560	0.631
	0.000	0.000	0.000
Question 53: <br	0.473	0.645	0.652
	0.000	0.000	0.000
Question 53: <br	0.508	0.571	0.556
	0.000	0.000	0.000
Question 53: <br	0.629	0.556	0.513
	0.000	0.000	0.000
Question 53: <br	0.423	0.485	0.429
	0.001	0.000	0.001
Enterprise Perfo	0.686	0.888	0.885
	0.000	0.000	0.000

Table 81: Correlations: IT Maturity, Question 53

	IT Maturity	Question 53: Sho	Question 53: <br
Question 53: Sho	0.535		
	0.000		
Question 53: <br	0.558	0.884	
	0.000	0.000	
Question 53: <br	0.461	0.560	0.631
	0.000	0.000	0.000
Question 53: <br	0.433	0.645	0.652
	0.001	0.000	0.000
Question 53: <br	0.444	0.571	0.556
	0.000	0.000	0.000
Question 53: <br	0.671	0.556	0.513
	0.000	0.000	0.000
Question 53: <br	0.496	0.485	0.429
	0.000	0.000	0.001
Enterprise Perfo	0.654	0.888	0.885
	0.000	0.000	0.000

Table 82: Correlations: EA Maturity, Question 53

EA Maturity Question 53: Sho Question 53: <br
Question 53: Sho 0.267
0.039

Question 53: <br 0.281 0.884
0.030 0.000

Question 53: <br 0.127 0.560 0.631
0.334 0.000 0.000

Question 53: <br 0.329 0.645 0.652
0.010 0.000 0.000

Question 53: <br 0.356 0.571 0.556
0.005 0.000 0.000

Question 53: <br 0.283 0.556 0.513
0.028 0.000 0.000

Question 53: <br 0.164 0.485 0.429
0.210 0.000 0.001

Enterprise Perfo 0.336 0.888 0.885
0.009 0.000 0.000

Table 83: General Linear Model: EP Level versus PM Level

Factor Type Levels Values
PM Level fixed 3 0, 1, 2

Analysis of Variance for EP Level, using Adjusted SS for Tests

Source DF Seq SS Adj SS Adj MS F P
PM Level 2 6.3487 6.3487 3.1744 13.52 0.000
Error 57 13.3846 13.3846 0.2348
Total 59 19.7333

S = 0.484580 R-Sq = 32.17% R-Sq(adj) = 29.79%

Table 84: General Linear Model: EP Level versus ISM Level

Factor Type Levels Values
ISM Level fixed 3 0, 1, 2

Analysis of Variance for EP Level, using Adjusted SS for Tests

Source DF Seq SS Adj SS Adj MS F P
ISM Level 2 2.7970 2.7970 1.3985 4.71 0.013
Error 57 16.9364 16.9364 0.2971
Total 59 19.7333

S = 0.545096 R-Sq = 14.17% R-Sq(adj) = 11.16%

Unusual Observations for EP Level

Obs EP Level Fit SE Fit Residual St Resid
2 0.00000 1.25455 0.07350 -1.25455 -2.32 R
11 0.00000 1.25455 0.07350 -1.25455 -2.32 R
19 0.00000 0.50000 0.38544 -0.50000 -1.30 X
21 2.00000 2.00000 0.31471 0.00000 0.00 X
28 2.00000 2.00000 0.31471 0.00000 0.00 X
33 0.00000 1.25455 0.07350 -1.25455 -2.32 R
41 2.00000 2.00000 0.31471 0.00000 0.00 X
48 1.00000 0.50000 0.38544 0.50000 1.30 X

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.

Table 85: General Linear Model: EP Level versus ITM Level

Factor Type Levels Values
ITM Level fixed 2 1, 2

Analysis of Variance for EP Level, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
ITM Level	1	5.5729	5.5729	5.5729	22.83	0.000
Error	58	14.1604	14.1604	0.2441		
Total	59	19.7333				

S = 0.494110 R-Sq = 28.24% R-Sq(adj) = 27.00%

Unusual Observations for EP Level

Obs	EP Level	Fit	SE Fit	Residual	St Resid	
2	0.00000	1.10638	0.07207	-1.10638	-2.26	R
11	0.00000	1.10638	0.07207	-1.10638	-2.26	R
19	0.00000	1.10638	0.07207	-1.10638	-2.26	R
33	0.00000	1.10638	0.07207	-1.10638	-2.26	R

R denotes an observation with a large standardized residual.

Table 86: General Linear Model: EP Level versus EAM Level

Factor Type Levels Values
EAM Level fixed 3 0, 1, 2

Analysis of Variance for EP Level, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
EAM Level	2	3.1279	3.1279	1.5639	5.37	0.007
Error	57	16.6055	16.6055	0.2913		
Total	59	19.7333				

S = 0.539744 R-Sq = 15.85% R-Sq(adj) = 12.90%

Unusual Observations for EP Level

Obs	EP Level	Fit	SE Fit	Residual	St Resid	
2	0.00000	1.06250	0.13494	-1.06250	-2.03	R
11	0.00000	1.24324	0.08873	-1.24324	-2.34	R
19	0.00000	1.06250	0.13494	-1.06250	-2.03	R
33	0.00000	1.24324	0.08873	-1.24324	-2.34	R

R denotes an observation with a large standardized residual.

Table 87: Regression Analysis: Enterprise Performance versus Process Maturity

The regression equation is
Enterprise Performance = 1.74 + 0.597 Process Maturity

Predictor Coef SE Coef T P
Constant 1.7434 0.2973 5.86 0.000
Process Maturity 0.59653 0.09035 6.60 0.000

S = 0.611593 R-Sq = 42.9% R-Sq(adj) = 41.9%

Analysis of Variance

Source DF SS MS F P
Regression 1 16.306 16.306 43.59 0.000
Residual Error 58 21.695 0.374
Total 59 38.000

Unusual Observations

Process Enterprise
Obs Maturity Performance Fit SE Fit Residual St Resid
27 2.04 4.3078 2.9607 0.1292 1.3471 2.25R

R denotes an observation with a large standardized residual.

Table 88: Regression Analysis: Enterprise Performance versus IS Maturity

The regression equation is
Enterprise Performance = 0.990 + 0.875 IS Maturity

Predictor Coef SE Coef T P
Constant 0.9900 0.3759 2.63 0.011
IS Maturity 0.8755 0.1218 7.19 0.000

S = 0.588725 R-Sq = 47.1% R-Sq(adj) = 46.2%

Analysis of Variance

Source DF SS MS F P
Regression 1 17.898 17.898 51.64 0.000
Residual Error 58 20.103 0.347
Total 59 38.000

Unusual Observations

IS Enterprise
Obs Maturity Performance Fit SE Fit Residual St Resid
3 2.50 4.4024 3.1765 0.0993 1.2259 2.11R
11 2.41 1.9020 3.0982 0.1066 -1.1962 -2.07R
13 3.05 2.2523 3.6594 0.0761 -1.4071 -2.41R
19 1.44 1.6546 2.2473 0.2076 -0.5927 -1.08 X
41 4.65 4.4324 5.0617 0.2125 -0.6293 -1.15 X

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.

Table 89: Regression Analysis: Enterprise Performance versus IT Maturity

The regression equation is
Enterprise Performance = 1.02 + 0.762 IT Maturity

Predictor Coef SE Coef T P
Constant 1.0174 0.4055 2.51 0.015
IT Maturity 0.7620 0.1158 6.58 0.000

S = 0.612393 R-Sq = 42.8% R-Sq(adj) = 41.8%

Analysis of Variance

Source DF SS MS F P
Regression 1 16.249 16.249 43.33 0.000
Residual Error 58 21.751 0.375
Total 59 38.000

Unusual Observations

IT Enterprise
Obs Maturity Performance Fit SE Fit Residual St Resid
2 2.80 1.7891 3.1482 0.1083 -1.3591 -2.25R
11 2.75 1.9020 3.1151 0.1118 -1.2131 -2.01R
12 3.43 2.2067 3.6285 0.0791 -1.4218 -2.34R
41 5.00 4.4324 4.8272 0.1975 -0.3948 -0.68 X

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.

Table 90: Regression Analysis: Enterprise Performance versus EA Maturity

The regression equation is
Enterprise Performance = 2.85 + 0.280 EA Maturity

Predictor Coef SE Coef T P
Constant 2.8475 0.3063 9.30 0.000
EA Maturity 0.2803 0.1031 2.72 0.009

S = 0.762360 R-Sq = 11.3% R-Sq(adj) = 9.8%

Analysis of Variance

Source DF SS MS F P
Regression 1 4.2911 4.2911 7.38 0.009
Residual Error 58 33.7092 0.5812
Total 59 38.0003

Unusual Observations

EA Enterprise
Obs Maturity Performance Fit SE Fit Residual St Resid
11 3.25 1.9020 3.7578 0.1082 -1.8559 -2.46R
19 1.00 1.6546 3.1277 0.2113 -1.4731 -2.01R
33 3.30 1.8248 3.7719 0.1105 -1.9471 -2.58R

R denotes an observation with a large standardized residual.

Table 91: Correlations: ESA Maturity, Question 53

ESA Maturity Question 53: Sho Question 53: <br
Question 53: Sho 0.554
0.000

Question 53: <br 0.605 0.884
0.000 0.000

Question 53: <br 0.471 0.560 0.631
0.000 0.000 0.000

Question 53: <br 0.521 0.645 0.652
0.000 0.000 0.000

Question 53: <br 0.552 0.571 0.556
0.000 0.000 0.000

Question 53: <br 0.682 0.556 0.513
0.000 0.000 0.000

Question 53: <br 0.402 0.485 0.429
0.001 0.000 0.001

Enterprise Perfo 0.696 0.888 0.885
0.000 0.000 0.000

Table 92: General Linear Model: EP Level versus ESAM Level

Factor Type Levels Values
ESAM Level fixed 3 0, 1, 2

Analysis of Variance for EP Level, using Adjusted SS for Tests

Source DF Seq SS Adj SS Adj MS F P
ESAM Level 2 5.3167 5.3167 2.6583 10.51 0.000
Error 57 14.4167 14.4167 0.2529
Total 59 19.7333

S = 0.502915 R-Sq = 26.94% R-Sq(adj) = 24.38%

Unusual Observations for EP Level

Obs EP Level Fit SE Fit Residual St Resid
2 0.00000 0.33333 0.29036 -0.33333 -0.81 X
11 0.00000 1.25000 0.06974 -1.25000 -2.51 R
18 2.00000 2.00000 0.22491 0.00000 0.00 X
19 0.00000 0.33333 0.29036 -0.33333 -0.81 X
21 2.00000 2.00000 0.22491 0.00000 0.00 X
28 2.00000 2.00000 0.22491 0.00000 0.00 X
32 2.00000 2.00000 0.22491 0.00000 0.00 X
33 0.00000 1.25000 0.06974 -1.25000 -2.51 R
37 2.00000 2.00000 0.22491 0.00000 0.00 X
48 1.00000 0.33333 0.29036 0.66667 1.62 X

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.

Table 93: Regression Analysis: Enterprise Performance versus ESA Maturity

The regression equation is
Enterprise Performance = 0.926 + 0.868 ESA Maturity

Predictor Coef SE Coef T P
Constant 0.9263 0.3746 2.47 0.016
ESA Maturity 0.8679 0.1176 7.38 0.000

S = 0.581185 R-Sq = 48.4% R-Sq(adj) = 47.6%

Analysis of Variance

Source DF SS MS F P
Regression 1 18.409 18.409 54.50 0.000
Residual Error 58 19.591 0.338
Total 59 38.000

Unusual Observations

ESA Enterprise
Obs Maturity Performance Fit SE Fit Residual St Resid
11 2.56 1.9020 3.1475 0.1000 -1.2455 -2.18R
19 1.53 1.6546 2.2551 0.2015 -0.6005 -1.10 X
27 2.34 4.3078 2.9578 0.1186 1.3499 2.37R

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.

Table 94: Correlations: IS-IT-Maturity, Question 53

	IS-IT-Maturity	Question 53: Sho	Question 53: <br
Question 53: Sho	0.591		
	0.000		
Question 53: <br	0.626	0.884	
	0.000	0.000	
Question 53: <br	0.527	0.560	0.631
	0.000	0.000	0.000
Question 53: <br	0.486	0.645	0.652
	0.000	0.000	0.000
Question 53: <br	0.510	0.571	0.556
	0.000	0.000	0.000
Question 53: <br	0.699	0.556	0.513
	0.000	0.000	0.000
Question 53: <br	0.495	0.485	0.429
	0.000	0.000	0.001
Enterprise Perfo	0.719	0.888	0.885
	0.000	0.000	0.000

Table 95: Regression Analysis: Enterprise Performance versus IS-IT Maturity

The regression equation is
Enterprise Performance = 0.599 + 0.940 IS-IT-Maturity

Predictor Coef SE Coef T P
Constant 0.5987 0.3923 1.53 0.132
IS-IT-Maturity 0.9405 0.1194 7.88 0.000

S = 0.562612 R-Sq = 51.7% R-Sq(adj) = 50.9%

Analysis of Variance

Source DF SS MS F P
Regression 1 19.641 19.641 62.05 0.000
Residual Error 58 18.359 0.317
Total 59 38.000

Unusual Observations

Enterprise
Obs IS-IT-Maturity Performance Fit SE Fit Residual St Resid
11 2.58 1.9020 3.0257 0.1062 -1.1238 -2.03R
19 1.87 1.6546 2.3544 0.1781 -0.6998 -1.31 X
27 2.65 4.3078 3.0889 0.1005 1.2189 2.20R
41 4.83 4.4324 5.1370 0.2040 -0.7046 -1.34 X

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.

Table 96: General Linear Model: EP Level versus IS and IT Maturity Level

Factor Type Levels Values
IS & IT Maturity Level fixed 3 0, 1, 2

Analysis of Variance for EP Level, using Adjusted SS for Tests

Source DF Seq SS Adj SS Adj MS F P
IS & IT Maturity Level 2 4.5603 4.5603 2.2801 8.57 0.001
Error 57 15.1731 15.1731 0.2662
Total 59 19.7333

S = 0.515940 R-Sq = 23.11% R-Sq(adj) = 20.41%

Unusual Observations for EP Level

Obs EP Level Fit SE Fit Residual St Resid
2 0.00000 1.21154 0.07155 -1.21154 -2.37 R
11 0.00000 1.21154 0.07155 -1.21154 -2.37 R
19 0.00000 0.50000 0.36482 -0.50000 -1.37 X
21 2.00000 2.00000 0.21063 0.00000 0.00 X
28 2.00000 2.00000 0.21063 0.00000 0.00 X
32 2.00000 2.00000 0.21063 0.00000 0.00 X
33 0.00000 1.21154 0.07155 -1.21154 -2.37 R
36 2.00000 2.00000 0.21063 0.00000 0.00 X
37 2.00000 2.00000 0.21063 0.00000 0.00 X
41 2.00000 2.00000 0.21063 0.00000 0.00 X
48 1.00000 0.50000 0.36482 0.50000 1.37 X

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.

Table 97: Best Subsets Regression: Enterprise Performance versus Process Maturity, IS Maturity

Response is Enterprise Performance

P
r
o
c
e
s I I E
s S T A

M M M M
a a a a
t t t t
u u u u
r r r r
i i i i
Mallows t t t t
Vars R-Sq R-Sq(adj) Cp S y y y y
1 47.1 46.2 16.4 0.58873 X
1 42.9 41.9 22.1 0.61159 X
1 42.8 41.8 22.3 0.61239 X
1 11.3 9.8 65.4 0.76236 X
2 55.6 54.0 6.8 0.54425 X X
2 54.4 52.8 8.4 0.55150 X X
2 52.0 50.3 11.7 0.56561 X X
2 47.1 45.3 18.4 0.59371 X X
2 42.9 40.9 24.1 0.61677 X X
3 58.2 55.9 5.3 0.53289 X X X
3 56.1 53.7 8.1 0.54607 X X X
3 56.0 53.6 8.2 0.54658 X X X
3 52.5 50.0 13.0 0.56776 X X X
4 59.8 56.9 5.0 0.52698 X X X X

Table 98: Regression Analysis: Enterprise Performance versus Process Maturity, IS Maturity, IT Maturity, EA Maturity

The regression equation is
Enterprise Performance = 0.535 + 0.331 Process Maturity + 0.394 IS Maturity
+ 0.360 IT Maturity - 0.134 EA Maturity

Predictor	Coef	SE Coef	T	P
Constant	0.5354	0.3683	1.45	0.152
Process Maturity	0.3313	0.1048	3.16	0.003
IS Maturity	0.3937	0.1720	2.29	0.026
IT Maturity	0.3597	0.1588	2.26	0.027
EA Maturity	-0.13390	0.08900	-1.50	0.138

S = 0.526981 R-Sq = 59.8% R-Sq(adj) = 56.9%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	4	22.7263	5.6816	20.46	0.000
Residual Error	55	15.2740	0.2777		
Total	59	38.0003			

Source	DF	Seq SS
Process Maturity	1	16.3057
IS Maturity	1	4.8110
IT Maturity	1	0.9812
EA Maturity	1	0.6286

Unusual Observations

Obs	Process Maturity	Enterprise Performance	Fit	SE Fit	Residual	St Resid
27	2.04	4.3078	2.9397	0.1135	1.3680	2.66R
41	2.54	4.4324	4.8733	0.3714	-0.4410	-1.18 X

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.

Table 99: Correlations: 22 – 26 Score, Question 53

	22-26-Score	Question 53: Sho	Question 53: <br
Question 53: Sho	0.562		
	0.000		
Question 53: <br	0.609	0.884	
	0.000	0.000	
Question 53: <br	0.418	0.560	0.631
	0.001	0.000	0.000
Question 53: <br	0.535	0.645	0.652
	0.000	0.000	0.000
Question 53: <br	0.603	0.571	0.556
	0.000	0.000	0.000
Question 53: <br	0.600	0.556	0.513
	0.000	0.000	0.000
Question 53: <br	0.348	0.485	0.429
	0.006	0.000	0.001
Enterprise Perfo	0.682	0.888	0.885
	0.000	0.000	0.000

Table 100: General Linear Model: EP Level versus IS Support of Operational Processes

Factor Type Levels Values

IS Support of Operational Proce fixed 3 0, 1, 2

Analysis of Variance for EP Level, using Adjusted SS for Tests

Source DF Seq SS Adj SS Adj MS F P
IS Support of Operational Proce 2 5.5284 5.5284 2.7642 11.09
0.000
Error 57 14.2050 14.2050 0.2492
Total 59 19.7333

S = 0.499209 R-Sq = 28.02% R-Sq(adj) = 25.49%

Unusual Observations for EP Level

Obs EP Level Fit SE Fit Residual St Resid
2 0.00000 1.17021 0.07282 -1.17021 -2.37 R
11 0.00000 0.66667 0.28822 -0.66667 -1.64 X
19 0.00000 0.66667 0.28822 -0.66667 -1.64 X
27 2.00000 0.66667 0.28822 1.33333 3.27 RX
33 0.00000 1.17021 0.07282 -1.17021 -2.37 R

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.

Table 101: Regression Analysis: Enterprise Performance versus 22 – 26 Score

The regression equation is
Enterprise Performance = 1.05 + 0.771 22-26-Score

Predictor Coef SE Coef T P
Constant 1.0457 0.3731 2.80 0.007
22-26-Score 0.7715 0.1088 7.09 0.000

S = 0.592319 R-Sq = 46.5% R-Sq(adj) = 45.5%

Analysis of Variance

Source DF SS MS F P
Regression 1 17.651 17.651 50.31 0.000
Residual Error 58 20.349 0.351
Total 59 38.000

Unusual Observations

Enterprise
Obs 22-26-Score Performance Fit SE Fit Residual St Resid
19 1.40 1.6546 2.1280 0.2259 -0.4733 -0.86 X
27 1.89 4.3078 2.5040 0.1769 1.8038 3.19R
33 3.03 1.8248 3.3800 0.0845 -1.5551 -2.65R
41 5.00 4.4324 4.9032 0.1944 -0.4708 -0.84 X
47 3.98 2.5775 4.1140 0.1020 -1.5365 -2.63R

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.

Table 102: Best Subsets Regression: Enterprise Performance versus ESA Maturity

Response is Enterprise Performance

E
S
A

M
a
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Mallows t
Vars R-Sq R-Sq(adj) Cp S y
1 48.4 47.6 2.0 0.58118 X

Table 103: General Linear Model: EP Level versus PM Level, ISM Level, ITM Level, EAM Level

Factor Type Levels Values
PM Level fixed 3 0, 1, 2
ISM Level fixed 3 0, 1, 2
ITM Level fixed 2 1, 2
EAM Level fixed 3 0, 1, 2

Analysis of Variance for EP Level, using Adjusted SS for Tests

Source DF Seq SS Adj SS Adj MS F P
PM Level 2 6.3487 2.9395 1.4697 7.75 0.001
ISM Level 2 1.4352 0.3996 0.1998 1.05 0.356
ITM Level 1 1.7205 0.9731 0.9731 5.13 0.028
EAM Level 2 0.3618 0.3618 0.1809 0.95 0.392
Error 52 9.8672 9.8672 0.1898
Total 59 19.7333

S = 0.435606 R-Sq = 50.00% R-Sq(adj) = 43.27%

Unusual Observations for EP Level

Obs EP Level Fit SE Fit Residual St Resid
19 0.00000 0.16194 0.32014 -0.16194 -0.55 X
21 2.00000 1.93163 0.28388 0.06837 0.21 X
28 2.00000 2.15997 0.28906 -0.15997 -0.49 X
41 2.00000 1.90840 0.27833 0.09160 0.27 X
48 1.00000 0.83806 0.32014 0.16194 0.55 X

X denotes an observation whose X value gives it large leverage.

Table 104: Regression Analysis: Enterprise Performance versus Question 11

The regression equation is
Enterprise Performance = 2.46 + 0.338 Question 11: To what extent do

Predictor Coef SE Coef T P
Constant 2.4637 0.3448 7.14 0.000
Question 11: To what extent do 0.33807 0.09564 3.53 0.001

S = 0.734196 R-Sq = 17.7% R-Sq(adj) = 16.3%

Analysis of Variance

Source DF SS MS F P
Regression 1 6.7357 6.7357 12.50 0.001
Residual Error 58 31.2646 0.5390
Total 59 38.0003

Unusual Observations

Question
11: To
what Enterprise
Obs extent do Performance Fit SE Fit Residual St Resid
11 4.00 1.9020 3.8160 0.1076 -1.9140 -2.64R
13 4.00 2.2523 3.8160 0.1076 -1.5637 -2.15R
19 2.00 1.6546 3.1398 0.1693 -1.4852 -2.08R
33 1.00 1.8248 2.8017 0.2542 -0.9769 -1.42 X

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.

Table 105: General Linear Model: EP Level versus Question 11 Level

Factor Type Levels Values
Qs 11 Level fixed 3 0, 1, 2

Analysis of Variance for EP Level, using Adjusted SS for Tests

Source DF Seq SS Adj SS Adj MS F P
Qs 11 Level 2 2.8545 2.8545 1.4273 4.82 0.012
Error 57 16.8788 16.8788 0.2961
Total 59 19.7333

S = 0.544168 R-Sq = 14.47% R-Sq(adj) = 11.46%

Unusual Observations for EP Level

Obs EP Level Fit SE Fit Residual St Resid
11 0.00000 1.39394 0.09473 -1.39394 -2.60 R
27 2.00000 0.83333 0.15709 1.16667 2.24 R

R denotes an observation with a large standardized residual.

Table 106: Correlations: Question 8: Acquiring Situation, Question 15: Acquiring Situation

Pearson correlation of Question 8: Acquiring situa and Question 15:
Acquiring situatio = -0.005
P-Value = 0.971

Table 107: Regression Analysis: Enterprise Performance versus Question 13

The regression equation is
Enterprise Performance = 2.72 + 0.317 Question 13: To what extent do

Predictor Coef SE Coef T P
Constant 2.7203 0.2360 11.53 0.000
Question 13: To what extent do 0.31748 0.07544 4.21 0.000

S = 0.708472 R-Sq = 23.4% R-Sq(adj) = 22.1%

Analysis of Variance

Source DF SS MS F P
Regression 1 8.8882 8.8882 17.71 0.000
Residual Error 58 29.1121 0.5019
Total 59 38.0003

Unusual Observations

Question
13: To
what Enterprise
Obs extent do Performance Fit SE Fit Residual St Resid
19 1.00 1.6546 3.0377 0.1690 -1.3831 -2.01R
41 1.00 4.4324 3.0377 0.1690 1.3946 2.03R
47 4.00 2.5775 3.9902 0.1244 -1.4127 -2.03R

R denotes an observation with a large standardized residual.

Table 108: General Linear Model: EP Level versus Question 13 Level

Factor Type Levels Values
Qs 13 Level fixed 3 0, 1, 2

Analysis of Variance for EP Level, using Adjusted SS for Tests

Source DF Seq SS Adj SS Adj MS F P
Qs 13 Level 2 3.2250 3.2250 1.6125 5.57 0.006
Error 57 16.5084 16.5084 0.2896
Total 59 19.7333

S = 0.538164 R-Sq = 16.34% R-Sq(adj) = 13.41%

Table 109: Regression Analysis: Question 53: versus Question 13

The regression equation is
Question 53: Industry perce = 3.52 + 0.0682 Question 13: To what extent do

Predictor Coef SE Coef T P
Constant 3.5199 0.3023 11.64 0.000
Question 13: To what extent do 0.06823 0.09665 0.71 0.483

S = 0.907562 R-Sq = 0.9% R-Sq(adj) = 0.0%

Analysis of Variance

Source DF SS MS F P
Regression 1 0.4105 0.4105 0.50 0.483
Residual Error 58 47.7728 0.8237
Total 59 48.1833

Table 110: General Linear Model: TL Level versus Question 13 Level

Factor Type Levels Values
Qs 13 Level fixed 3 0, 1, 2

Analysis of Variance for TL Level, using Adjusted SS for Tests

Source DF Seq SS Adj SS Adj MS F P
Qs 13 Level 2 1.2018 1.2018 0.6009 1.57 0.216
Error 57 21.7815 21.7815 0.3821
Total 59 22.9833

S = 0.618168 R-Sq = 5.23% R-Sq(adj) = 1.90%

Unusual Observations for TL Level

Obs TL Level Fit SE Fit Residual St Resid
16 0.00000 1.33333 0.12618 -1.33333 -2.20 R
25 0.00000 1.33333 0.12618 -1.33333 -2.20 R
30 0.00000 1.46154 0.17145 -1.46154 -2.46 R
33 0.00000 1.33333 0.12618 -1.33333 -2.20 R

R denotes an observation with a large standardized residual.

Table 111: Regression Analysis: Question 12 versus Question 13

The regression equation is
Question 12: To what extent do = 1.75 + 0.503 Question 13: To what extent do

Predictor Coef SE Coef T P
Constant 1.7483 0.3131 5.58 0.000
Question 13: To what extent do 0.5035 0.1001 5.03 0.000

S = 0.939963 R-Sq = 30.4% R-Sq(adj) = 29.2%

Analysis of Variance

Source DF SS MS F P
Regression 1 22.355 22.355 25.30 0.000
Residual Error 58 51.245 0.884
Total 59 73.600

Unusual Observations

Question Question
13: To 12: To
what what
Obs extent do extent do Fit SE Fit Residual St Resid
52 3.00 1.000 3.259 0.122 -2.259 -2.42R

R denotes an observation with a large standardized residual.

Table 112: General Linear Model: Question 12 Level versus Question 13 Level

Factor Type Levels Values
Qs 13 Level fixed 3 0, 1, 2

Analysis of Variance for Qs 12 Level, using Adjusted SS for Tests

Source DF Seq SS Adj SS Adj MS F P
Qs 13 Level 2 10.0500 10.0500 5.0250 8.91 0.000
Error 57 32.1334 32.1334 0.5637
Total 59 42.1833

S = 0.750828 R-Sq = 23.82% R-Sq(adj) = 21.15%

Unusual Observations for Qs 12 Level

Obs Qs 12 Level Fit SE Fit Residual St Resid
36 0.00000 1.52174 0.15656 -1.52174 -2.07 R
47 0.00000 1.52174 0.15656 -1.52174 -2.07 R
48 0.00000 1.52174 0.15656 -1.52174 -2.07 R
58 0.00000 1.52174 0.15656 -1.52174 -2.07 R

R denotes an observation with a large standardized residual.

Table 113: Correlations: Question 15: Acquiring Situation, Question 21: Acquiring Situation

Pearson correlation of Question 15: Acquiring situatio and Question 21:
Acquiring situ = 0.226
P-Value = 0.082

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