AN ALGORITHM FOR SYSTEMATIC INTEGRATION OF INFORMATION TECHNOLOGY MANAGEMENT PROCESSES USING EVENT-DRIVEN PROCESS CHAINS AND BUSINESS PROCESS MODEL NOTATION

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A

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By

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Abstract

Information Technology (IT) managers have spent millions of dollars implementing IT governance, IT project management, enterprise architecture, and IT operations management programs with mixed results. IT organizations continue to struggle to meet expectations of their parent organizations and their own management. Organizations that integrate these processes may increase organizational efficiency. This thesis proposes an algorithm to integrate IT management processes. The proposed algorithm leverages well-known, simple-to-use tools to provide insights into the relationships among the processes, identifies specific points of integration, and models future-state processes. The algorithm is applied to a case study organization and the results simulated. From the results, there does appear to be an opportunity to increase efficiency by integrating IT management processes using the algorithm.

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Table of Contents

Page

المنارة للاستشارات
www.manaraa.com

Page

المنارة للاستشارات
www.manaraa.com

Page

www.manaraa.com

Page

المنارة للاستشارات
www.manaraa.com

Page

www.manaraa.com

List of Figures

المنارة للاستشارات
www.manaraa.com

Page

المنارة للاستشارات
www.manaraa.com

List of Tables

المنارة للاستشارات

www.manaraa.com

List of Appendices

المنارة للاستشارات
www.manaraa.com

Chapter 1 Introduction

1.1. Problem Statement

Businesses are increasingly dependent on information technology (IT) to gain a competitive advantage. Dependency on technology leads to increased investment in technology. As investment in technology grows, IT managers look to improve organizational efficiency. IT organizations have implemented programs such as IT governance, IT project management, enterprise architecture, and IT operations management in an attempt to increase efficiency, many to no avail. Simply instituting a program is likely too narrowly focused and, in itself, unlikely to optimize efficiency. Well-designed programs, while partially effective, unless well integrated are unlikely to increase the organization's efficiency. Understanding the relationship among IT governance, IT project management, enterprise architecture, and IT operations management and integrating their related processes could help IT departments improve efficiency. This thesis explores a general integration approach. The suggested algorithm expands on existing tools and concepts to integrate the processes into a holistic IT strategy. Using this strategy, IT organizations may improve efficiency.

1.2. Scope

This thesis focuses on the integration of four IT management domains: IT governance, IT project management, enterprise architecture, and IT operations management. The concepts and algorithm developed in this thesis are extensible. These techniques may also be extended to integrate risk management processes or other management domains.

1.3. Significance

IT management processes must be well integrated and complementary to attain the full benefit of component processes. If out of balance, an IT organization may not be operating efficiently. Although there is significant literature on IT governance, IT project management, enterprise architecture, and IT operations management, what is missing is

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an integration algorithm to bind these best practices together in a functional way and a methodology to measure the collective impact on efficiency. The proposed algorithm may provide additional unrealized benefits by improving organizational efficiency.

1.4. Research Question

How can IT managers increase organizational efficiency by integrating related management processes, using existing tools and system design principles such as modeling the current-state, understanding the relationships among processes, and modeling a future integrated state?

1.5. Assumptions

The major assumption in this thesis is that variables used to calculate efficiency must be significantly tailored to the organization performing the integration. The integration itself must be customizable. While generalizations exist, what is important to one organization is not necessarily important to other organizations.

A case study is used throughout this thesis to discuss application of this algorithm. Given that this is an algorithm that must be applied to a specific organization, there is no empirical evidence provided that absolutely confirms the algorithm is without issue. Instead, the value of the algorithm is demonstrated using the case study example.

This thesis uses Event-driven Process Chain (EPC) and Business Process Model and Notation (BPMN) to model current- and future –state processes. These tools are not a requirement of the algorithm. Both EPC and BPMN could be replaced with other modeling tools. EPC and BPMN were selected because both can model processes and software was readily available.

While the literature review provides a quick summary of the relevant issues, frameworks, and their weaknesses, this thesis assumes that the reader has some foundational knowledge of modern information technology.

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1.6. Case Study Organization

Throughout this thesis, a case study organization is used to illustrate the algorithm and concepts surrounding its application. The case study organization is a member-owned, non-profit financial institution (NAICS 52). This organization has approximately five billion dollars in assets under management. 2012 revenue approached $50 million. It is one of the largest institutions of its class in the U.S. The organization is experiencing growth beyond its original geographic region, expanding into four states.

Because of its size and expansion, the organization is experiencing pressures related to a rapidly growing business: increasing IT operating expense due to increasing complexity, number of deployed systems, and geographic resiliency through site diversity employed as a continuity measure. The organization's architectural business model contains more than 700 business processes. Those processes are supported by more than 300 applications, deployed on more than 700 servers. The IT operation is distributed between two data centers approximately 3500 miles apart, which presents a significant technology challenge due to communications latency between the facilities.

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Chapter 2 Literature Review

This thesis discusses several IT management domains, processes, and modeling techniques. The literature review was prepared to provide the reader foundational knowledge, discuss relevant issues, and introduce applicable frameworks, standards, and their weaknesses regarding process integration algorithms. Each sub-section includes a high-level description of the case study organization's current state of maturity. The literature was collected from a variety of sources, including the University of Alaska Anchorage Consortium Library, Google Scholarly Articles, the Institute of Electrical and Electronic Engineers (IEEE) website, The Open Group website, and the Information Systems Audit and Control Association (ISACA) website. Table 2.1 shows the distribution of reference material used in this thesis.

Table 2.1

Literature Review

Research area	Journal	Professional Publication	Book	Academic Paper	Government Publication	Thesis	Software	Total	Cited
IT Governance methodology	4	1		1				6	5
IT Project Management	2	1	2					5	5
Enterprise Architecture		1	1	1	1	2		6	2
IT Operations Management	2	1	2					5	4
Modeling	1	2		2			3	8	6
IT Integration Algorithms						3		3	2

2.1. IT Integration Algorithms

Much of the literature discussed integration with other IT management processes, in particular IT governance and enterprise architecture; however, none of the literature specifically proposed an algorithm to perform the integration of IT management

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processes. Enterprise architecture literature did provide insight into appropriate integration terminology that is used throughout this thesis (e.g. current-state, future-state, etc.). As Day (2011) discussed in his Ph.D. dissertation related to quality models, there seems to be a gap in the literature related to integration algorithms, despite several related frameworks calling for such an integration algorithm. Although his conclusion is limited to software quality frameworks, his research analyzes several of the same frameworks. Sage (2006) discussed in her Ph.D. dissertation related to business and information technology alignment, that there is a gap in the ability for enterprise architecture frameworks to integrate with IT and corporate governance. The Control Objectives for Information and Related Technology (COBIT) framework specifically called for process integration, yet provided no actual algorithm to integrate processes. There does appear to be a gap in the literature between theoretical integration of IT management processes and a practical algorithm demonstration of that integration. This thesis proposes an algorithm to close that gap and a practical demonstration of that algorithm.

2.2. IT Governance

IT governance is a necessary element to organizational strategic alignment. The IT organization and business are aligned through strong governance (Brobst, 2005). IT governance is an extension of corporate governance. IT governance is the boundaries established to effectively manage the IT organization. It controls the flow of projects into the IT project management domain. It guides us in our efforts to deliver our services and then ensures our performance is measured against business goals and objectives (IT Governance Institute, 2012). Governance establishes the "rules of engagement". It is primarily focused on process not technology. A governance framework should describe the rules to apply to the process. IT governance is not IT management (IT Governance Institute, 2012). It guides IT management by establishing a framework for the IT organization to be successful. As seen in Figure 2.1, IT Governance has a strategic and leadership focus.

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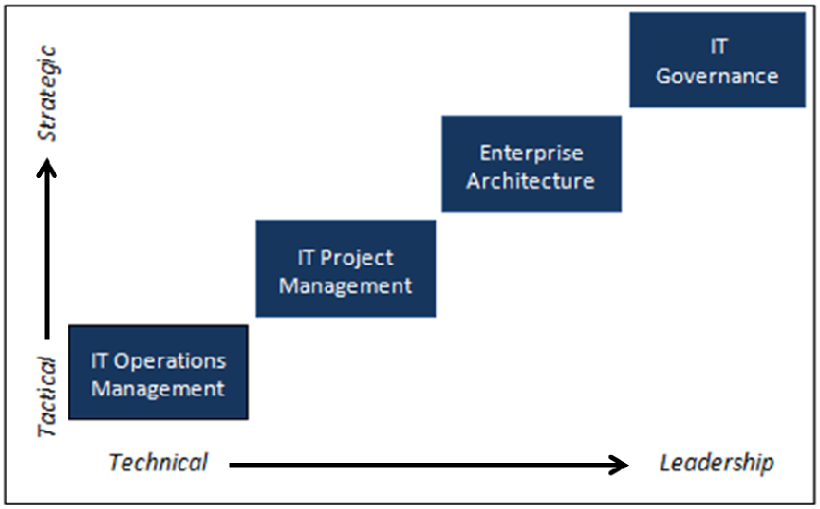

Figure 2.1. IT management focus

COBIT 5 is the most common IT governance framework. The case study organization uses COBIT 5. Although a major driver for the development of COBIT 5, integration of governance with other IT management processes was not specifically demonstrated (IT Governance Institute, 2012). The COBIT 5 Framework established five guiding principles (IT Governance Institute, 2012):

- Meeting stakeholder needs
- Covering the enterprise end-to-end
- Applying a single, integrated algorithm
- Enabling a holistic approach
- Separating governance from management

2.2.1. Meeting stakeholder needs.

The goal of any high-functioning IT organization is to meet stakeholder needs. The boarder term "stakeholder" refers to those in the business that are affected by IT. In today's IT organization, this implies alignment with business objectives. Business objectives are established by a subset of stakeholders, and it is the goal of IT to meet those objectives for the betterment of the entire organization. IT stakeholders may be, but are not limited to, executives, IT managers, and business process owners.

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2.2.2. Covering the enterprise end-to-end.

If governance is to cover the enterprise end-to-end, then governance must create controls to ensure IT is consistently working with the organization's vision. Nothing should be able to enter or exit the system without flowing through governance (see Figure 2.2) (IT Governance Institute, 2012). A simple method to manage this is through controlling the flow of projects into the organization. In this model, IT is only working on projects approved through the organization's IT governance. Projects are only completed after meeting the business objectives set by management and verified by the stakeholders. This closed system ensures nothing can enter the system without approval of the governing body and nothing can exit the system without the approval of the governing body. With this tight span of control, it is impossible to provide products and services without meeting the business objectives identified (Chaudhuri, 2011).

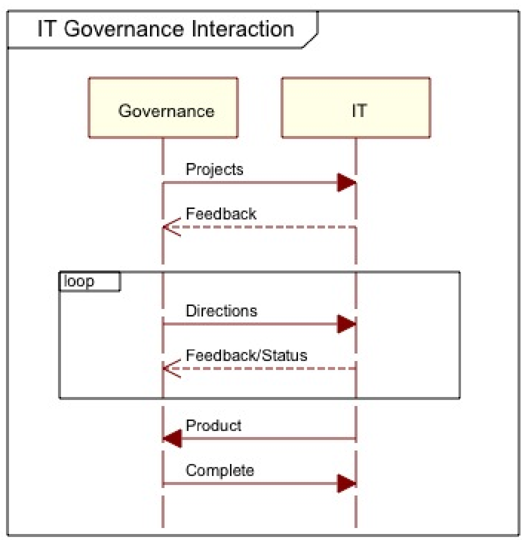

Figure 2.2. IT and Governance

2.2.3. Applying a single, integrated algorithm.

There should be one algorithm used in an organization (IT Governance Institute, 2012). This tightens span of control and ensures there is no interference from other algorithms in the process. IT functions are managed and performed by people, and

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people work best in environments where expectations are clearly defined (Brown & Leigh, 1996). Using only one algorithm provides clarity of vision and consistent business objectives that will guide the IT organization (Chaudhuri, 2011).

2.2.4. Enabling a holistic approach.

Enabling a holistic approach to governance implies that everything in the IT organization is within the scope of IT governance. If too narrowly focused, governance can become overly complicated or lack appropriate controls. IT governance should consider all types of projects and work. It should include issues related to those projects and work. IT governance is the single source for guidance regarding the technology investment (Chaudhuri, 2011).

2.2.5. Separating governance from management.

Governance and management are different activities. IT governance is about guiding IT toward accomplishing or supporting organizational business objectives (IT Governance Institute, 2012). It defines how to use technology investment. Management is focused on how to execute the activities to accomplish those business objectives. Governance tells us what to work on; management tells us how to work on it.

2.3. Enterprise Architecture

The IT organization is an enabling resource used by the business to effectively carry out its mission. It automates or compliments business processes, making the business more efficient. The IT organization does this by providing services. Arranged in a hierarchy, business processes are supported by services, services are provided by applications, and applications are supported by infrastructure (see Figure 2.3). Enterprise architecture is a component of IT management that focuses on describing this hierarchy. It specifies how to use technology to support or satisfy business processes. It centralizes control of architectural decisions to ensure alignment with business objectives (Chief Information Officer Council, 2001). To do this, enterprise architecture programs standardize terminology to promote good communications among stakeholders. They help organize technology into clearly defined artifacts in a hierarchical structure.

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Understanding the complexity and subtleties surrounding these layers is fundamentally enterprise architecture. In organizing our thinking, enterprise architecture can increase efficiency, mitigate risk, and reduce complexity in the environment (The Open Group, 2009).

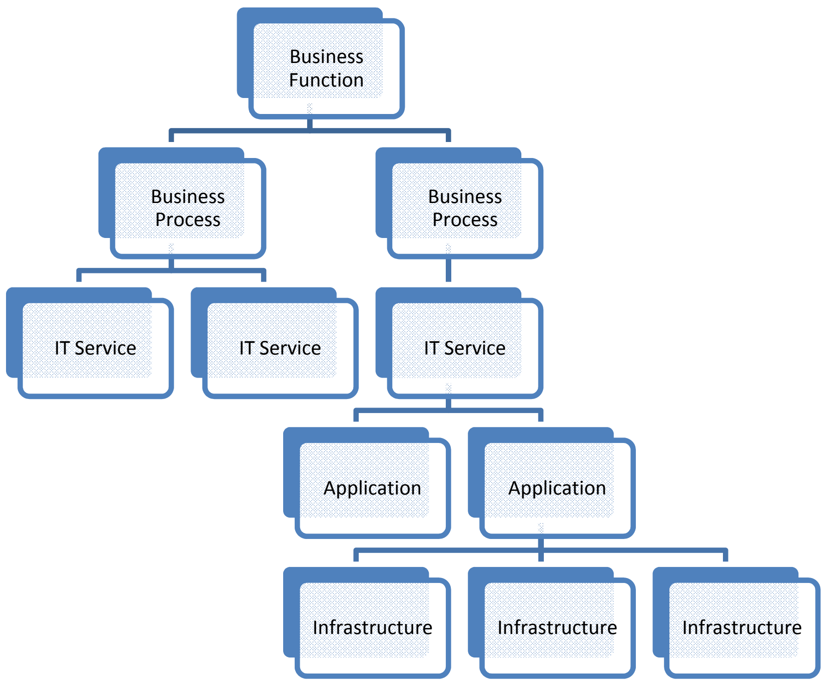

Figure 2.3. Enterprise architecture hierarchy

2.3.1. Efficiency.

Enterprise architecture increases efficiency within an organization by providing a single source for all architectural information. Before an enterprise architecture program is in place, this information is typically stored in disparate locations throughout the organization. It is common for more than one organization to maintain copies of the same data. As the data changes, not everyone updates their source and the result is several copies of inconsistent data. Organizations make decisions based on this inconsistent information. Enterprise architecture establishes a central point of control for architectural documentation. All architectural artifacts are stored in the same central

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repository, reducing the chance that decisions are made based on inconsistent or incomplete architectural artifacts. (The Open Group, 2009)

2.3.2. Mitigate risk.

Enterprise architecture mitigates the risk of changing the environment (Chief Information Officer Council, 2001). Given the complexity of the technology investment, change is a high-risk endeavor. Changes in the environment that seem insignificant can cause significant damage to business operations, disrupting business functions and affecting productivity within the organization. By understanding the relationship between the business and its supporting technology, enterprise architects can review changes in the environment and accurately understand the risks. (The Open Group, 2009)

2.3.3. Reduce complexity.

Without enterprise architecture, there is no overriding vision behind the technology investment. Technology is implemented without consideration to business objectives or cost, leading to potentially unnecessary complexity in the enterprise. Enterprise architecture is meant to reduce this complexity by centralizing control and providing a vision behind the investment. Enterprise architects review business functions for similarities and reuse technology where possible, ensuring new artifacts are not introduced unnecessarily. (The Open Group, 2009)

Enterprise architecture is intended to help information technologists successfully manage growth and complexity through effective management of technology resources. It introduces tools that can be used tactically, strategically, and operationally but focuses on long-term strategic decisions and only supports short-term tactical decisions. It must take a holistic view of the infrastructure and help organize and align the business-to-technology relationship. Enterprise architecture can provide tools to assess the risk of disrupting business processes during an architecture changes. By consolidating this information into one system of record accessible by all stakeholders, communications and collaboration can be improved. This will promote transparency and improve stakeholder

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relations. For consistency, enterprise architecture programs should adopt a standardized documentation algorithm to simplify comparison of current and proposed future-state architectures. This architectural knowledge base can facilitate deep collaboration and enable strategic infrastructure planning.

At the case study organization, a business is a collection of related processes working together for a common goal. A business process is a collection of procedures to carry out an activity in support of business objectives. The impact to the organization and likelihood of losing a process or its supporting systems can be categorized by criticality. The impact is measured in units such as customer service, lost revenue, productivity, or damaged reputation. Typically negotiated with the business unit that is responsible for the process, impact ratings are assigned to each business process.

Change describes how the current-state of an application, system, or infrastructure component will become the proposed future-state. Understanding the implications of this transition can be difficult to manage. To this end, analysts review the system documentation to uncover any subtleties that may lead to a service disruption. The supporting documentation, current- and future-state architectures are typically stored in a system referred to as enterprise architecture management systems (EAMS). It is imperative that this documentation is consistent and integrated to be completely useful. Managing consistent change in the environment is dependent upon the accuracy of the information in the system.

2.4. IT Project Management

IT Project Management refers to the project management activities implementing the technology investment of an organization. IT project management activities are typically consistent with corporate-level project management. This is not the case at the case study organization, where there is no corporate-level project management. Project Management includes several related disciplines: primarily program management and portfolio management. Program management groups interrelated projects for the purposes of managing them as single unit. A program is a complex project decomposed

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into a series of smaller projects to simplify the management process. Project Portfolio Management groups related programs or projects into portfolios to consolidate the management of the projects (Project Management Institute, 2008). Typical drivers behind this grouping are alignment with organizational objectives and/or a requirement for common reporting.

Organizations implement IT project management programs to reduce the likelihood of projects failing to meet objectives, exceed budget, or exceed time constraints (Spelta & Albertin, 2012). For these reasons, seven out of 10 companies have adopted project management programs (Feldman, 2010). By establishing rules to control scope, time, and budget, project management programs are established to reduce the chance of project failure by standardizing how an organization manages projects (Project Management Institute, 2008). Adopting this discipline increases the likelihood of project success (Jugdev & Muller, 2005).

According to the Project Management Institute's *A Guide to the Project Management Body of Knowledge (PMBOK)* (2008), project management can be modeled using five process groups and nine knowledge areas (see Table 2.2). Every project has an initiating, planning, executing, monitoring and controlling, and closing process group. The process groups vary in complexity in relation to the complexity of the project. They may be informal or formal depending on the project details, organizational project management policy, complexity, or scope. At the case study organization, this process is not fully developed; however, the organization is adopting a PMBOK-based project management methodology.

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Table 2.2

PMBOK Process Group Matrix

Knowledge Areas	Process Groups				
	Initiating	**Planning**	**Executing**	**Monitoring & Controlling**	**Closing**
4. Integration Management	4.1 Develop Project Charter	4.2 Develop Project Management Plan	4.3 Direct and Manage Project Execution	4.4 Monitor and Control Project Work 4.5 Perform Integrated Change Control	4.6 Close Project or Phase
5. Scope Management		5.1 Collect Requirements 5.2 Define Scope 5.3 Create WBS		5.4 Verify Scope 5.5 Control Scope	
6. Time Management		6.1 Define Activities 6.2 Sequence Activities 6.3 Estimate Activity Resources 6.4 Estimate Activity Durations 6.5 Develop Schedule		6.6 Control Schedule	
7. Cost Management		7.1 Estimate Costs 7.2 Determine Budget		7.3 Control Costs	
8. Quality Management		8.1 Plan Quality	8.2 Perform Quality Assurance	8.3 Perform Quality Control	
9. Human Resource Management		9.1 Develop Human Resource Plan	9.2 Acquire Project Team 9.3 Develop Project Team 9.4 Manage Project Team		
10. Communications Management	10.1 Identify Stakeholders	10.2 Plan Communications	10.3 Distribute Information 10.4 Manage Stakeholder Expectations	10.5 Report Performance	
11. Risk Management		11.1 Plan Risk Management 11.2 Identify Risks 11.3 Perform Qualitative Risk Analysis 11.4 Perform Quantitative Risk Analysis 11.5 Plan Risk Responses		11.6 Monitor and Control Risks	
12. Procurement Management		12.1 Plan Procurements	12.2 Conduct Procurements	12.3 Administer Procurements	12.4 Close Procurements

2.4.1. Project initiation.

The goal of the project initiation is to define the preliminary scope of the effort. This is accomplished by understanding the business objectives the project will attempt to satisfy. Typically, a project charter is created during the initiation process group. The charter will outline the scope along with stochastic budget and time estimates. The charter typically identifies the key project stakeholders. (Project Management Institute, 2008)

2.4.2. Project planning.

Project planning removes variability in the detailed scope, budget, and time by analyzing the desired outcomes and creating a detailed project plan to satisfy the business objectives. The results are deterministic scope, budget, and time estimates. During the

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planning, project managers create a detailed project plan specifying the level of effort and resources needed. The project plan explains the relationship between project tasks. During this process group, project managers determine the risks to the project and develop mitigation strategies. (Project Management Institute, 2008)

2.4.3. Project execution.

During the execution process group, deliverables are created and stakeholder expectations managed. During this process group, project managers spent significant time managing the expectations of everyone involved in the project. (Project Management Institute, 2008)

2.4.4. Project monitoring and controlling.

Throughout the project, project managers ensure the project remains focused on satisfying the business objectives. Project managers will monitor project performance and take corrective action if needed. An important component of this process group is to manage the scope, budget, and time and ensure they remain within initial expectations. If that is not possible, the project manager must manage project change. (Project Management Institute, 2008)

2.4.5. Project closing.

During project closing, the project manager ensures the expectations of the project sponsor(s) were met and that the business objectives were satisfied. All project records are archived. Project managers incorporate lessons learned into project management processes to ensure mistakes are not repeated and, more importantly, successes are repeated. (Project Management Institute, 2008)

2.5. IT Operations Management

IT operations management describes how IT supports and maintains the technology investment. It is more technical and tactical than IT governance, IT project management, or enterprise architecture (see Figure 2.1). It is a fabric woven from several interrelated programs. Each program represents activities inside the organization, the

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orchestration of which effects organizational efficiency. There are several operations management frameworks in the industry today. The most prevalent is IT Infrastructure Library (ITIL) (ITIL, 2013). ITIL is a derivative of IT Service Management (ITSM) (van Bon, et al., 2010). The case study organization has implemented ITIL best practices but does not claim to be ITIL compliant. A significant portion of its IT staff is ITIL certified, including all the enterprise architects. While ITIL provides a framework for IT operations management, it does not provide an integration algorithm. Without integration, many efficiency opportunities may be missed.

The case study organization defines IT operations management as eight functional areas:

- Capacity Management
- Incident and Problem Management
- Change Management
- Configuration Management
- Service Management
- Asset Management
- Procurement Management
- Patch Management

2.5.1. Capacity management.

Capacity management is used to manage the performance and predict the future capacity needs of the IT environment. Information systems meet production requirements and organizational goals through monitoring and capacity planning. The overall goal is to capture and communicate relevant information to ensure system resources are appropriately available and to meet business demands. Capacity planning can improve overall system reliability by ensuring information systems are properly sized to meet or exceed availability goals (van Bon, et al., 2010). Another important objective is to proactively increase information system capacity by forecasting future capacity requirements based on historical trends. Capacity planning can improve business process

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performance by continuously improving information systems performance. Ultimately, capacity planning will provide actionable reporting of both capacity and performance events, reduce capacity-related incidents through preemptive performance monitoring, and establish methods for tuning and optimizing of the performance of IT services.

2.5.2. Incident and problem management.

Incidents describe interruptions or degradation in IT services. Problems are clusters of related incidents and indicate a systemic problem (van Bon, et al., 2010). Incident and problem management also addresses how lessons-learned are incorporated into IT management. Root cause analysis is performed on incidents and problems to ensure issues are avoided in the future. Another important element of this functional area describes how incidents and problems are handled.

2.5.3. Change management.

Change management is the process that introduces change in the IT production environment (van Bon, et al., 2010). The environment may include computer systems, business processes, software, or procedures governing the environment. Strong change management processes define a set of rules that must be followed during the implementation of a change.

2.5.4. Configuration management.

Configuration management standardizes software and hardware configurations, limiting the number of unique combinations (IEEE, 2012). This dramatically simplifies maintenance since there are a small number of configurations. By thoroughly designing each configuration, the risk of disruption can be reduced, leading to lower incidents, which directly increases efficiency. Budget planning is simplified because there is only a finite menu of hardware and software needed to build each configuration.

2.5.5. Service management.

Service management is about managing customer expectations. The central component of service management is the Service Level Agreement (SLA). SLAs are

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negotiated with the IT organization's customers. The case study organization created impact ratings to describe each business process in the environment. Each impact rating will have an associated recovery time objective (RTO) and recovery point objective (RPO). The RTO is the average time to recover the system after an unplanned interruption. The RPO is the length of time since the last backup and therefore, describes the length of time that organization can tolerate loss or corruption of data for a system.

2.5.6. Asset management.

Asset management is the management of all technology assets owned by an organization. Core to asset management is the asset management database (Thompson, 2009). At the case study organization, asset management is performed at two levels. In the IT organization, for most technology assets, a record exists in the asset management repository (there are plans in the future to add all technology assets). At the corporate level, non-technology assets are tracked. Together these processes govern all the assets of the organization.

2.5.7. Procurement management.

At the case study organization, procurement management is the management of all technology purchases. In addition to managing purchases, procurement management also includes budgeting and forecasting future expenses for planning purposes. It is closely aligned with corporate level procurement management, but operates independently of that program.

2.5.8. Patch management.

Patch management is the process surrounding updating software and firmware with applicable software releases to address issues like security vulnerabilities and bugs. At the case study organization, Information Security and Operations Management departments jointly address patch management. The processes within patch management include monitoring for new patches, assessing the need to apply patches, applying patches, and status reporting.

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2.6. Modeling

Information technology is a complex endeavor, requiring graphical, descriptive techniques to show relationships and the procedural flow of activities through a process. Processes requiring interaction among domains are particularly troublesome to model. Ullah & Lai (2011) described a two-stage process to model the business/IT relationship. This same process is useful in modeling the relationship among IT management domains. Their approach used Business Process Modeling Notation (BPMN) and Unified Modeling Language (UML).

There are two types of modeling strategies presented in this thesis: "loosely-coupled" and "tightly-coupled" connections. Loosely-coupled connections are policy driven where an IT management process is encapsulated by another process. For example, the IT governance domain may completely contain the project management domain. The modeling of these relationships in this thesis is demonstrated using Event-driven Process Chains (EPC). In tightly-coupled processes, there is an interconnected relationship in which processes are woven together in a fabric. BPMN will be used to demonstrate these relationships.

2.6.1. Event-driven Process Chains (EPC).

EPC was first introduced by Keller, Nuttgens, and Scheer (1992) in 1992. In 1999, van der Aalst (1999) formalized the use of EPC to model Petri Nets. Although it is possible to model Petri Nets with EPC, EPC does not provide the alignment with mathematics that is available in Petri Nets. Today, it is a widely used, accepted modeling notation built into commercially available enterprise modeling tools (Korherr & List, 2006). Modeling business processes in EPC allows architects to understand the relationships among events and functions. EPC is useful when modeling high-level processes especial when a process can be deconstructed into a series of sub-processes. It is not particularly useful when modeling a series of complex, interrelated steps that make up an integration. There are four components to EPC: functions, events, local

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connectors, and interfaces (van der Aalst, 1999). This thesis uses an application named Cubetto Flow running on iPad to generate EPC (Semture, 2013).

2.6.1.1. Events.

An event (see Figure 2.4 item 1) is a moment in time when something significant occurs in the process.

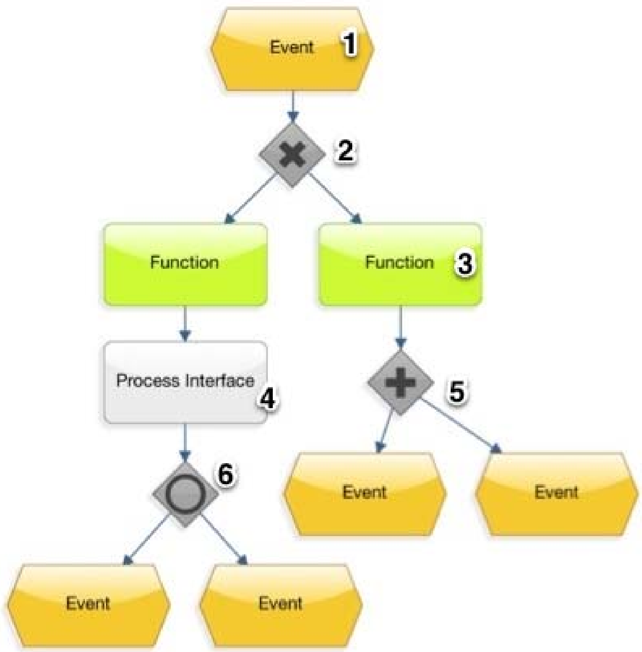

Figure 2.4. Example EPC

2.6.1.2. Functions.

A function (see Figure 2.4 item 3) is the atomic component of a process. Together functions are combined to accomplish the process. Functions can trigger events or flow into other processes.

2.6.1.3. Logical connectors.

Logical connectors are binary operators linking functions and events. Logical connectors represent decisions. The decisions can have one of three outcomes, which can

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be described by the binary operators. The notation defines the binary operators AND, XOR, and OR.

XOR (see Figure 2.4 item 2) – Is the exclusive OR binary operator, following the truth table (see Table 2.3).

Table 2.3

XOR Operator Truth Table

P	**Q**	**P XOR Q**
T	T	F
T	F	T
F	T	T
F	F	F

AND (Figure 2.4 item 5) – Is the AND binary operator, following the truth table in Table 2.4.

Table 2.4

AND Operator Truth Table

P	**Q**	**P AND Q**
T	T	T
T	F	F
F	T	F
F	F	F

OR (Figure 2.4 item 6) – Is the OR binary operator, following the truth table in Table 2.5.

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Table 2.5

OR Operator Truth Table

P	Q	P OR Q
T	T	T
T	F	T
F	T	T
F	F	F

2.6.1.4. Interfaces.

Interfaces (see Figure 2.4 item 4) represent a relationship with another business process. For example, an event from an interface may be the input to a function in a different process.

2.6.2. Business Process Model and Notation (BPMN).

BPMN is a standard modeling language for business process introduced by the Object Management Group (OMG) (Object Management Group, 2011). The language was designed to provide business analysts a standard language to describe a variety of business processes. As with EPC, the notation used in this thesis is generated by Cubetto Flow (Semture, 2013). BPMN provides a complex modeling language to model the most complex processes and integrations. It is particularly useful in modeling complex integration, where process steps can be organized in swim-lanes. Swim-lanes allow the model to show the relationship among participating processes in an integration.

Figure 2.5 shows Cubetto Flow's BPMN key. BPMN diagrams in this thesis will exclusively use this modeling software. As with EPC's logical connector, a BPMN gateway is a binary Boolean operator. Figure 2.6 shows an event colored in green. Green events are events at the beginning of the process, yellow events are events in the middle of a process, and red events are events at the end of a process.

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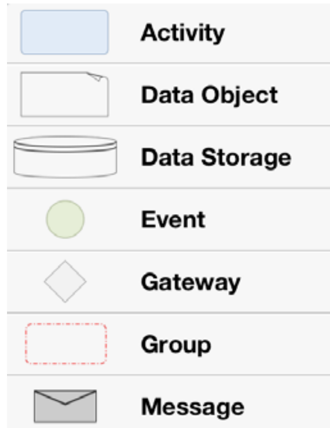

Figure 2.5. Cubetto Flow BPMN key

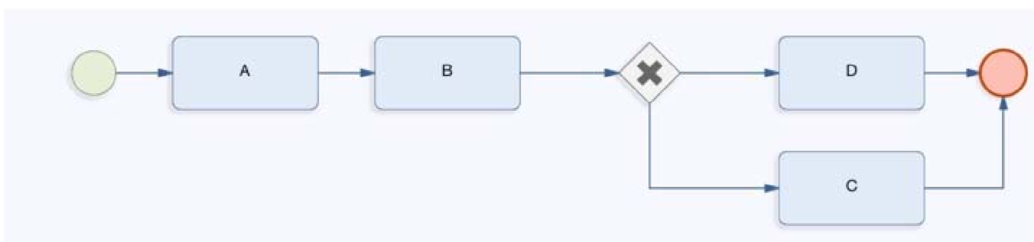

Figure 2.6. BPMN example

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Chapter 3 Methodology

3.1. Research Methodology

The research question introduced in Section 1.4 asks, "How can IT management increase organizational efficiency by integrating related management processes, using existing tools and system design principles such as modeling the current-state, understanding the relationships among processes, modeling a future integrated state?" Therefore, the goal of the proposed algorithm is to increase organizational efficiency.

3.1.1. Measuring efficiency.

Efficiency is a ratio or quantitative measurement. It is defined has the ratio of output and input (Equation 3.1) (Cooper, Seiford, & Zhu, 2011). As output increases and input decreases, a system becomes more efficient. This thesis uses θ to represent efficiency. Consider the example in Table 3.1 and the graph of the efficiency in Figure 3.1. In the example, there is an exponential relationship between the output and input. As the output increases and the input decreases, the efficiency exponentially increases. A system with efficiency of one is efficient. When efficiency is less than one, the system is inefficient.

$$efficiency = \frac{output}{input} \quad [3.1]$$

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Table 3.1.

Example Efficiency Calculation

Output	Input	θ
0	2	0.0
0.1	1.9	0.1
0.2	1.8	0.1
0.3	1.7	0.2
0.4	1.6	0.3
0.5	1.5	0.3
0.6	1.4	0.4
0.7	1.3	0.5
0.8	1.2	0.7
0.9	1.1	0.8
1	1	1.0
1.1	0.9	1.2
1.2	0.8	1.5
1.3	0.7	1.9
1.4	0.6	2.3
1.5	0.5	3.0
1.6	0.4	4.0
1.7	0.3	5.7
1.8	0.2	9.0
1.9	0.1	19.0

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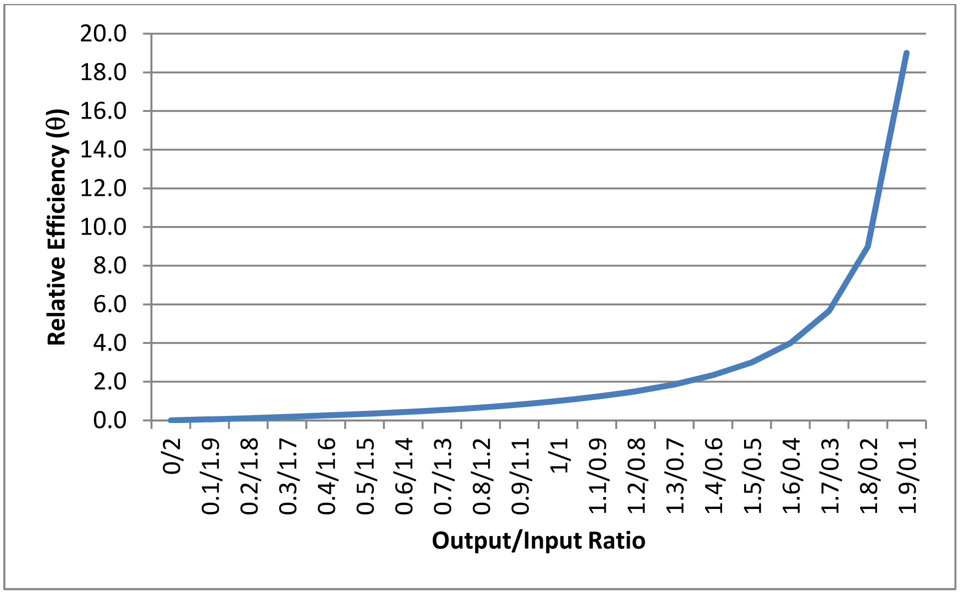

Figure 3.1. Example efficiency graph

This thesis focuses on efficiency, using an operations research technique called data envelopment analysis (DEA) to measure efficiency (Cooper, Seiford, & Zhu, 2011). DEA is a linear programming technique used to compare relative efficiency among several like processes referred to as decision-making units (DMU). DEA defines relative efficiency as the ratio of sum of the weighted outputs to the sum of the weighted inputs (see Equation 3.2). The weights are calculated relative to the efficiencies being compared (i.e. the most efficient system being measured will be one).

[3.2]

$$\theta_t = \frac{\sum_{i=0}^{i\to n} \lambda_i y_i}{\sum_{i=0}^{i\to n} \delta_i x_i}$$

$$where\ \lambda\ and\ \delta\ are\ weights, y\ is\ output,$$
$$x\ is\ input, \theta\ is\ efficiency\ at\ time\ (t)$$

To illustrate this, let operating expense and potential level of effort or available man hours be input variables. Let use assets under management and level of development effort be output variables. Figure 3.2 shows an Excel spreadsheet used to calculate efficiency with DEA.

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	A	B	C	D	E	F	G	H
1		Inputs			Outputs			
2		OPEX	LOE	Σ	Assets	LOE DEV	Σ	θ
3	*Weights*	1.00	1.00		1.00	1.00		
4	2007	$ 15.9	62428	62444	$ 3,664	44766	48430	0.7756
5	2008	$ 20.7	77953	77974	$ 3,871	43487	47358	0.6074
6	2009	$ 22.6	77884	77907	$ 4,010	34569	38579	0.4952
7	2010	$ 25.0	81394	81419	$ 4,285	32275	36560	0.4490
8	2011	$ 28.2	93137	93165	$ 4,650	35011	39661	0.4257
9	2012	$ 31.2	102916	102947	$ 5,100	35842	40942	0.3977

Figure 3.2. DEA spreadsheet

Calculating the weights can be easily accomplished with the Solver excel plug-in (see Figure 3.3). Because it is the most efficient, H4 is selected as the target cell. Cell B4, C4, E4, and F4 are the weights. Solver will automatically find a combination weight values that make the system efficient. After running Solver, the weights are calculated as 1, 0.87, 1.01, and 1.12 respectively (see Figure 3.4).

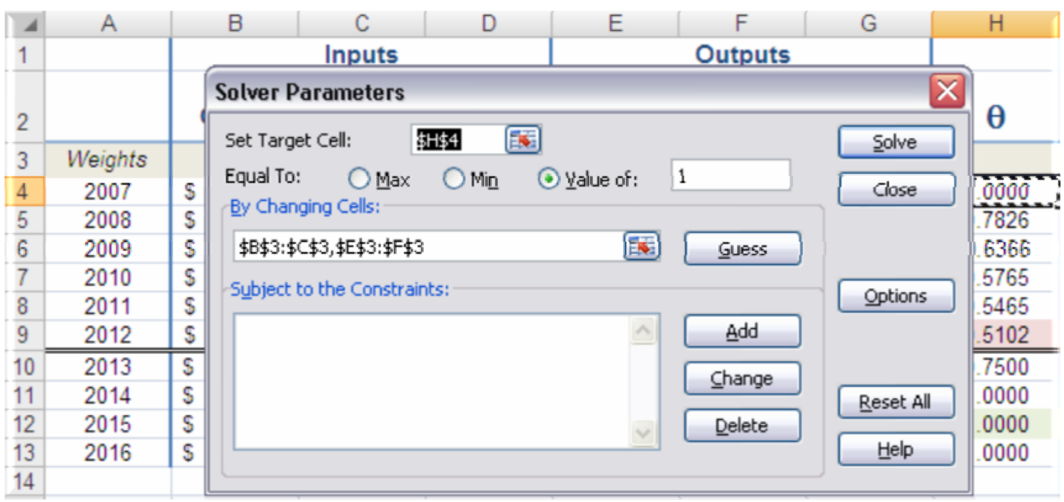

Figure 3.3. Using Excel Solver to find DEA weights

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	A	B	C	D	E	F	G	H
1		Inputs			Outputs			
2		OPEX	LOE	Σ	Assets	LOE DEV	Σ	θ
3	*Weights*	1.00	0.87		1.01	1.12		
4	2007	$ 15.9	62428	54039	$ 3,664	44766	54039	1.0000
5	2008	$ 20.7	77953	67479	$ 3,871	43487	52810	0.7826
6	2009	$ 22.6	77884	67421	$ 4,010	34569	42923	0.6366
7	2010	$ 25.0	81394	70461	$ 4,285	32275	40621	0.5765
8	2011	$ 28.2	93137	80627	$ 4,650	35011	44066	0.5465
9	2012	$ 31.2	102916	89092	$ 5,100	35842	45455	0.5102

Figure 3.4. DEA with calculated weights

3.1.2. Case studies.

Case studies are used to provide examples of a theoretic concept in action. They help us understand the complexities of the principles and provide data to apply the research methodology (Yin, 2009). The case study organization is used to illustrate the proposed algorithm. The weakness of using this method is that it provides only one example of employment of the algorithm. A better approach would be to apply this algorithm in numerous organizations and compare the results. Given time constraints, it is impractical to include this level of detail in this thesis.

In this thesis, the case study is a member-owned, non-profit financial institution (NAICS – 52). This organization has approximately five billion dollars in assets under management. 2012 revenue approached $50 million. It is one of the largest institutions of its class in the U.S. The organization is experiencing growth beyond its original geographic region, expanding into four states. Because of its size and expansion, the organization is experiencing pressures related to growth: increasing IT operating expense due to increasing complexity, number of deployed systems, and geographic resiliency employed as a continuity measure.

3.2. Research Goals

The research goal of this thesis is to propose an algorithm to integrate IT governance, IT project management, enterprise architecture, and IT operations management in a way that increases efficiency. To measure efficiency, DEA is proposed

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to measure and compare relative efficiency. This is a widely known linear programming technique and is widely accepted as a method to compare efficiency.

Since the proposed algorithm is demonstrated using a single case study approach, to have value, the algorithm must be extensible. Extensible in that the method to measure efficiency can be expanded to include additional input and output variables beyond those demonstrated in the case study. In the example in section 3.1.1, efficiency is calculated with operating expense and potential level of effort as input variables and assets under management and development level of effort as output variables. For this algorithm to be extensible, the mathematic model must be able to accommodate additional input and output variables.

The algorithm must be only a generalization. That is, generic enough such that another organization can employ the technique and still measure benefit. The algorithm must be generic enough to be used in other organizations in addition to the one in the case study.

3.3. Verification Criteria

The goal of the verification is to enhance the credibility of the results. Increasing the creditability allows readers to trust the conclusions herein. The verification also supports the claim that the results are measured and repeatable. The verification will use several statistical techniques to measure the algorithm's potential to increase efficiency based on simulated and practical application of case study data.

3.3.1. Verification of efficiency measurements.

The verification will use DEA, linear regression, and a Monte Carlo simulation to determine if the efficiency goals set by the case study organization are statistically plausible (see Figure 3.5). The case study organization will collect performance metrics for use as DEA variables for the period 2007 to 2012. The verification will use DEA to calculate the historical efficiency of the organization. Using linear regression (i.e., Excel's FORECAST function), the variables for 2013 will be estimated. The Monte Carlo simulation will use the forecasted 2013 variables as input. After 1000 simulations,

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DEA will use the simulated mean of each variable as input and calculate the 2013 efficiency. The resulting simulated 2013 input and output variables will be used to forecast 2014. The process will repeat until the data for 2017 is collected (Microsoft, 2013). The verification will repeat this process until obtaining the simulated efficiency for five years in the future. The verification will plot the trend of the forecasted efficiency without the simulated application of the algorithm against the result of the simulated algorithm. The verification will compare the trend of the efficiencies. If the algorithm is successfully employed, the trend will change during the period 2013 - 2017. Based on the comparative analysis, the verification will draw conclusions.

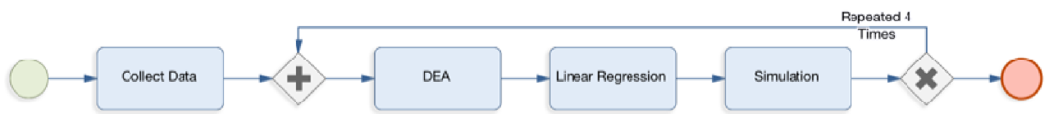

Figure 3.5. Verification of efficiency process flow

3.3.2. Extensibility.

The verification will demonstrate the algorithm's extensibility during the application to case study data.

3.3.3. Sufficiently generic.

The verification will demonstrate the algorithm is sufficiently generic for application in myriad situations. For the algorithm to be successful, it must be applicable to different situations not simply the case study.

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Chapter 4 Proposed Algorithm

The proposed algorithm is a series of steps used to understand the current- and future-states and identify potential integration points (see Figure 4.1):

- Measure current efficiency
- Set efficiency goals
- Understand the current-state design
- Find potential integration points
- Classify the integrations (e.g. “loosely-coupled”, “tightly-coupled”)
- Design the future-state
- Implement the future-state design
- Measure efficiency

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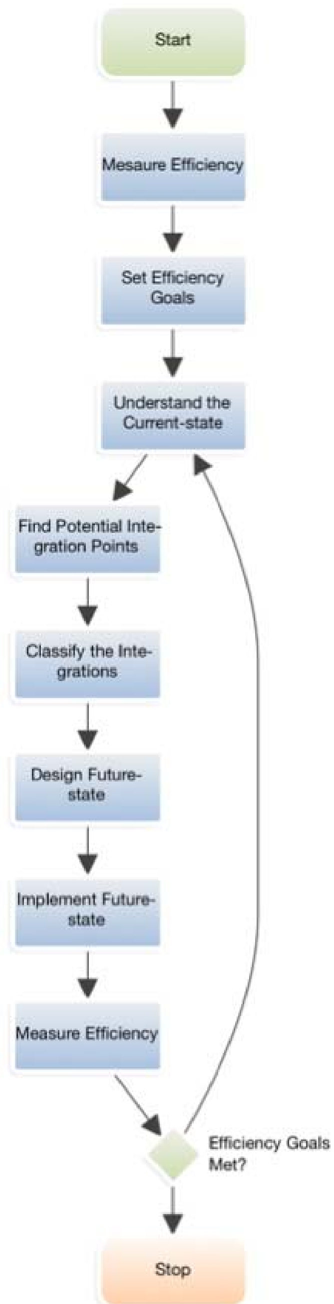

Figure 4.1. Algorithm process flow

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4.1. Measure Current Efficiency

One of the most important aspects of applying the algorithm is measuring its effect on efficiency within the organization. If the integrations do not increase efficiency, the organization needs to know to react and adjust the integration. In section 3.1.1, DEA is introduced as a technique used to measure efficiency within an organization. DEA is the ratio of the sum of the weighted outputs to the sum of the weighted inputs. Selecting the outputs and inputs is critical to accurately measuring organizational efficiency gains. This process, albeit subjective, can be approached systematically; however, each organization will measure efficiency differently. For example, in the case study example, profit is not a primary consideration and will not be an output. In a for-profit company, this would be a major output and not including it may be irresponsible. Key Performance Indicators (KPI) are a good source of variables. KPIs may be statistical measurements like the number of defects, percentage of failed changes, number of work orders, incidents resulting from changes, etc. Using existing KPIs that already measure the efficiency of processes before integration and combining them in the DEA to provide a holistic measurement are ideal.

4.1.1. Input variables.

Input variables are variables that if changed can affect the output of the system. During the writing of this thesis and exercising this algorithm, my selection of input variables is biased toward selecting input variables that measure potential. For example, leading indicators like operating income and potential hours to work on important organizational goals might represent good input variables. In the case study organization's case, these variables are extremely important. One of the benefits of DEA is that it can accommodate unlimited variables.

4.1.2. Output variables.

Output variables result from the effects of the system or changing input variables. These lagging indicators should consider not just technology metrics but business metrics that may be impacted by the efficiency of the IT organization.

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4.2. Set Efficiency Goals

Goals should be set for each input and output variable. The goals must be realistic and achievable or simulations will be inaccurate. During the demonstration of the algorithm, the goals are measured in percentage of change in the environment, assuming a successful implementation of the future-state process.

4.3. Understand the Current-state Design

To understand the scope of the domains to be integrated, the components and subcomponents of the domains must be identified. This can be accomplished by modeling the current-state process. Consider process 1 in Figure 4.2. An event begins the process. Function A1 is the result of the event. To get to the next step in the flow, function B1, the path flows through an OR gate. The OR can receive input from A1 or the XOR gate after B1. From B1, the path flows through the XOR. The flow can either continue to C1 or return to B1 but not both. Completing function C1 will result in another event.

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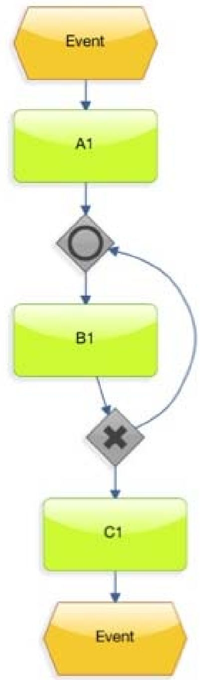

Figure 4.2. Example process 1

Processes can be modeled in BPMN. Figure 4.3 contains two processes modeled using BPMN. The flow through the process is trivial: A1 to B1 to C1. Cubetto Flow, used to create all BPMNs in this thesis, color codes starting events with green, ending events with red, and intermediate events with yellow.

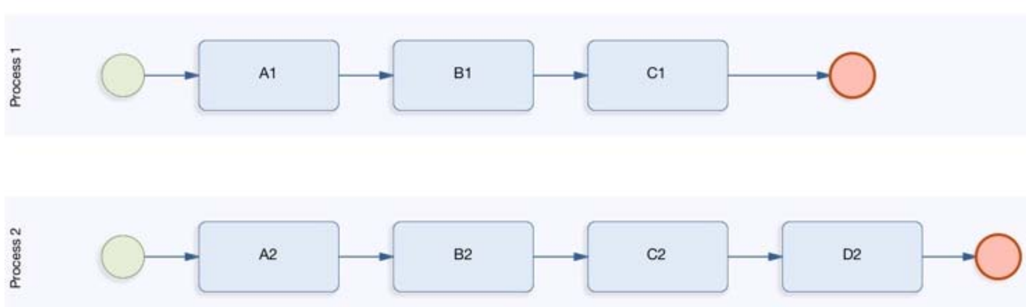

Figure 4.3. Example BPMN

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4.4. Find Potential Integration Points

To find integration points, each domain must be fully understood. This can be modeled using a matrix where the number of possible integrations is equal to the square of the processes being integrated minus the number of processes being integrated. For example, consider integrating process A, B, and C. This is a 3 by 3 matrix, with six possible integration points. Creating a table and describing how the columns influence the processes in the rows for each integration point will help identify integrations (see Table 4.1).

Table 4.1

Integration Matrix

	A	**B**	**C**
A		Describe how A influences B	Describe how A influences C
B	Describe how B influences A		Describe how B influences C
C	Describe how C influences A	Describe how C influences B	

In this example, there are six potential points of integration. The intersections represent the interaction from the prospective of the left hand column. The matrix is meant to provide a systematic approach to addressing all the relationships among the domains. If row A is the input, the intersection represents how the input domain influences the domain in the column. The intersection of the A row and the B column, for example, is meant to answer the question how does A influence B.

4.5. Classify the Integrations

The interaction between the processes being integrated now understood, each integration must be further considered. Integrations fall into two classifications, loosely-coupled and tightly-coupled.

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4.5.1. Loosely-coupled integrations.

Two discrete processes are "loosely-coupled" when the output from one is the input to the other. For example, if process A and B are "loosely-coupled", then the output of process A is the input to process B. A process may encapsulate another process or it may be follow in the logical flow of the process. During the application of this algorithm, EPC notation is used to model "loosely-coupled" integrations.

4.5.2. Tightly-coupled integrations.

Two discrete processes are "tightly-coupled" when the flows are woven together to accomplish both processes. For example, if process A and B are "tightly-coupled", a function in process A receives the output of a function in B, or an event in process A may result in a function in B. During the application of this algorithm, BPMN is used to model "tightly-coupled" integrations.

4.6. Design Future-state

After modeling the current-state of the process and identifying the possible integration points, joining the points of integration together is straightforward. Consider process 1 and 2 in Figure 4.3. If step A, B, and C in both processes are the same, then performing the steps together may be more efficient than performing them separately. Figure 4.4 shows a possible integration resulting from combining process 1 and 2.

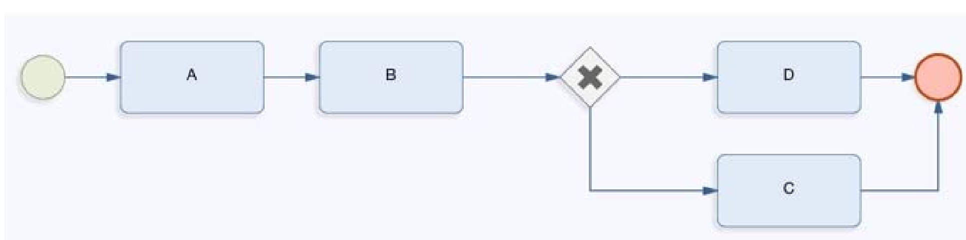

Figure 4.4. Integration example

4.7. Implement Future-state Design

During the planning of the implementation of the future-state design, architects need to be careful not to introduce unreasonable risk into the organization without proper

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notification. Once all process stakeholders understand the risks, the architects must manage their expectations regarding disruptions or service degradation. A phased implementation approach may reduce the overall risk of the implementation.

The case study organization is in the beginning stages of implementing the proposed algorithm. Given the complexity of the implementation, it may take a significant amount of time to measure accurately the real efficiency improvements in the organization. It is unlikely that the case study organization will have sufficient data to understand the true efficiency gains for several years.

4.8. Measure Efficiency

Measuring the efficiency post implementation requires continuously monitoring the same metrics used in the initial DEA over a period of time after the implementation. Once a trend is estimated, the results can be evaluated to see if organizational efficiency not only improved but improved consistent with expectations. If expectations have not been met, the algorithm can be repeated to investigate other possible efficiencies.

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Chapter 5 Results

The application of the algorithm at the case study organization required the direct participation of the enterprise architects in the organization and IT management. To demonstrate the results of the algorithm in practice, case study organization architects and IT management applied the algorithm to several IT domains. The results were simulated, using the technique described in section 3.3.1, based on the goals to determine if the architect's assumptions are plausible.

5.1. Practical Application of the Algorithm at the Case Study Organization

The architects used the algorithm to determine the potential success of integrating several practical examples. In one practical example, the architects integrated processes in the enterprise architecture, IT project management, and IT operations management domains. In another example, they integrated IT governance and project management. IT management approved the later integration for implementation beginning in 2013. The IT organization is expanding the use of the algorithm in 2013 to other domains to improve the overall department efficiency.

In the next sections, the application of the algorithm at the case study organization allows the algorithm's flow to demonstrate its application in a practical environment. The results are verified using the verification criteria and conclusions are made.

5.1.1. Measure efficiency.

As previously discussed, the organization can measure efficiency with DEA. Since efficiency is a ratio of input and output variables, incorrectly selecting the variables can significantly change the relative efficiency. Beginning with a list of common metrics for ITIL processes (Pink Elephant, 2005), an enterprise architect identified several metrics that were relevant to efficiency. Figure 5.1 describes the metrics considered as DEA input and output variables.

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Budget
- Operating Expense
- Capital Expense
- Number of available FTE hours
- Assets under management

Service Catalogue
- Number of services
- Number of business units using each service
- Number of users using each service
- Frequency of service requests

Change Management
- Total changes
- Total changes vs. successful changes
- Total changes vs. emergency changes
- Change horizon (e.g., a measure of proactively and planning)
- Changes from projects
- Changes from problems or incidents
- Person hours spent on changes

Incident Management
- Total incidents
- Total incidents vs. first call resolution
- Total incidents vs. successful resolutions (e.g., closed within SLA)
- Average time to resolve incident
- Person hours spent on incidents

Problem Management
- Ratio of problems to related incidents
- Total number of problems
- Average age of problems
- Problems that will never have a fix (e.g., only a workaround)

Configuration Management
- Average number of configuration items per service
- Churn, frequency of configuration item changes

Availability Management
- Availability goal
- Total goal vs. achieved
- Total downtime

Capacity Management
- Capacity problems incurred
- Capacity problems prevented

Project Management
- Total number of projects
- Total vs. on time
- Total vs. on budget
- Number of project supporting business goals
- Number of hours spent on projects associated with major organization goals

Figure 5.1. Metrics considered for DEA

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The architect selected variables based on two factors: relevance to efficiency and availability of historical data. In the simulation, each variable will include variations following a normal distribution. The architect selected the following:

- Operating expense
- Number of available FTE hours
- Assets under management
- Number of services
- Number of business units using each service
- Total changes
- Total changes vs. successful changes
- Total changes vs. emergency changes
- Total incidents
- Number of hours spend on project associated with major organizational goals

5.1.1.1. Operating expense.

Operating expense is a fundamental input variable. For the case study organization, it is a metric the executive leadership uses to measure IT performance. IT operating expense has been growing annually since 2007 (see Figure 5.2). IT operating expense as a percentage of organization operating expense is also increasing (see Figure 5.3). IT operating expenses are outpacing industry average trend (see Figure 5.4) (U.S. Census Bureau, 2012). The organization has a 2013 goal to reduce IT operating expense by 4%. To accomplish this organizational goal, the IT organization is looking to increase efficiency and reverse the steadily increasing trend. The enterprise architect involved in the application of the algorithm estimated that integrating domains would account for approximately a 2% reduction in operating expense for the first year and a 1% reduction in year two. After that, no additional reduction is expected.

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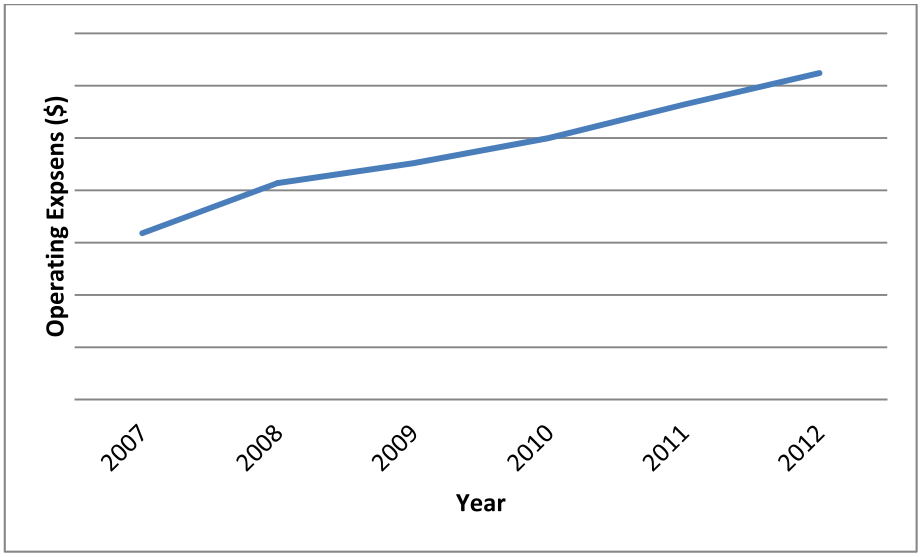

Figure 5.2. IT operating expenses growth since 2007

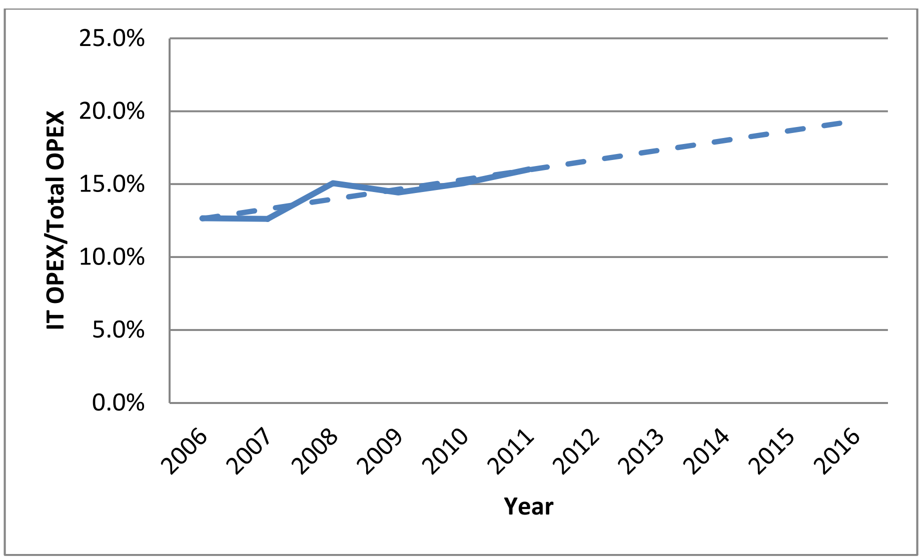

Figure 5.3. IT operating expense (OPEX) vs. total corporate operating expense

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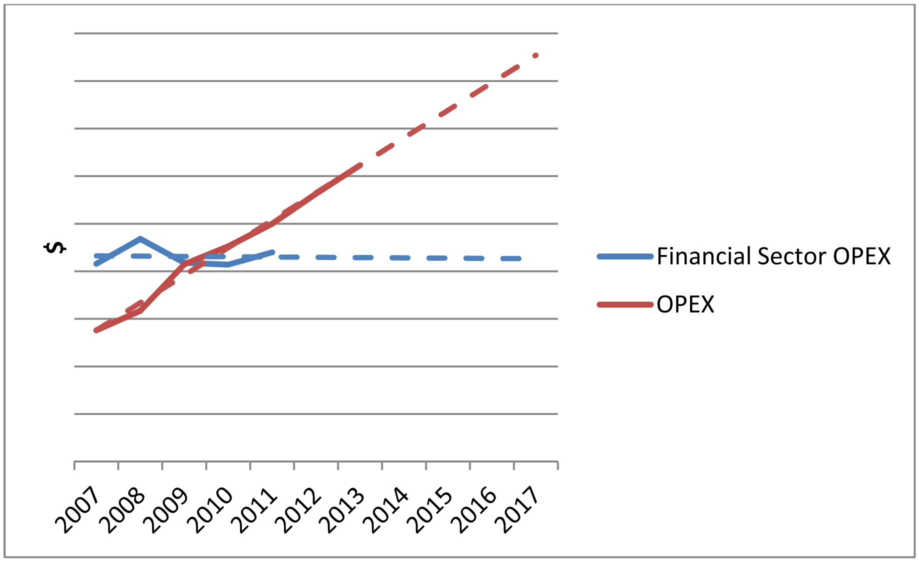

Figure 5.4. IT operating expense rate of change vs. industry average

5.1.1.2. Number of available FTE hours.

This is the number of hours (measured in full-time employees (FTE)) the IT organization can apply to processes. For the department to be as efficient as possible, it must use these hours to meet organizational priorities in support of business objectives. The number of available hours to work on projects continues to increase (see Figure 5.5). As seen in Figure 5.6, the rate of the increase is consistent with the pace that the department adds more personnel to keep pace with the growth of the organization and the complexity of the technology investment. Number of available FTE hours is an input variable. The organization has set a goal for a 2% reduction in year one only.

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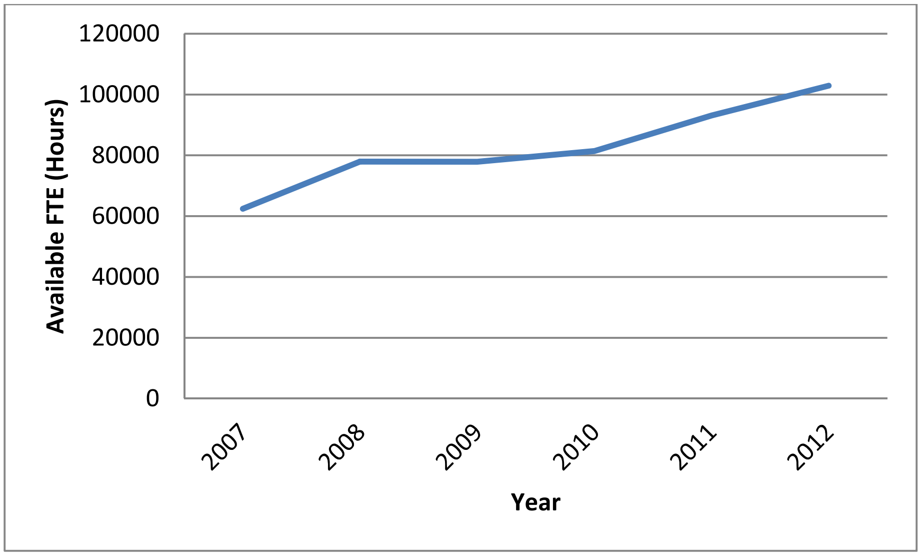

Figure 5.5. Number of available FTE hours

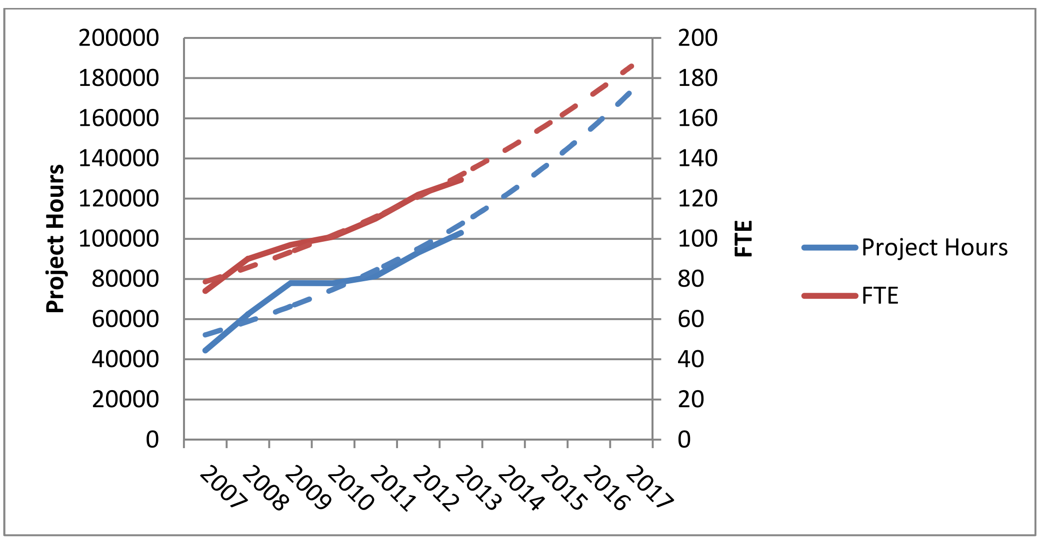

Figure 5.6. Project hours vs. FTE hours comparison

5.1.1.3. Assets under management.

Assets under management are an output variable that describes the size of the business for this class of company. The technology investment should be improving or supporting the size of the business; therefore, it may be acceptable that when operating

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expenses increase, assets under management increase. The organization does not expect the assets under management to change because of applying the algorithm.

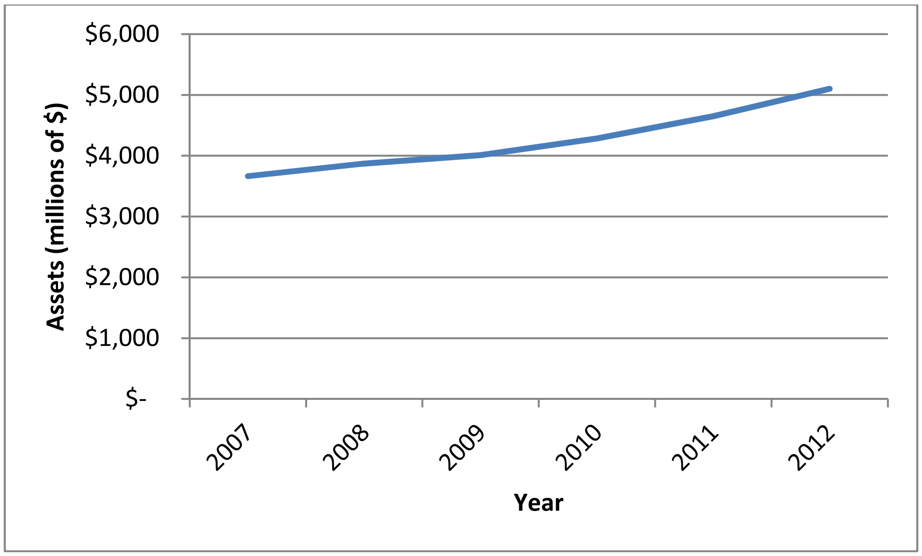

Figure 5.7. Assets under management

5.1.1.4. Number of services.

The number of services is another input variable that describes the total environment. The IT organization provides services to the business units to carry out their mission. The number of services in the environment is a reflection of the complexity of the IT environment: the more services, the more complex the technology investment. The organization does not expect the number of services to change because of applying the algorithm.

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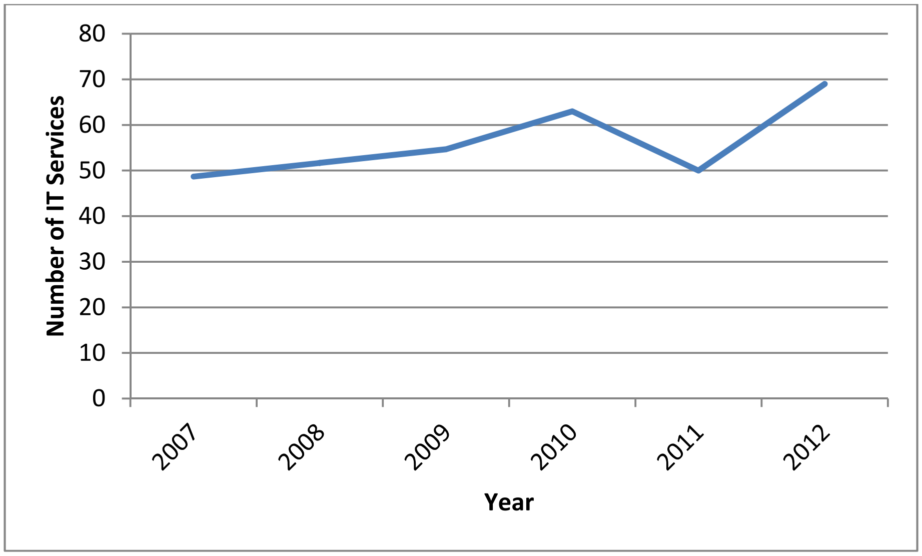

Figure 5.8. Number of IT services

5.1.1.5. Number of business units using services.

All business units in the organization are using IT services. The IT organization wants to ensure IT services are not duplicated in the environment and understanding the ratio between services and business units is an indication of complexity and possible duplication. Since 2007, as seen in Figure 5.9, there has not been a significant change in the number of business units. The organization does not expect the number of business units to change because of applying the algorithm.

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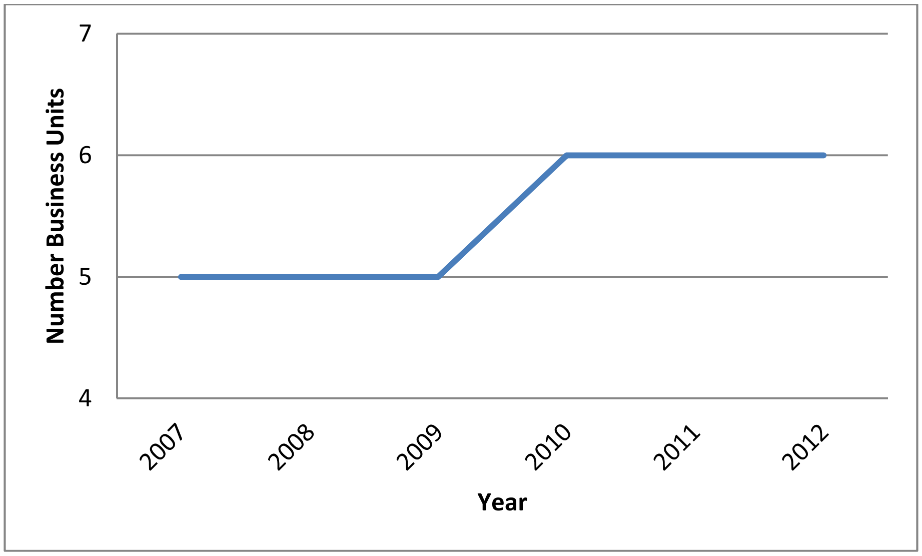

Figure 5.9. Number business units using IT services

5.1.1.6. Total changes.

The total changes in the environment is an indication of the volatility in the system. A certain level of change is reasonable, as it is an indication of project completion and change related to adding new services to the IT environment. However, a high number of incidents and problems in the environment requiring changes to correct poorly functioning processes may be an indication of increasing inefficiency. Total changes are an input variable. The number of IT environment changes at the organization has been relatively consistent since 2007 (see Figure 5.10). The organization expects a significant change in the number of changes resulting from adopting the integration algorithm. In the first year, the architects believe a 20% reduction in change is a realistic goal, 10% the second year, and 5% the third year.

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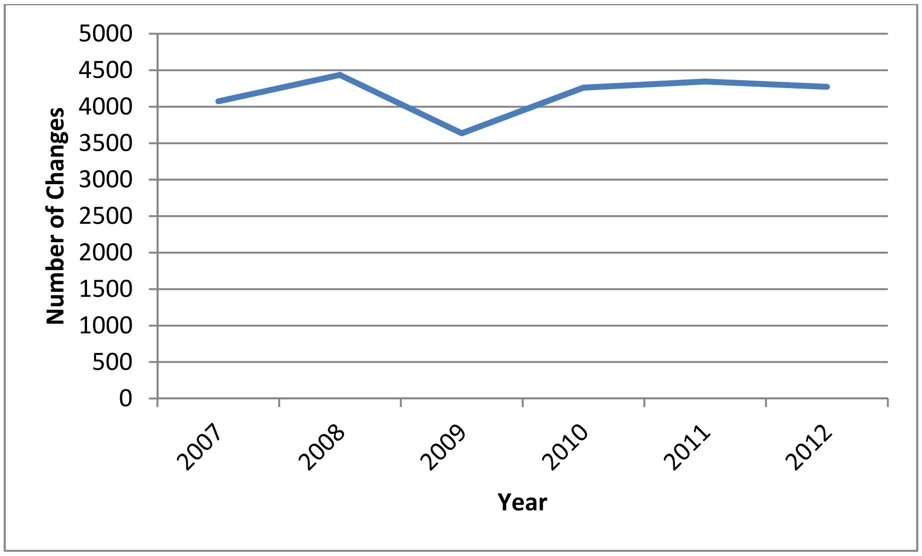

Figure 5.10. Total changes

5.1.1.7. Number of successful changes.

The number of successful changes in the organization is relatively stable (see Figure 5.11). The number of unsuccessful changes may be an indication of poor planning resulting from inefficient processes within the organization. Unsuccessful changes can interrupt services and effect organizational efficiency. Since the number of successful changes is a result of the IT process, it is an output variable. The organization has set a goal to increase the number of successful changes by 20% per year, which will approach 100% success.

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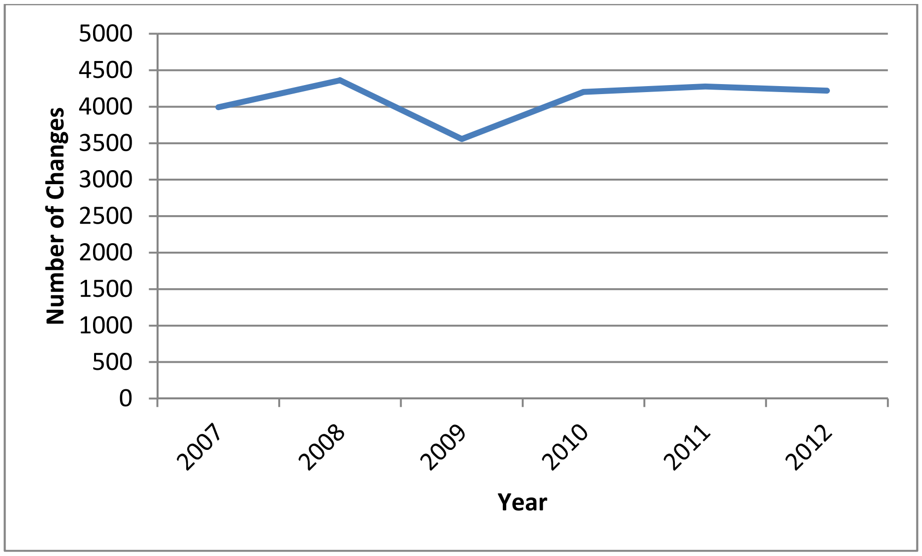

Figure 5.11. Number of successful changes

5.1.1.8. Number of non-emergency changes.

The number of non-emergency changes is a measurement of stability in the environment. Increasing numbers of emergency changes may indicate that there are an increasing number of problems in the environment. The number of non-emergency changes is relatively stable since 2007 (see Figure 5.12). The number of non-emergency changes will change because of the IT process and is, therefore, an output variable. The organization set a goal to improve the number of non-emergency changes by 20% per year, which is approaching 100%.

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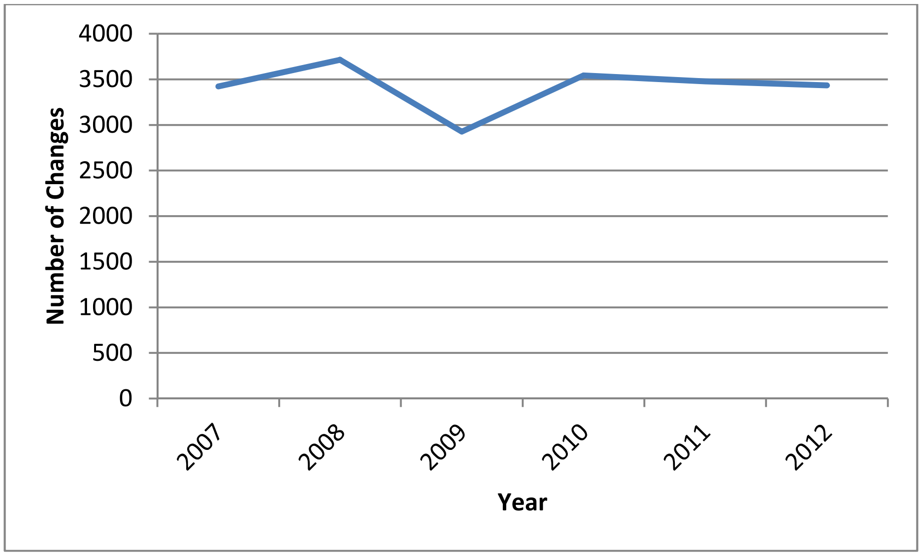

Figure 5.12. Number of non-emergency changes

5.1.1.9. Number of incidents.

The number of incidents is a measure of the number of problems in the environment. An increasing number of incidents can be an indication of inefficiency or other issues. The organization has experienced a significant increase in incidents since 2011 (See Figure 5.13). The organization expects a continued significant decline in incidents related to implementing an integrated process. The architects have set a 20% per year goal.

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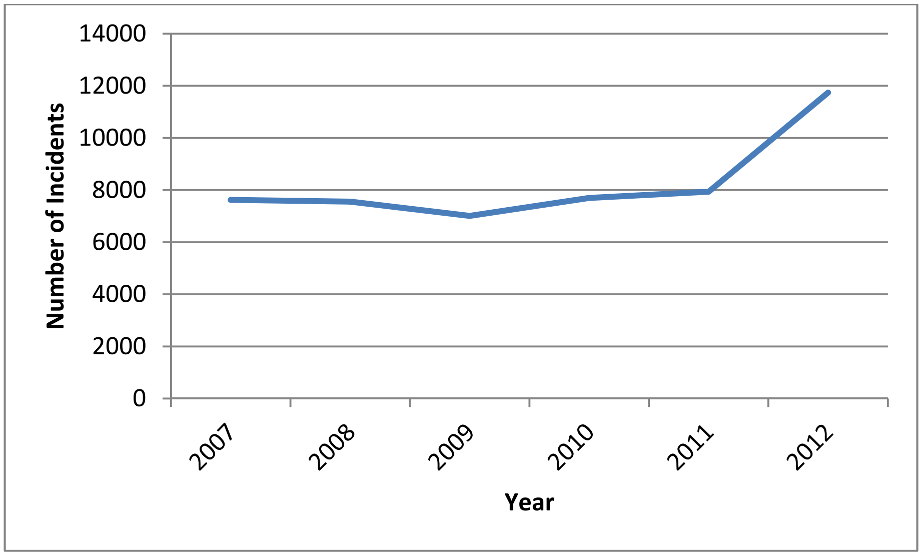

Figure 5.13. Number of incidents

5.1.1.10. Number of hours spent on projects associated with major organization goals.

The organization wants to maximize the number of hours spent on major initiatives. Major initiatives directly support organizational goals. These initiatives typically represent new IT services. In the project management domain, these projects are classified as development. The organization wants to increase the hours spent on development projects compared to the total effort available. Currently, the number of hours spent on development projects is declining (see Figure 5.14). While employees are spending more time on projects (as measured by increasing FTE), the trend number of hours spent on development projects is decreasing (see Figure 5.15). The organization would like to reverse this trend. The organization has set a goal to increase hours spent on major initiatives by 20% per year.

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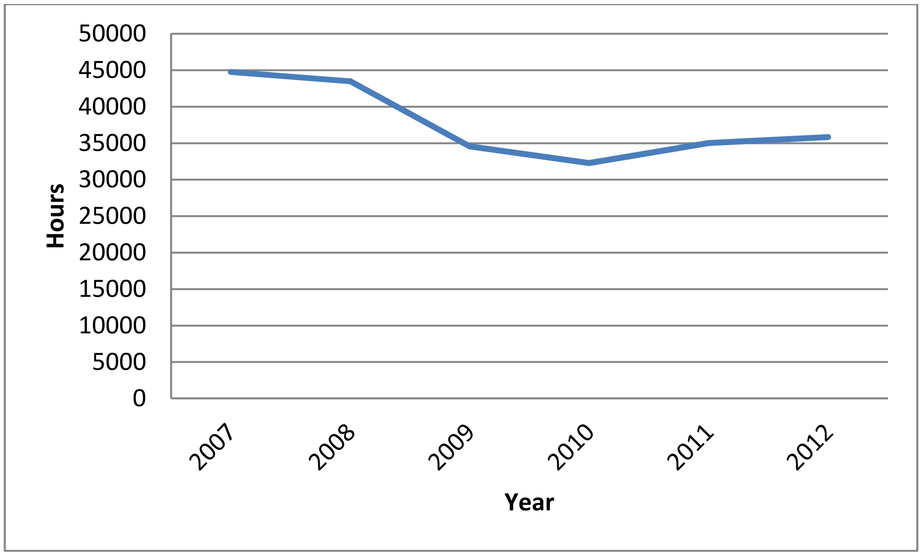

Figure 5.14. Number of hours spent on major initiatives

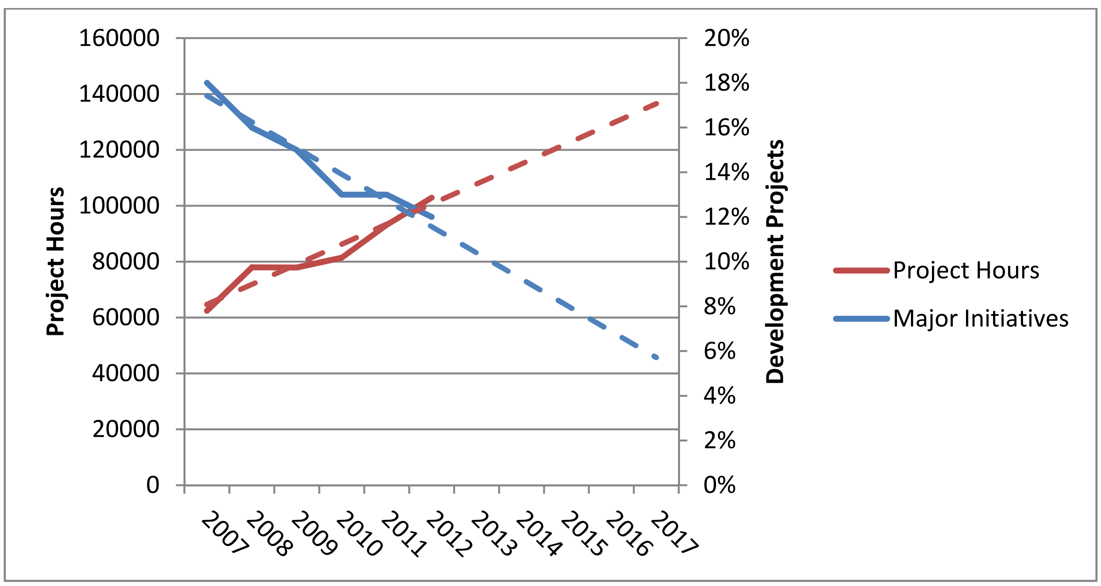

Figure 5.15. Project hours vs. development projects comparison

Using DEA to calculate the relative efficiency of each year, the downward trend of the organization is apparent in Figure 5.16. The organization must make adjustments to increase efficiency or risk becoming even more inefficient.

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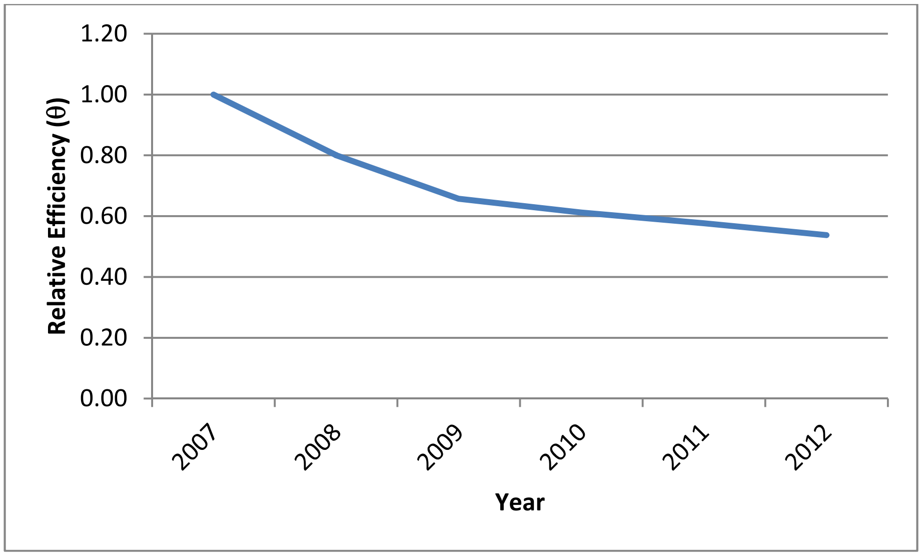

Figure 5.16. Relative efficiency since 2007

5.1.2. Set efficiency goals.

The following table summarizes the efficiency goals discussed in the previous section. In Table 5.1, μ represents the expected annual change, if any, of the variable if the organization applies the algorithm to all IT domains, and σ represents the variability expected based on the standard deviation of historical trends.

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Table 5.1

Efficiency Goals for Input and Output Variables

		OPEX	LOE	Number of Changes	Number of Services	Assets	LOE DEV	Total incidents	Non-Emergency Changes	Successful Changes	Number of Business Units
013	μ	-2%	-2%	-20%	0%	0%	20%	20%	20%	20%	0%
	σ	6%	8%	14%	20%	2%	13%	22%	16%	14%	7%
2014	μ	-1%	0%	-10%	0%	0%	20%	20%	20%	20%	0%
	σ	6%	8%	14%	20%	2%	13%	22%	16%	14%	7%
2015	μ	0%	0%	-5%	0%	0%	20%	20%	20%	20%	0%
	σ	6%	8%	14%	20%	2%	13%	22%	16%	14%	7%
2016	μ	0%	0%	0%	0%	0%	20%	20%	20%	20%	0%
	σ	6%	8%	14%	20%	2%	13%	22%	16%	14%	7%
2017	μ	0%	0%	0%	0%	0%	20%	20%	20%	20%	0%

5.1.3. Understand the current-state.

Describing all the integrations for IT domain processes at the case study is beyond the scope of this thesis. Instead, to illustrate the results of the work, this thesis demonstrates the current-state of the IT governance, IT project management, enterprise architecture, and change management within IT operations management domains. In the organization today, these domains are not fully integrated. Because of the lack of integration, the enterprise architects believe the organization is not as efficient as possible. To increase efficiency, the organization is using the proposed algorithm to integrate the processes within the domains.

The current-state IT governance process (see Figure 5.17) is set up to control the flow of projects, ensuring projects are aligned with business objectives. Since IT governance is a closed system, projects must originate from the governance process and are only complete after meeting the strategic objectives for which the project was originally created to satisfy. Executives or the Board of Directors establish new business objectives within the organization. Executives create a strategy to accomplish the business objectives. Executives and managers create projects, in the form of project

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requests, in support of the strategies. Employees work the project in a separate process. If the project does not meet the objectives, executives reevaluate the strategy, adjusting it to align more closely to the business objectives. The governance process evaluates the success of the project without consideration of the project reporting; instead, it is accomplished through qualitative measures discussed during meetings.

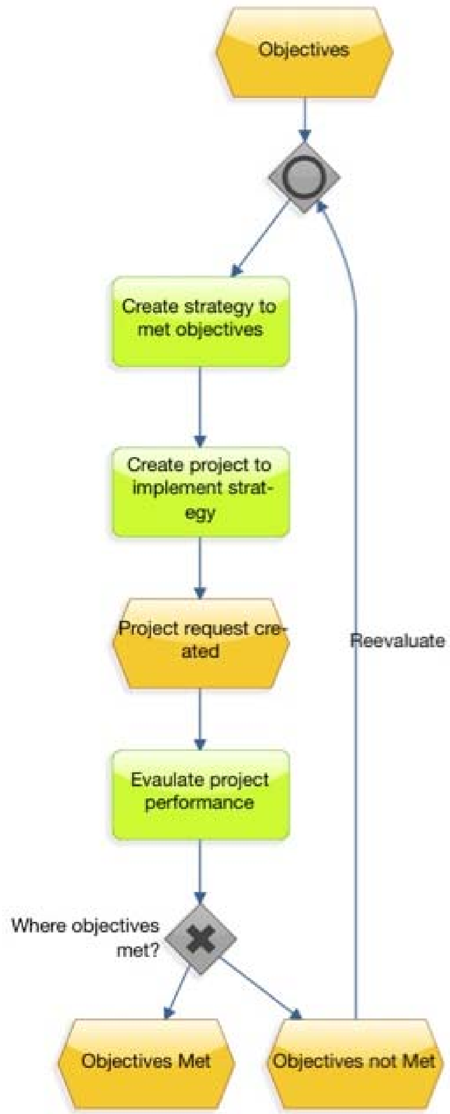

Figure 5.17. IT governance current-state

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Given the complexity of the project management domain, enterprise architects choose to divide the process into three parts: portfolio assignment, portfolio initiation, and project management. Figure 5.18 describes the portfolio assignment process, which encapsulates both the portfolio initiation and project management processes. The organization's management classifies projects as either maintenance or development. Development projects are those that specifically support business objectives and are typically new IT services. Considering efficiency, the organization believes it is desirable to maximize the effort spent on these projects. After classification, a project management group (PMG) selects the appropriate portfolio based on the reporting requirements. If an appropriate portfolio exists, the PMG adds the project to the portfolio. If not, they create a new portfolio, using the process included in Appendix C. The internal processes of the project management domain are not important in the demonstration of the integration.

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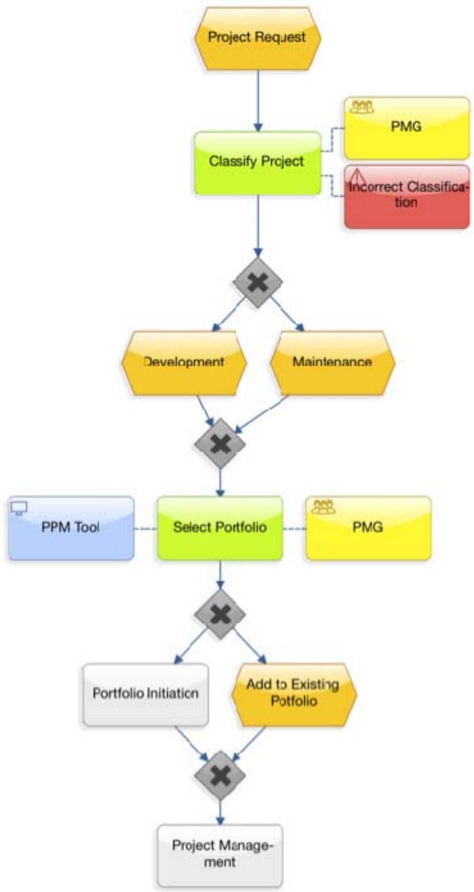

Figure 5.18. Portfolio selection current-state

Figure 5.19 shows the current-state process for adding new artifacts to the architecture. As new business needs are determined, business functions are created by the business unit and documented in the EAMS. The EAMS is this organization's single repository for all architectural information, including the business model. Business processes can result from one of two possible inputs. Business processes that support the business function or new business processes supporting an existing function are identified by the business unit and documented in the EAMS. This pattern continues through the model with IT services supporting business processes, applications supporting IT services, and infrastructure supporting applications. The problem with this approach is that the model will get out of date unless architects continue to monitor the business and

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technology architectures to ensure all changes are captured. This will become untenable as the complexity and the rate of change increases. The organization believes this is impossible to maintain given the environment today.

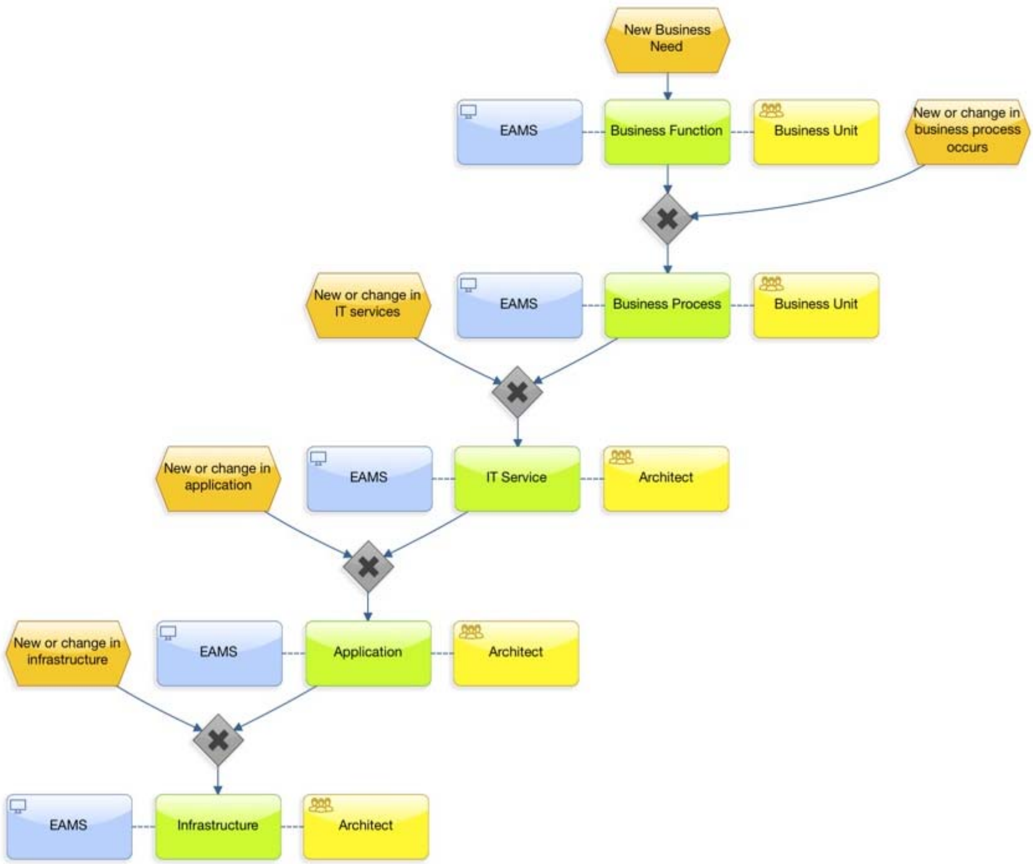

Figure 5.19. Enterprise architecture current-state

Figure 5.20 shows the current-state process to introduce change into the organization's environment. Managers create a change request in a change management system. The Change Advisory Board (CAB) reviews all pending changes once per day. If the CAB approves the change, engineers implement the change. After implementation, an administrative post-implementation process occurs, only then is the change complete.

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At the next CAB meeting, engineers discuss failed changes and communicate lessons learned. This is a simple process; however, changes occur many times daily.

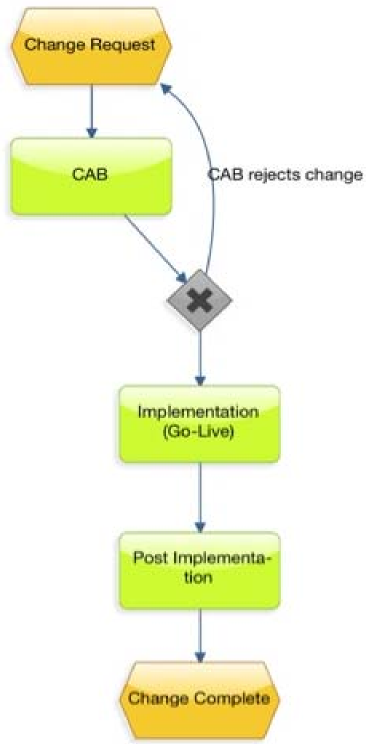

Figure 5.20. Change management current-state

5.1.4. Find potential integration points.

There are 12 possible points of integration in the four-by-four integration map. Of the 12 points, there are several possible concepts that could be included. The demonstration of the algorithm limited to the six integrations in Table 5.2.

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Table 5.2

Integration Map

	Enterprise Architecture	Governance	Project Management	Operations Management – Change Management
Enterprise Architecture			Project scope could be better estimated by reviewing architectural complexity	
Governance			Projects are created to meet strategies created by governance	
Project Management	Designs could be staged and approved in enterprise architecture	Governance monitors projects to ensure they continue to meeting objectives		Project resulting in a change to the environment will initiate change requests
Operations Management – Change Management	Changes to the environment could be staged and approved in enterprise architecture			

5.1.4.1. Enterprise Architecture – Project Management.

Enterprise architecture could interact with project management to help project manager more accurately estimate project scope, budget, and effort. Enterprise architecture organizes the technology investment. The environment's architectural artifacts are stored in an EAMS. The EAMS is the single source of all architectural information in the organization. Project managers could use enterprise architect information to understand the complexity of the environment. The EAMS contains information about the interfaces between all the business processes, IT services, applications, and infrastructure.

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5.1.4.2. IT Governance – Project Management.

IT governance creates projects to support strategies created to meet business objectives. Project management is a closed system that only accepts projects from the IT governance process. This is essential to ensure the IT organization is working on projects that benefit the business by aligning with established business objectives. IT governance could require project management reporting and/or reporting resulting from the implementation of new IT services resulting from the project to include metrics, ensuring fully supported strategies. This will reduce missed strategic objectives, and therefore, decrease rework hence increasing efficiency.

5.1.4.3. Project Management – Enterprise Architecture.

The organization is acutely concerned with the accuracy of the EAMS. Having an accurate, centrally managed architecture reduces rework during projects, system design, and troubleshooting existing systems. The integrity of this system is essential to efficiency. Architects could stage future-state system designs results from projects in the EAMS. If the project management process requires the EAMS to contain all future-state system designs, it will be difficult for the EAMS to become outdated. The change management process could provide additional benefit by ensuring the future-state designs are promoted to current-state designs after implementation.

5.1.4.4. Project Management – Governance.

The current-state governance processes do not include reporting directly from the project management domain. The current-state project management process includes reporting and project reporting rolls up to portfolio reporting. The future-state portfolio reporting could inject into the IT governance process. The IT governance process can use this information to determine if projects are appropriately supporting strategies. This will reduce the chances of a project not supporting its strategy, and therefore, increase efficiency. IT governance could also dictate the metrics used to measure the effect of a project's implementation on the supported strategy.

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5.1.4.5. Project Management – Change Management.

Projects that change the environment will require a change request during implementation. The change request process's CAB could be an approval gate that ensures architects entered all architectural information into the EAMS before approval. Supporting the Project Management – Enterprise Architecture integration point, this check would provide defense in-depth against an outdated EAMS.

5.1.4.6. Change Management – Enterprise Architecture.

Architects could stage all changes to the environment in the EAMS. Staging future-state architecture in the EAMS will allow the CAB, security, and enterprise architects to review the prospective changes before implementation. This will reduce the risk of incidents or problems after implementation. Incidents caused by changes are very common, and because resolving incidents reduces the number of hours spent working on major initiatives, they create inefficiency. The organization is considering ways to track this information. In the future, the organization intends to add incidents or problems caused by changes as DEA output variables.

5.1.5. Classify the integrations.

5.1.5.1. Enterprise Architecture – Project Management.

The integration of enterprise architecture and project management adds to the project management flow. During the project initiation, the project manager should use architectural information in the EAMS, if appropriate, to aid in determining project scope, budget, and effort. The project management process completely encapsulates this step; therefore, these processes are "loosely-coupled" and an EPC is likely the best modeling tool.

5.1.5.2. IT Governance – Project Management.

All projects entering the project management process originate from the IT governance process. The governance process uses the project management output to determine if the project met its supported strategy. The governance process encapsulates

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the project management process, and therefore, is “loosely-coupled” to the project management process.

5.1.5.3. Project Management – Enterprise Architecture.

System designs resulting from projects could be stored in the EAMS. Before the CAB approves a change, the organization requires a security and architectural review. The EAMS contains the most up to date information about the architecture. To ensure architects update the EAMS with system designs created during project, the project management process must integrate with the enterprise architecture process. New information can enter the enterprise architecture process at the business process, IT service, application, or infrastructure points. Because a business unit can add a new business process, the project management process does not encapsulate enterprise architecture. These two processes are “tightly-coupled” and BPMN is likely the best modeling tool.

5.1.5.4. Project Management – Governance.

The governance process uses project reporting. The reporting ensures the project is fully supporting the strategy created in the governance process. Project reporting is an output from project management used in governance and governance creates projects; therefore, these are “loosely-coupled” processes.

5.1.5.5. Project Management – Change Management.

Project management may require a change to the environment. If it requires a change, the project manager will submit a change request. Managers generate change requests for reasons other than project management. These two processes are interconnected and are, therefore, “tightly-coupled” processes.

5.1.5.6. Change Management – Enterprise Architecture.

The integration between project management and enterprise architecture will require architects to enter future-state system designs to in the EAMS. During the change management process, future-state system designs will become current-state designs after

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implementation. The organization can accomplish this during the post implementation step in the change management process. These processes are "tightly-coupled".

5.1.6. Integrate the domains accordingly.

The integration of the domains is straightforward using the integration map and the analysis performed during the classification of the integrations. Integrations will overlap. When it simplifies describing the system, show the integrations combined into one design. This section describes the future-state integration designs. Because of the complexity and size of the future-designs, for practical purposes the appendices contain the future-state integration designs.

5.1.6.1. Enterprise Architecture – Project Management.

The EPC in Appendix E describes the future-state of the "loosely-coupled" relationship between enterprise architecture and project management. The integration is trivial. The future-state process has a new system input from the EAMS. Project manager and architects will use the architectural information about the existing environment during the planning of the project.

5.1.6.2. IT Governance – Project Management.

The EPC in Appendix B describes the integrated IT governance and project management processes. Governance completely encapsulates the project management process. Once governance creates a project, the request flows into the project management process shown as an interface in the EPC. The embedded project management process refers to the current-state portfolio selection process, which includes the project management process.

5.1.6.3. Project Management – Enterprise Architecture.

Project management, enterprise architecture, and change management are all "tightly-coupled". Appendix H shows the future-state integration combined for clarity. From the project management perspective, the risk analysis, resource planning, time planning, and cost steps use the EAMS as a data source. The architect enters the

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proposed future-state design to the EAMS. After implementation, the architect moves the proposed future-state design to the current-state design.

5.1.6.4. Project Management – IT Governance.

Appendix B shows the future-state integration for project management and governance. The current-state governance EPC now has an interface including portfolio selection. The EPC is the same as the IT governance and project management integration.

5.1.6.5. Project Management – Change Management.

As with project management and enterprise architecture, Appendix H shows the relationship between project management and change management. During project execution, project management may require a change to the environment. A request for change (RFC) will be required to initiate the change. The appropriate reviews occur, and the CAB approves the change, if appropriate.

5.1.6.6. Change Management – Enterprise Architecture.

Appendix H and I demonstrates the integration between change management and enterprise architecture. The architectural and security reviews use the proposed future-state designs stored in the EAMS. During the post-implementation, the architect changes the future-state system design to the current-state system design.

5.1.7. Implement future-state.

The case study organization is using a phased approach to implement the future-state processes. During planning for the implementation, architects look for quick wins first, expanding on the successes. This strategy allows the organization to redesign ineffective processes before causing a major impact the organization. This approach is useful when there is a risk of negatively affecting the operation of the business. After a phase is completed, architects use a continuous improvement model to incorporate lessons learned into future phases.

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5.1.8. Measure efficiency.

The case study organization is in the beginning stages of implementing the proposed algorithm. Given the complexity of the implementation, it may take a significant amount of time to measure accurately the real efficiency improvements in the organization. It is unlikely that the case study organization will have sufficient data to understand the true efficiency gains for several years.

As proposed in section 3.3.1, the plausibility of the algorithm increasing efficiency was determined using a Monte Carlo simulation.

Figure 5.21 shows the relative efficiency for each year since 2007, including the predicted results after the simulation. If the organization realizes the goals (see section 5.1.2), the simulation shows a material change in the IT organization's efficiency, ending its significant decline since 2007. Assuming the DEA variable goals are realistic and, in fact, achievable, the algorithm does appear to provide additional relief to the organization's declining efficiency.

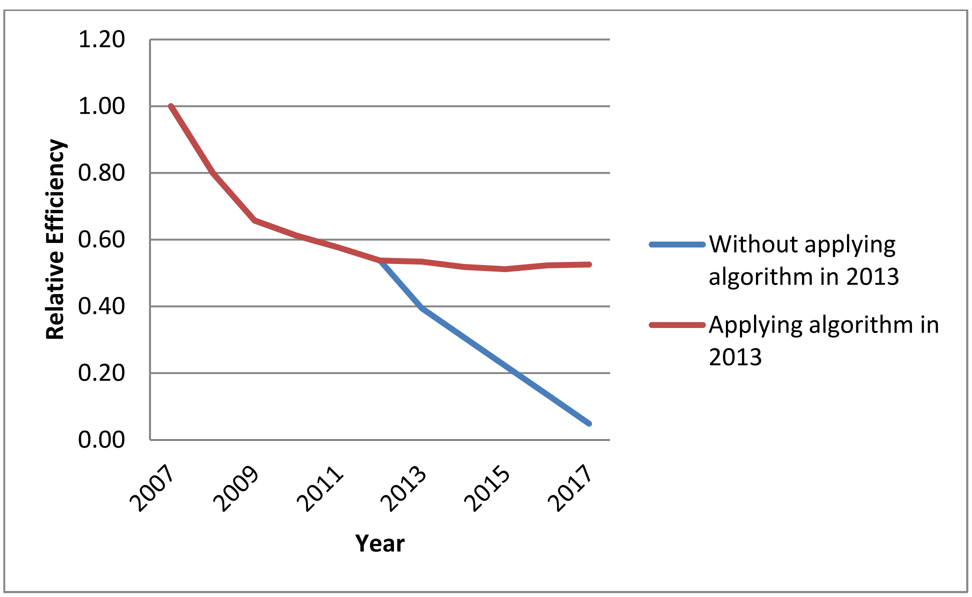

Figure 5.21. Comparison of applying the algorithm versus not applying

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The preceding sections demonstrated the extensibility of the algorithm. By using DEA, which in itself is extensible, the organization can add additional or change exiting input variables. The demonstration compared efficiency over a period of years. This was the author's choice. The organization could have used the DEA to compare several possible future-state designs to determine the most efficiency.

This approach is not specific to this organization. Any organization, regardless of size, type, or industry, could apply the algorithm as seen in the demonstration as well as the examples used to describe it. There is nothing in the algorithm specific to the case study organization. Another organization would select different DEA variables, but the algorithm steps remain constant; therefore, the algorithm is sufficiently generic to support a wide-range of different situations.

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Chapter 6 Conclusion and Recommendations

6.1. Conclusion

After a thorough review of the available literature, there appears to be a gap in the research. While academic research and industry-developed management frameworks call for IT management process integration, there does not appear to be an integration algorithm. This thesis proposes such an algorithm. After applying the algorithm to the case study organization and predicting changes based on simulation, declining efficiency trends at the case study organization where stopped. The relative efficiency after the first year improved 25% and after the fifth year, 91%. Assuming the goals are realistic, the algorithm does appear to provide some benefit and increase efficiency. The research question posed in this thesis is, "How can IT management increase organizational efficiency by integrating related management processes, using existing tools and system design principles such as modeling the current-state, understanding the relationships among processes, modeling a future integrated state?" Based on the results, the proposed algorithm does appear to provide an opportunity to improve efficiency.

Additionally, this thesis provides insight into possible tools to use during an integration effort. Event-driven Process Chains (EPC) and Business Process Modeling and Notation (BPMN) are used to model current- and future-state integrations. Using EPC and BPMN is not a requirement of the algorithm but provides one possible approach to modeling integrations. A method to analyze integrations was established. Architects can use a simple matrix to analyze how the intersecting processes interrelate. From this approach, architects will understand how two processes influence each other. Organizations can use this information to create the future-state integrations.

6.2. Recommendations for Future Work

Future work should include measuring several organizations' efficiency after applying the algorithm to integrate IT management processes. This thesis concludes that there is an opportunity for efficiency gains by applying the proposed algorithm, but conducting a study to verify the simulated results would be a reasonable next step. Data

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is being collected at the case study organization as it integrates its management processes. This data may aid in that research.

Hypothesis testing could be used to determine the best alternative from a set of proposed integrations. If two competing future-state processes are designed after applying the algorithm, a reasonable approach is to use hypothesis testing to determine the process most likely to provide the most benefit.

Industry standard financial models (e.g. EVA, etc.) may help standardize efficiency within IT organizations. Measuring efficiency through financial analysis could provide a holistic efficiency score for IT investment but may miss some of granularity that DEA provides. Ideally, efficiency would be a standard metric applied at all organizations. IT management software tools could incorporate the calculation of that standard metric to broaden its use throughout the organization.

Organizations other than IT organizations may be able to benefit from the algorithm. Although the thesis limits the scope to the IT management domain, nothing in the algorithm is specific to IT management. Any two related processes could benefit from integration using the tools and steps in the algorithm. In other industries, such as manufacturing, researchers have invested significant time analyzing process integration. There may be opportunities learned in this research that may be relevant to IT management integration.

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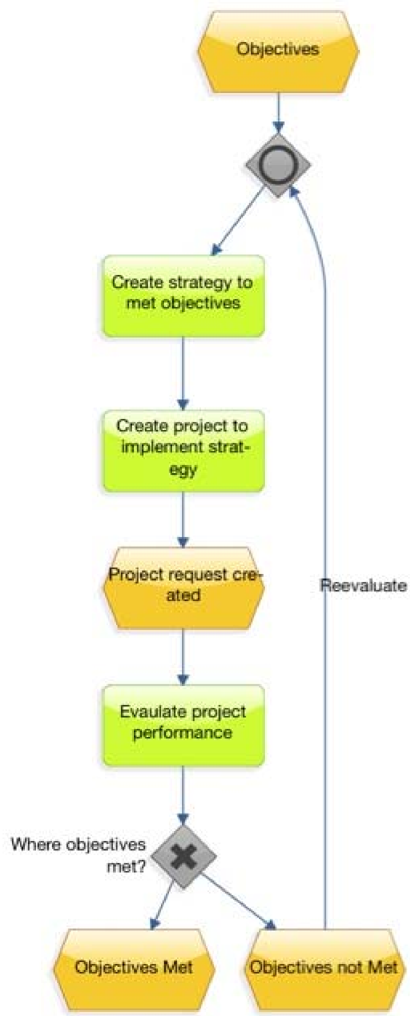
Appendix A

IT Governance Current-state EPC



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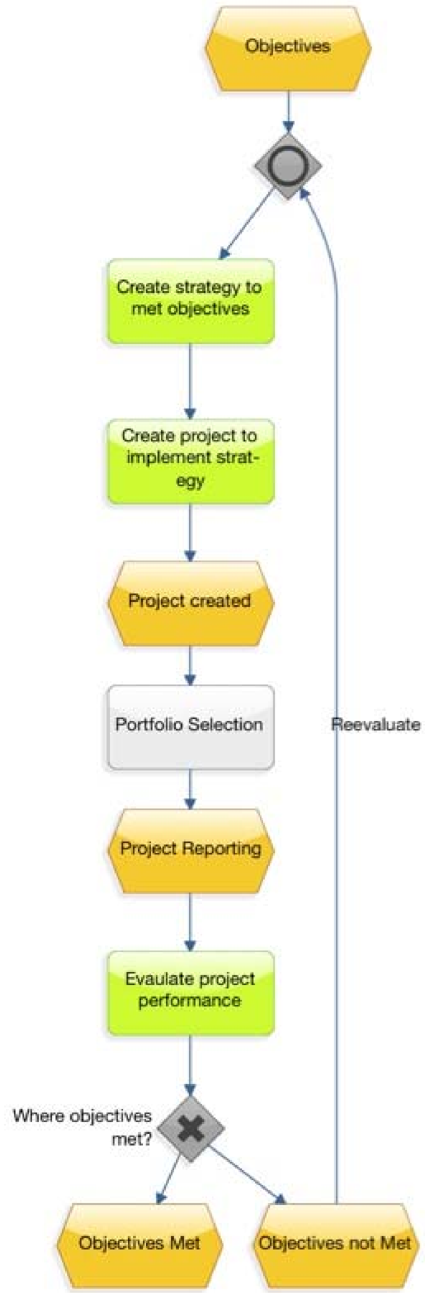
Appendix B

IT Governance and Project Management Future-state EPC



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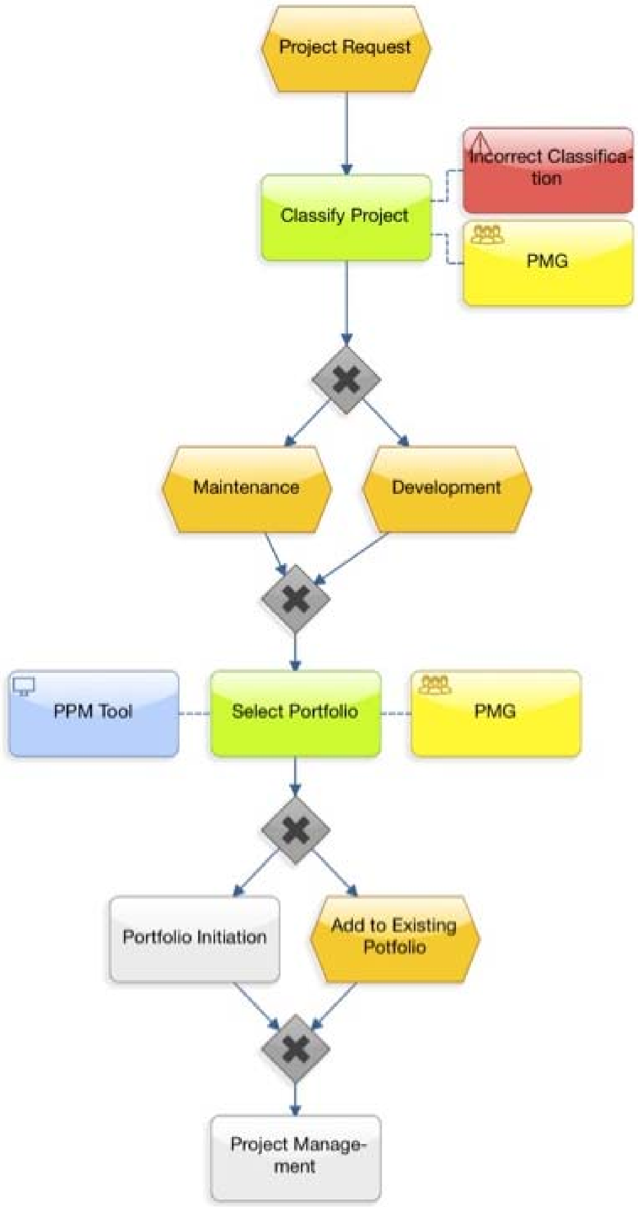
Appendix C

Portfolio Selection Sub-process EPC



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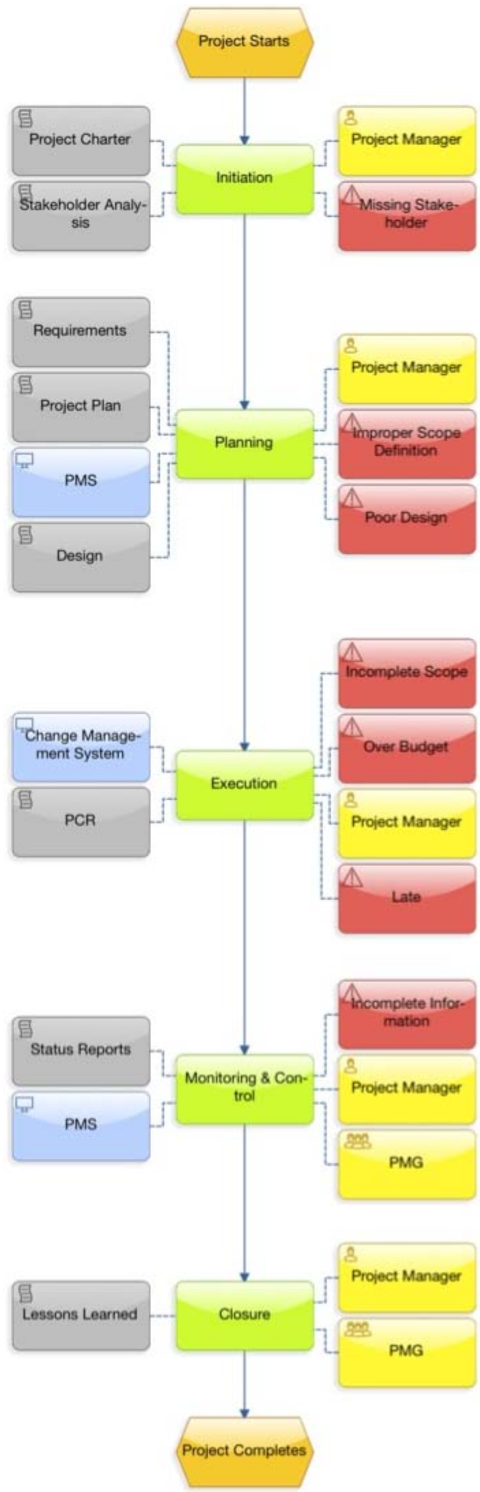
Appendix D

Project Management Current-state EPC



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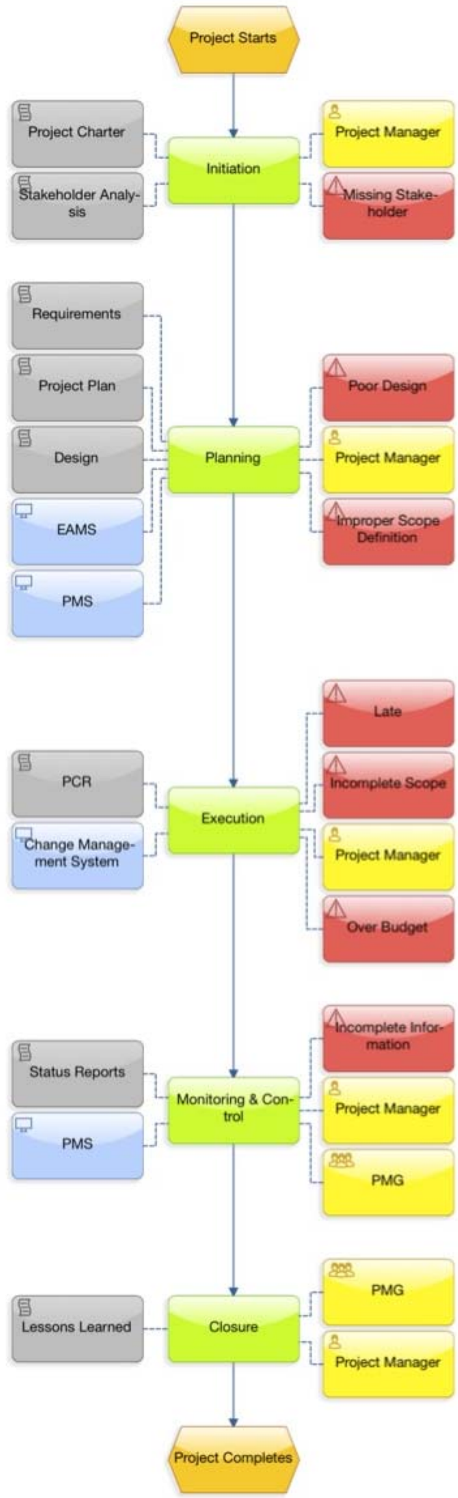
Appendix E

Project Management Future-state EPC



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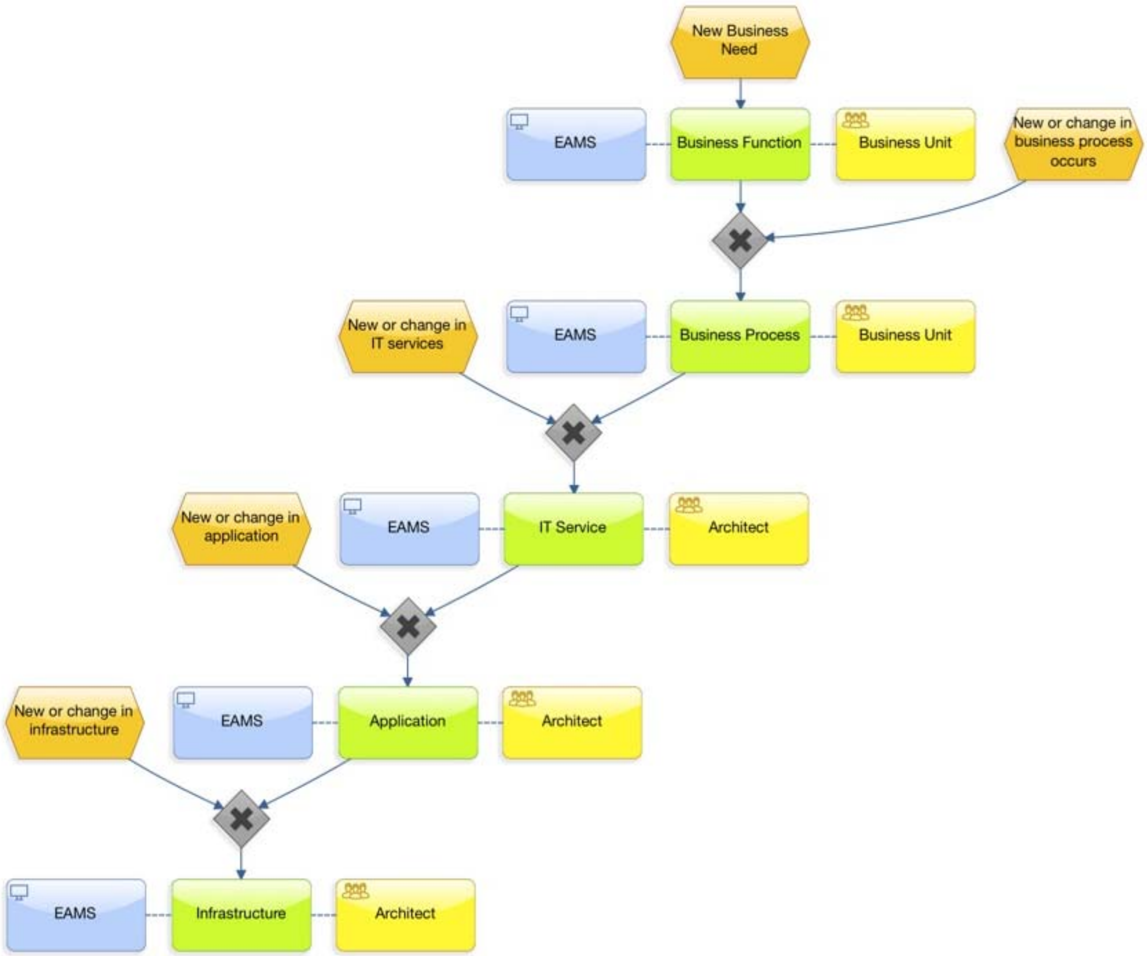
Appendix F

Enterprise Architecture Current-State



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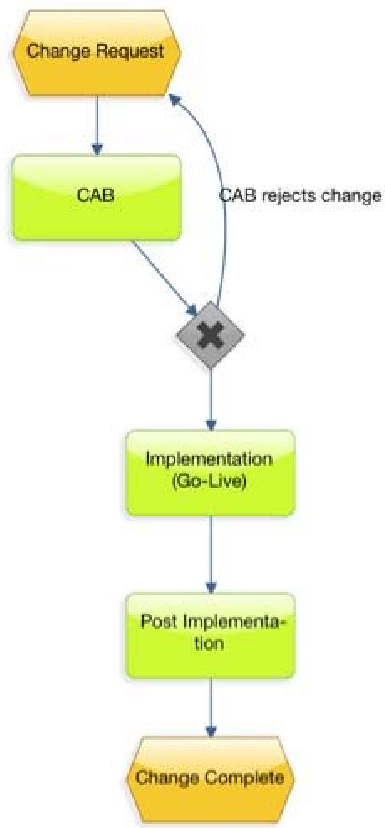
Appendix G

Change Management Current-state EPC



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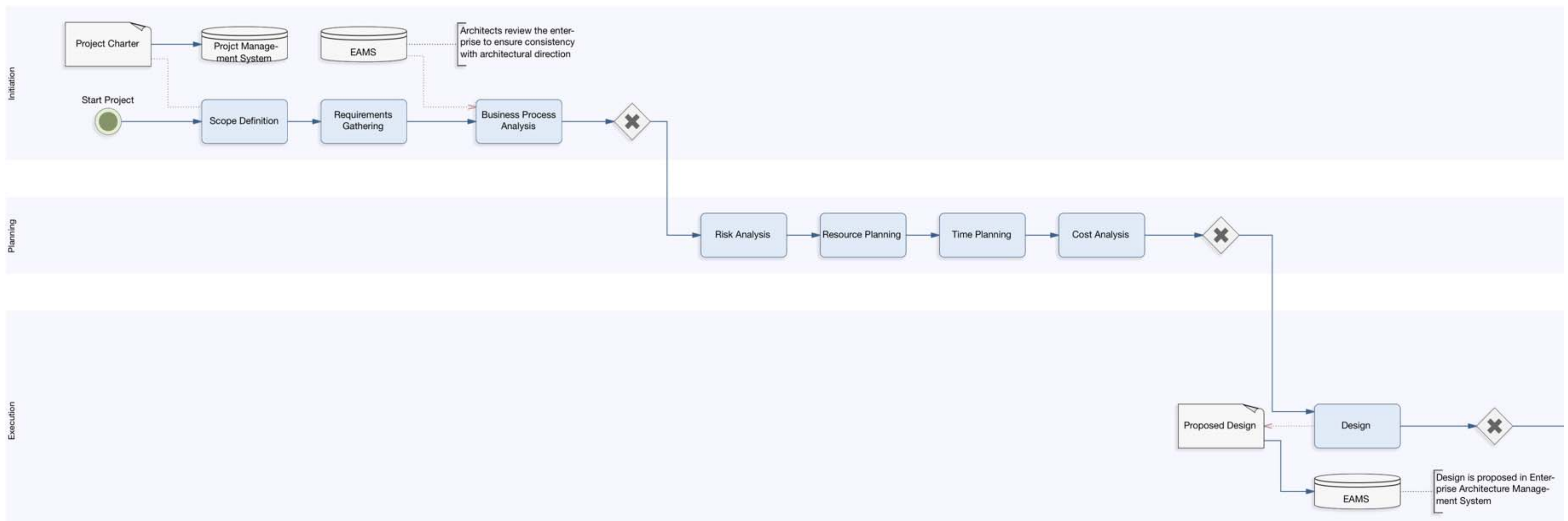
Appendix H

Project Management/Enterprise Architecture/Change Management Future-state BPMN



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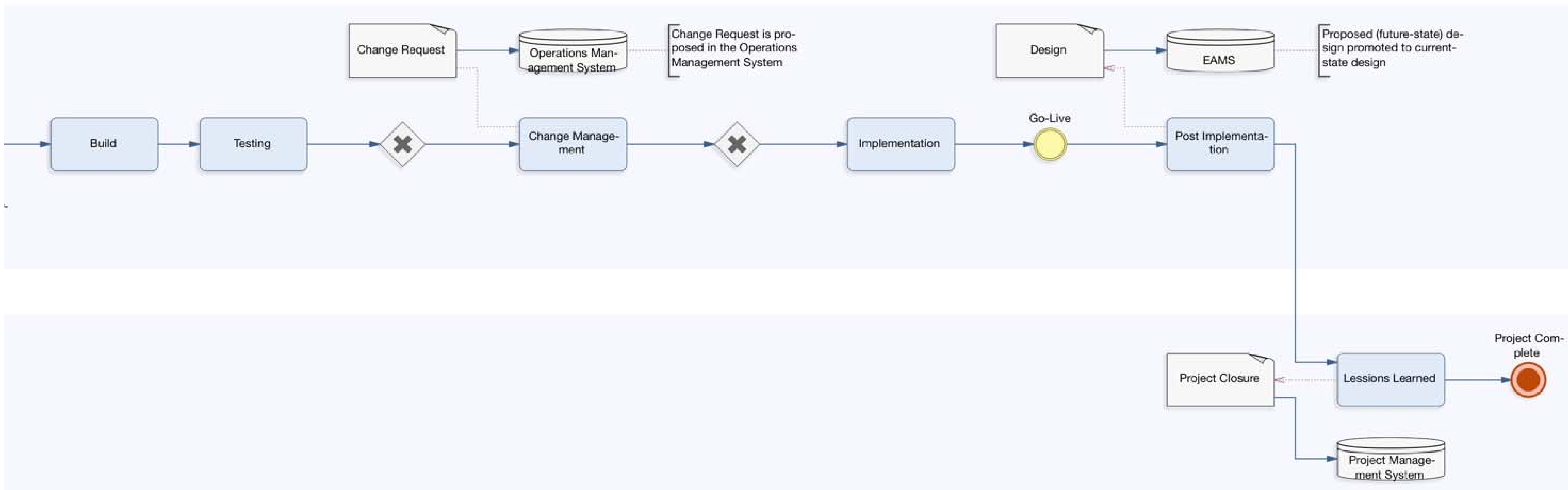

Project Management/Enterprise Architecture/Change Management Integration
from the Perspective of the Project Management Process

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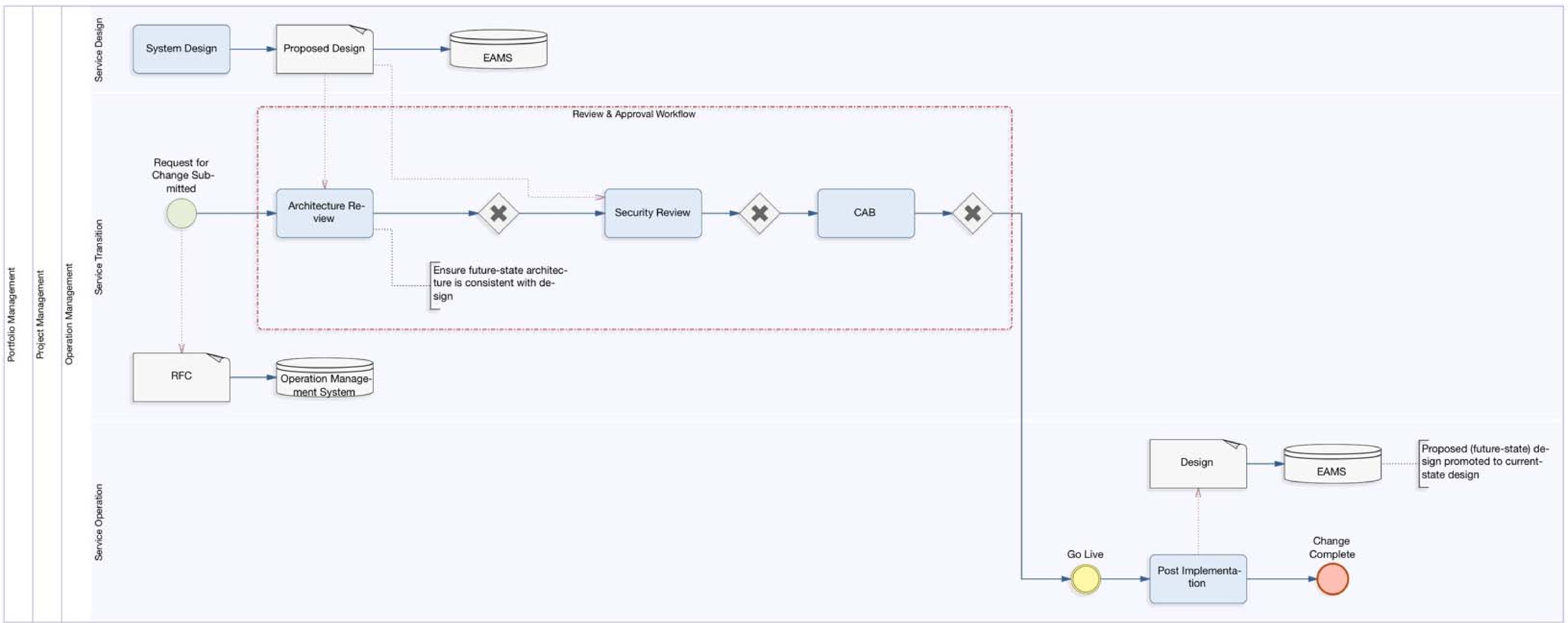
Appendix I

Project Management/Enterprise Architecture/Change Management Future-state BPMN



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