3-2003

A System Dynamics Approach for Information Technology Implementation and Sustainment

Nathan W. Fonnesbeck

A SYSTEM DYNAMICS APPROACH FOR INFORMATION TECHNOLOGY

IMPLEMENTATION AND SUSTAINMENT

THESIS

Nathan W. Fonnesbeck, Captain, USAF

AFIT/GEE/ENV/03-08

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright Patterson Air Force Base, Ohio

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

AFIT/GEE/ENV/03-08

A SYSTEM DYNAMICS APPROACH FOR INFORMATION TECHNOLOGY IMPLEMENTATION AND SUSTAINMENT

THESIS

Presented to the Faculty

Department of Systems and Engineering Management

Graduate School of Engineering and Management

Air Force Institute of Technology

Air University

Air Education and Training Command

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Engineering and Environmental Management

Nathan W. Fonnesbeck, BS

Captain, USAF

March 2003

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

AFIT/GEE/ENV/03-08

A SYSTEM DYNAMICS APPROACH FOR INFORMATION TECHNOLOGY IMPLEMENTATION AND SUSTAINMENT

Nathan W. Fonnesbeck, BS

Captain, USAF

Approved:

Michael L. Shelley, PhD (Advisor) Associate Professor, Engineering and Environmental Management Department of Systems and Engineering Management	7 Mar 03 Date
Heidi Brothers, Lt Col, USAF (Reader) Assistant Professor, Engineering and Environmental Management Department of Systems and Engineering Management	7 Mar 03 Date
Daniel Holt, Maj, USAF (Reader) Assistant Professor, Engineering and Environmental Management Department of Systems and Engineering Management	7 MAR 03 Date

Acknowledgements

I would like to express my sincere appreciation to my faculty advisor, Dr. Michael Shelley, for his excellent guidance and support throughout this thesis effort. His knowledge of system dynamics modeling and how to convey its complexity, as simply as possible, to an audience were highly appreciated. I would also like to thank the other members of my thesis committee, Lt Col Heidi Brothers and Maj Danny Holt, for their excellent insight and guidance. I am grateful for Col Brian Cullis and the research clients from the AMC GeoBase staff, Capt Matt Donnithorne, Dr. James Kofron, and Richard Updike, for their financial support and superb system insight during the course of this research.

I would also like to thank my wife for her patience and support over the long days and nights devoted to research during my time at AFIT. I believe in the mantra, "Happy Wife, Happy Life;" she has been as happy as possible under difficult conditions, which has given me the fortitude to keep pressing forward to completion. I also appreciate my children for their sweetness and joy, even when daddy was grumpy.

Table of Contents

Page

Page

List of Figures

Figure Page

Figure Page

Figure Page

Figure Page

Figure Page

Figure Page

List of Tables

Table Page

Table Page

AFIT/GEE/ENV/03-08

Abstract

The goal of this research is to bring a new, dynamic modeling perspective to organizational information technology (IT) implementation systems (using the Air Force GeoBase initiative as a real-world example) without compromising principles from the research literature. Undesired behavior patterns, from historically poor IT implementation performance, versus desired behavior patterns are incorporated into the model structure.

Using a system dynamics approach, multiple simulation runs under various initial conditions and organizational contexts are performed and compared over a short-term versus a long-term period of time. Based on these simulation runs, various mixes of management interventions, under varying conditions, are recommended to improve IT implementation performance based on manager and organizational goals.

Generally, for better long-term system performance, learning management, with a focus on team learning, is the best single IT implementation tool. With a low level of organizational buy-in at the beginning of the IT implementation effort, change process management should be the initial focus of management effort. Reward system management provides a short-term spark, but its implementation effects are not carried over for long-term sustainment as readily as learning management or change process management. Continuity management, though beneficial, does not provide as much "bang for the buck" as the other management interventions.

A SYSTEM DYNAMICS APPROACH FOR INFORMATION TECHNOLOGY IMPLEMENTATION AND SUSTAINMENT

I. Introduction

Background

When significant technological innovations are introduced into organizations, organizational personnel must traverse a typically unpleasant mountain of change. Individual routines are disrupted, self-efficacy issues arise, organizational resistance reigns, and managers are left to pick up the broken pieces of the status quo and try to join them back together into a better way of doing business. Oftentimes, managers do not know exactly how to put the pieces back together to create a better way of operating. They may do something, which may result in a strangely configured organizational mosaic that only someone like Picasso could appreciate or they may do nothing, which would allow the shattered pieces of the status quo to gently merge back together on their own. At other times, however, talented managers, well versed in change management and organizational dynamics, are able to beautifully guide their compatriots on a path of enlightenment that amazingly improves performance, using the innovation that started the whole change process in the first place.

Air Force organizations are attempting to implement significant information technology (IT) innovations, which introduce significant change into an organization's dynamics. History has shown that Air Force organizations have had limited success with IT implementation and sustainment. This is a major problem because significant IT innovations require a large upfront investment of money and manpower, which dissolves if the IT implementation effort is unsuccessful. Top-level leaders usually envision, either implicitly or explicitly, the concept of a payback period when considering an IT investment – if I invest these resources in this IT innovation, what type of organizational performance enhancements can I expect and when will I see them? This concept can be called a performance payback period – when will I recoup my initial investment in the form of performance enhancement?

The following quote sums up the historical problem with IT implementation efforts: "Post mortems of failed IT investments clearly diagnose an overemphasis on short-term technology issues and insufficient attention to sustainment concerns [people issues] as the cause of their early death" (Department of the Air Force, 2002b:I). The short-term technology focus, though necessary, does not address the long-term, people-driven factors that make IT sustainment possible. This research hopes to assist organizational IT managers recognize and address these long-term sustainment issues before their IT investment suffers an early death.

The words implementation and sustainment have a dynamic flavor. A manager has to do something over time to implement and sustain an IT innovation, yet there has not been any published research that holistically considers the dynamic aspects of IT implementation and sustainment. This research takes a dynamic view of the IT implementation process and presents a fresh, new, innovative way of looking at it. Relevant research literature presents a multitude of different methods managers can use to implement IT, but how do these management interventions affect organizational performance in the short-term as opposed to the long-term? Are there tradeoffs and, if so, how can a manager balance them in such a way as to maximize system performance in either the short-term or long-term, based on organizational goals?

This research presents a generalized view of an IT implementation and sustainment system, using the Air Force GeoBase initiative as a specific case study, and proposes various combinations of management interventions that address performance in either the short-term or long-term. Even though the IT focus of this research is the GeoBase initiative, this approach can be used generally for any type of IT innovation implementation effort.

GeoBase Management

The Air Force is embarking on a significant change journey as a result of an IT innovation called GeoBase. GeoBase is an Air Force initiative aimed at transforming both how personnel deal with information and IT on Air Force installations. GeoBase changes the way people think about and use database information – spatially enabling databases and sharing information across installation functional units (Cullis, 2002). GeoBase also allows a wide range of personnel to access spatial data using a geographic information system (GIS). A GIS is an "automated system for the capture, storage, retrieval, analysis, and display of spatial data" (Clarke, 2001:3). Much like IT implementation in general, the Air Force has historically not done very well with GIS implementation efforts of the past. Lieutenant General Zettler, AF/IL, stated, "When it comes to management/fielding of new IT capabilities, 'we do extremely poorly'" (Department of the Air Force, 2002a).

It is understandable that managers would have a difficult time managing and fielding new IT capabilities. Organizations are made up of people. Managers must function in these human systems. Humans display highly dynamic and often confusing behavior – there are motivations hinging on personal as well as organizational goals, perceptions of reality that may or may not be accurate, dynamic social interaction, and a plethora of other influences that make understanding social behavior and organizational dynamics difficult (Kim, 1993; Rogers, 1995; Cullis, 2000; Agarwal & Prasad, 2000).

In organizations, managers are tasked to focus human effort to achieve organizational goals and objectives. In complex, dynamic organizations, managers are often not aware of how their programs and policies will affect organizational performance and how significant time delays can be. Is there a tool that can help the manager better understand these complex human systems so he or she can more effectively guide the organization where it should go? This research hopes to help with this question, and yes, there is a tool that can help – namely, system dynamics. System dynamics can be instrumental in helping the manager understand how his organizational system interacts and how his management interventions affect the organizational system.

System Dynamics Approach

System dynamics provides an analysis methodology that captures a system's dynamic behavior by simulating the interaction of variables over time (Sterman, 2000). System dynamics allows the researcher to simulate simultaneous continuous-time processes rather than discrete event processes. As such, the researcher can explore time lags, nonlinear dynamic complexity, and other dynamic behavior (Sterman, 2000).

Dynamic system behavior is modeled by the interaction of variables locked into causal loop structures. Causal loops are feedback processes (A affects B, which, in turn, affects A) that define how a system responds to system inputs. The natural behavior of a system is derived from its endogenous structure (system variables that affect one another). A portion of this research aims to identify the aggregated, substantial variables present within the IT organizational implementation system. Organizing these aggregate variables into structures that give rise to hypothesized or historical behavior patterns over time allows the modeler to analyze different combinations of management intervention strategies that dynamically affect the system in different ways. The organizational-level manager will then better understand how to affect change within the system and explore how his actions affect the system using simulation and experimentation.

GIS and GeoBase

Referring back to the definition of a GIS, an "automated system for the capture, storage, retrieval, analysis, and display of spatial data" (Clarke, 2001:3), the word "spatial data" stands out. The term "spatial data" refers to a collection of geographic features and their attributes. Three features can be modeled in a GIS – points, lines, and polygons. For example, a point could be used to locate a wellhead, a line could designate an underground water pipeline, and a polygon could distinguish a building footprint, or any object with a large area. A GIS also attaches attribute information to each of these geographic features. For example, tabular information about a building (building number, number of floors, etc.) could be attached to a polygon feature in the GIS.

The power of GIS is derived from its ability to sort geographic features onto map layers. Any Air Force base has many geographic features dispersed throughout its physical area – buildings, underground pipelines, roads, water bodies, etc. On one layer, all of a base's roads, with associated attributes, could be depicted. On another layer, all of the underground water pipelines could be shown. The GIS user can choose to simultaneously display as many of these layers as desired, each stacked one on top of the other. A digital map, included as a separate layer, could also be inserted to provide location context for the objects. Layering allows the user to perform geographic and/or attribute queries (i.e., show me all of the points that lie within 100 feet of this building footprint), construct digital maps, analyze geographic patterns, observe (i.e., has a land feature appreciably changed over time?), or plan (i.e., will digging a hole impact underground lines, endangered species habitat, etc?). Dramatic advancements in computer, database, satellite imagery, and global positioning system (GPS) technology over the past few decades have fueled the usefulness and power of GIS and enabled its diffusion throughout the marketplace (Clarke, 2000; Cullis, 2000:6-7). Figure 1 presents a screen shot from a functioning GIS. In this figure, a map with overlaid attributes is pictured. Each attribute has attached database information and a digital picture. The combination of the map, attributes, database, and the personnel manipulating these items makes up the GIS.

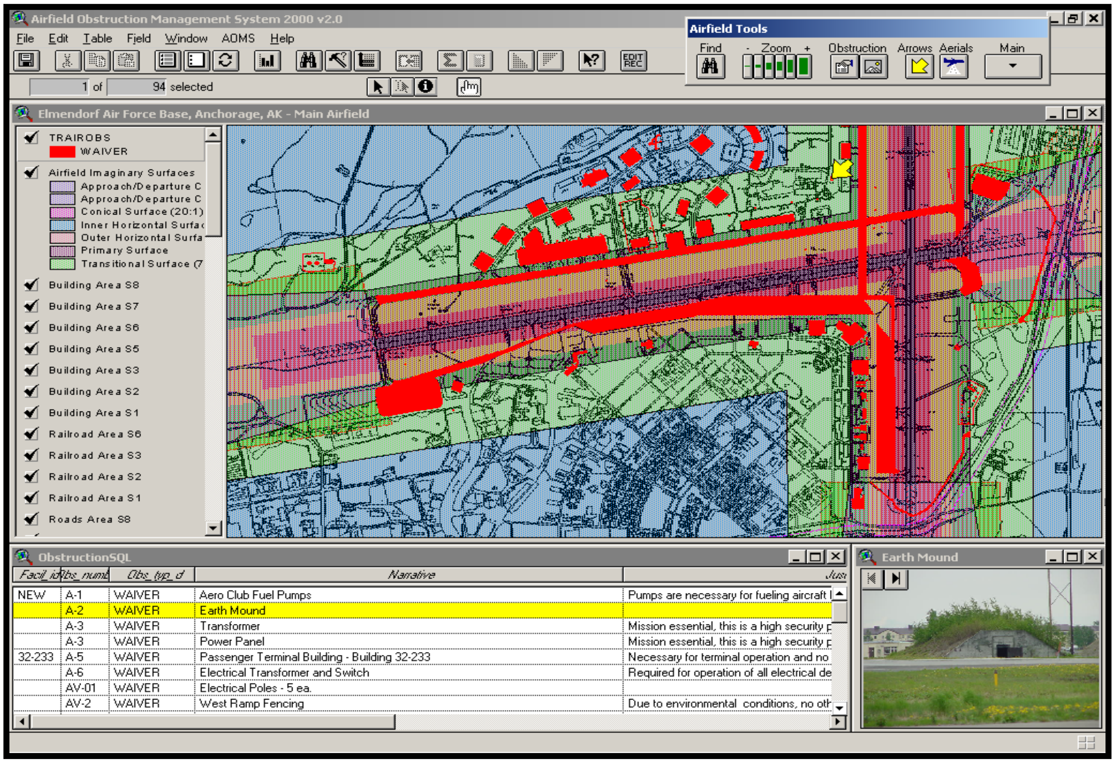


Figure 1: Example of a GIS (with Geographic Features and Attributes Shown) (Cullis, 2002)

Beginning in the late 1980s, innovative Air Force personnel recognized the usefulness of GIS and began integrating GIS systems into applicable work functions (Cullis, 2000:4). This adoption occurred as autonomous AF organizations collected spatial data, digital maps, and computer hardware and software to use in their own units (Cullis, 2000:5). Often, organizations spent unnecessary money and time populating redundant databases and multi-ordering base aerial photographs (Cullis, 2002; Geo InSight, 1999). Uncoordinated collection efforts led to inconsistencies between databases, inducing data standardization, data maintenance, and data accuracy problems across the installation (Cullis, 2000:5-6; Geo InSight, 1999). Installation commanders were unable to get a complete and accurate view of base assets – an especially daunting problem during emergency situations where data and map accuracy are mandatory to quickly make informed decisions. There was no sustained effort to provide knowledgeable GIS personnel, recurring monetary resources, or implementation management guidance, so many of the early GIS investments were "dead, dying, or increasingly irrelevant" (Cullis, 2000:3). In this context, one can see why GIS use and adoption were not initially successful within the Air Force.

To help alleviate this GIS management ailment, the Air Force created the Headquarters Air Force Geo Integration Office (HAF GIO). HAF GIO provides GeoBase policy, programming, and database architectural guidance for the Air Force as a whole (Department of the Air Force, 2002b:4-11). GeoBase is HAF GIO's response to GIS implementation problems. The technological goal of GeoBase is to rid bases of data standardization, data maintenance, and data accuracy problems by creating a common installation picture (CIP) for each base (Department of the Air Force, 2002c:5). The long-term impact of GIS in the Air Force (through GeoBase) will be greatly improved if everyone can access the same data, have confidence in its accuracy, and not waste time and money gathering and maintaining redundant information.

The vision of GeoBase is "one installation…one map" (Department of the Air Force, 2002c:5). The mission of GeoBase is to "attain, maintain, and sustain one geospatial infostructure to address installation requirements" (Department of the Air Force, 2002c:5). The purpose of GeoBase is to improve, even significantly improve, Air Force business processes (more effective and efficient) and improve command and control decision-making. The Air Force can only realize the GeoBase vision by sustaining the GeoBase system long-term (Department of the Air Force, 2002b:9).

Research Problem and Questions

The general research problem is as follows:

> **How can significant technological innovations be effectively integrated into organizations for long-term sustainment?**

To provide a more specific context of study for this general problem, the researcher asks the question:

> **How can GeoBase, a significant Air Force IT innovation, be effectively integrated into an organization for long-term sustainment?**

Based on this more specific research question, the researcher poses these three research questions:

1. **Can the important organizational components affecting IT implementation be identified?**
2. **Can dynamic simulation over time assist understanding?**
3. **Can the researcher distinguish management approaches that address short-term versus long-term performance?**

Thesis Overview

The remainder of this thesis is divided into the following four chapters: literature review, methodology, results and analysis, and discussion. Chapter 2 presents an aggregated model of relevant information focused on the research question. The majority of the literature discussed in Chapter 2 is drawn from research in the fields of innovation and information technology adoption, diffusion of innovations, organizational change, and organizational learning. Chapter 3 outlines the system dynamics approach methodology and how this research fits into this approach. Chapter 4 contains the results of the research and analysis, in line with the system dynamics approach methodology outlined in Chapter 3. Chapter 5 provides a summary, outlines recommendations for managers, identifies the limitations of this work, and describes areas for future research.

II. Literature Review

Aggregation of Literature Concepts

This research was started by gaining background in the relevant literature associated with the research problem. To avoid as much bias as possible, the instinct to form early, definitive mental models on how an IT implementation system would function and behave was depressed. However, after fruitful meetings with the client (AMC GeoBase Management Team) and useful insight from the 2002 Computer-Aided Drafting and Design/Geographical Information System (CADD/GIS) Symposium, held in San Antonio, Texas in August 2002, a mental model, focusing on how the system in question would behave over time and what would significantly contribute to this behavior, was formed. Throughout the research process, a general trend in the literature was observed; researchers often focus on similar issues and problems in their investigations and studies, but call relevant concepts, which are usually very similar in nature, by different names. For example, consider the information shown in Figure 2. Armenakis and Bedeian sifted through the major contributions in the field of organizational change in the 1990s and were able to boil down the significant concepts from a multitude of journal articles into two general categories: 1) phases within which change agents act and 2) stages through which change targets progress. The intricacies of Figure 2 will not be discussed at this time, but the concept of aggregating concepts from the literature into more general categories is a powerful tool in the system dynamics approach. Modelers cannot hope to capture all of the complexity of the real system in a model, so they have to aggregate much of this complexity in order to intelligently discuss how best to intervene in the system to push it in a desired direction (discussed more fully in Chapter 4).

The general organizational system model for IT implementation, derived from this research, is presented in Figure 3. This model aggregates concepts from the research literature and provides a relatively simple view of how the IT implementation system might function in a relatively small organization. Based on the research question, the system boundary must be constrained to those portions of the system the manager can control. Basically, the portions of the system falling within the system boundary circle in Figure 3 (operating capability, adoption, integration, management interventions, and organizational inertia) are endogenous to the system, which means the system manager can control them. The portions of the system falling outside of the system boundary circle (funding, organizational culture, top level support, and the innovation meeting needs) are exogenous to the system, meaning the manager cannot control them. The exogenous variables provide the context within which the manager operates and intervenes in the system. The Air Force GeoBase initiative provides an excellent real-world example to study this general pattern in a squadron-size organization. The literature review for this research will be organized around the model shown in Figure 3 for clarity.

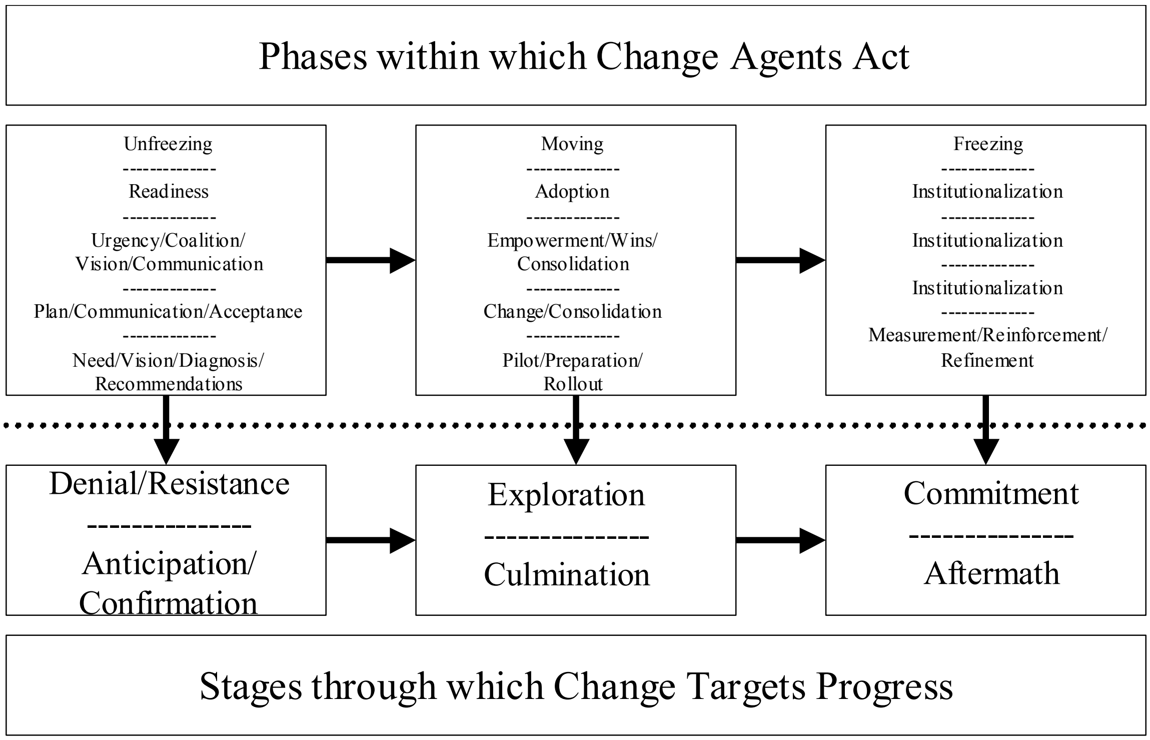


Figure 2: Change Agent Phases and Change Target Stages (Armenakis & Bedeian, 1999:305)

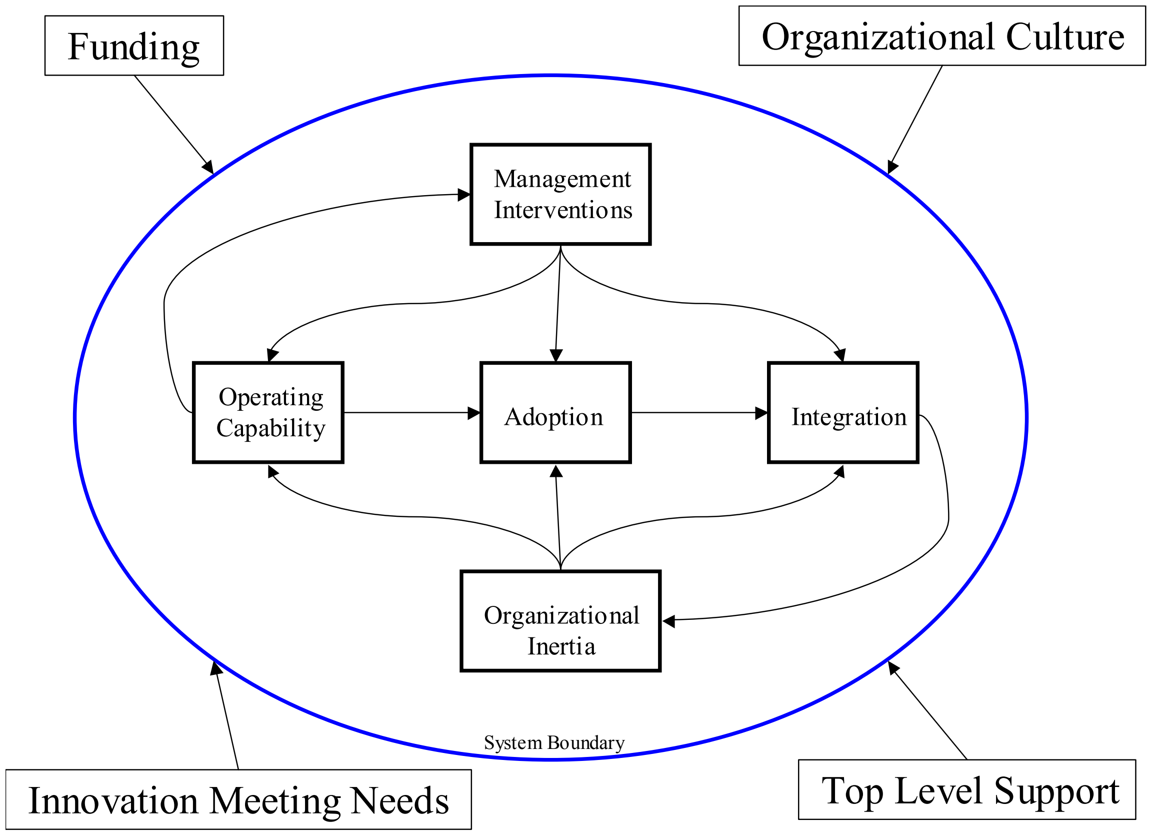


Figure 3: General IT Implementation Model

Before each of the endogenous, aggregate portions of the IT implementation model are explored, the reader should have some background on the history and vision for the GeoBase initiative from the Air Staff perspective and understand how this research approaches the research problem from a system dynamics perspective.

GeoBase Capabilities

The USAF GeoBase Initiative began in the fall of 1998 as an extension of a 1995 scientific research paper prepared by Brian Cullis examining the factors affecting successful use of geospatial information technologies by military organizations on US defense installations (Department of the Air Force, 2002b). Results from this research concluded that the current methods for geospatial information system integration on defense installations were "resulting in high development costs with dubious long-term sustainability at best and all too frequent abandonment and fiscal waste at worst" (Department of the Air Force, 2002b). Appendix A contains information on the history of GIS to provide a historical context of its development.

The Headquarters Air Force Geo Integration Office (HAF GIO) was established in July 2001 by the Air Force to operationalize GeoBase capabilities across USAF interests and serve as the focal point for installation geospatial information and services. HAF GIO recognizes that "post mortems of failed IT investments clearly diagnose an overemphasis on short-term technology issues and insufficient attention to sustainment concerns as the cause of their early death" (Department of the Air Force, 2002b:I). As such, HAF GIO desires to pair technology sustainment abilities with technology advancements as GeoBase is integrated into AF processes. Technology issues such as system and data architectures will be mixed with crucial crosscutting issues such as planning, education, and training (Department of the Air Force, 2002b:I).

In the early stages of AF GIS implementation, autonomous AF organizations began developing GIS applications and databases with a bottom-up perspective. A bottom-up perspective focuses development on the needs of a smaller unit, without regard for compatibility with other units in the larger organization. Hence the smaller units, using a bottom-up development approach, were not concerned with installation-consistent software, database architecture, or formatting, so these efforts resulted in stove-piped applications (mutually exclusive unit applications) and differing installation viewpoints for each organizational unit. The GeoBase initiative aims to take a top-down perspective on GIS development, where inter-organizational compatibility is one of the primary development concerns. Figure 4 contrasts the concepts of bottom-up development and top-down development. The GeoBase initiative aims to overcome the stovepipe application problem that currently exists by a taking a top-down approach.

In the GIS stovepipe application context, command and control decision-making capacity was diminished because installation commanders did not have a consistent installation view from a GIS perspective. This problem was especially daunting when emergency situations arose that required critical, time-sensitive decisions. GeoBase aims to collect the relevant portions of each of these stove-piped applications and transform them into one common installation picture (CIP), allowing everyone on each installation the ability to manipulate and view the same information at all times.

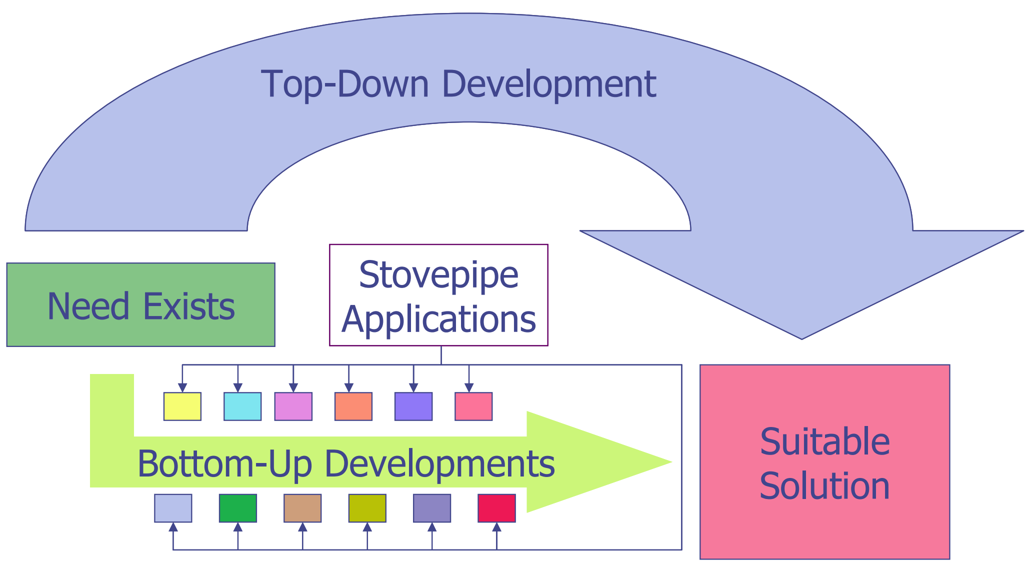


Figure 4: Bottom-up Development versus Top-down Development Paradigm (Hopper, 2002)

HAF GIO has three strategic goals with subordinate objectives that will guide how they manage the GeoBase creation process (Department of the Air Force, 2002b:II):

Goal 1: Develop Core GeoBase Capabilities

- Establish a Baseline Assessment of Existing GeoBase Investments
- Establish a Common Definition and Understanding of GeoBase
- Build Operational Architecture Based on Functional Requirements
- Define and Document GeoBase System Architecture
- Define and Document GeoBase Technical Architecture
- Establish a GeoBase Imagery Architecture
- Develop a Standards-Based GeoBase Data Architecture
- Create an Application Framework to Access GeoBase Services

Goal 2: Infuse the Mission with GeoBase Capabilities

- Establish a Detailed View of the GeoBase System Interfaces
- Consolidate Mapping Processes Through the GeoBase Service
- Enhance Key Mission Systems Through the GeoBase Service
- Identify Opportunities to Improve Air Force Mission Processes

Goal 3: Sustain the GeoBase Program

- Develop Strategic and Implementation Planning Guidance
- Establish a GeoBase Education and Training Plan
- Promote the GeoBase Program
- Partner with Other Organizations for Mutual Benefit
- Establish Policy and Guidance
- Establish a Viable Program Management Process
- Establish a Sound Programming Strategy.

The GeoBase initiative is more than just creating a CIP for decision support for each installation. In order for the investment of time and money into an AF-wide GIS tool to be sustainable, it must significantly improve the efficiency of Air Force business processes, provide an excellent management tool for emergency situations, and improve the effectiveness of personnel using the system. The first goal, “Develop Core GeoBase Capabilities,” is focused on moving the technology and support functions to an initial operating capability (IOC). GeoBase will have various levels of management and user responsibility. It will be partitioned into segments for users, doers, and viewers. Where increased capacity for geospatial investigation is necessary, users will have increased power when working with the CIP. The doers are the data maintainers. The database is typically the most costly and difficult technical portion of the GIS to manage since installation dynamics force constant updates to the database, not to mention the heavy expense of simply populating a database with new information (Geo InSight, 1999). If the database is not properly maintained, it will not accurately reflect base assets and its credibility will disappear. The data maintainers have a very important job – GeoBase will not be sustainable if the database is not maintained properly. The viewers are those who have a requirement to view the CIP, but do not require extensive analysis tools when dealing with spatial data. They will have access to the CIP, but in a "stripped-down" form (Department of the Air Force, 2002d). When all of the GIS software, data architecture, and GIS technical support personnel are in place and functioning, GeoBase will have reached IOC.

The second goal, "Infuse the Mission with GeoBase Capabilities," moves the system to a point where the investment begins to pay-off. Without a clear financial/manpower benefit to GeoBase, it is likely that its continued funding will dry up. To provide this financial/manpower benefit and allow funding to continue, integrating GeoBase into the business processes of the organization to dramatically improve mission performance will be the hallmark of GeoBase success. If personnel can accomplish their jobs more effectively and efficiently, they will continue to integrate GeoBase into more and more processes. Information sharing will take the place of information hoarding.

Cross-functional communication will replace no communication. As a result, great performance dividends will be realized.

The third goal, “Sustain the GeoBase Program,” is probably the most important of the three for the overall health of the GeoBase program. GeoBase must meet the needs of the organization and its personnel to realize its full potential. Excellent system management is a key factor in assisting personnel in finding how GeoBase applies to them. Often, the thought, “build it and they will come,” permeates IT investment at the unit level. It takes a lot more than availability to get personnel to use a new system they are unfamiliar with (Department of the Air Force, 2002b). Social network diffusion processes play a great role in getting people talking about GeoBase (Rogers, 1995). Personnel must be trained and educated to be able to have some level of competence when dealing with the system (Geo InSight, 1999). As people begin using the system and seeing what it can do, they will be the champions to carry it forward into their business processes. It will not be a mandate from above that will get GeoBase integrated sustainably into AF business processes; it will be personnel, trained and educated, that will carry the program forward, but only if it meets their needs (Department of the Air Force, 2002c).

GeoBase has lofty goals – it is not merely an IT investment – it also, and more importantly, represents a change in the way people use and share information. Responsibilities for database maintenance will be required not only for individual units, but for a wide swath of units throughout an installation. If one of the units does not maintain their data, the whole installation suffers because that portion of the database is unreliable. This research focuses on IT implementation in only one organizational unit (squadron-size organization). Though the scope of this research is trimmed-down to this level, the dynamics within one organization make the GeoBase implementation system difficult to understand. Whenever people are involved in a system, there are many variables that complicate it. To effectively deal with this complication, a tool that aggregates these variables and welcomes dynamic interactions over time becomes necessary. System dynamics is one such tool and following its methodology can help the researcher and system manager uncover much of this dynamic complexity.

System Dynamics Approach Methodology

The reader must understand that system dynamics is a method of dealing with questions about the dynamic tendencies of complex systems, which is to say, the behavior patterns they generate over time. System dynamicists are generally not concerned with precise numerical values of system variables in certain years. This lack of precision is acceptable in the system dynamics approach and makes it possible for the modeler to explore systems where a great deal of quantified data is absent. Modelers from other modeling schools of thought may question the validity of the system dynamics approach (Meadows, 1980) since it is not reliant on empirically quantified data. However, Meadows (1980) outlined these differences of opinion and found that different modeling schools of thought, such as system dynamics and econometrics, can co-exist and provide meaningful analysis to the scientific community. The key element for deciding which method to use lies in the type of problem requiring analysis. Some problems are good system dynamics problems and some problems are not. Some problems are more effectively analyzed by other statistically based modeling methods like econometrics (where exogenously driven open-system problems with ample amounts of data are the focus). This research uses a system dynamics approach to analyze this system, since this problem can be well addressed using a system dynamics view. There are portions of this system that follow predictable patterns of behavior, there is an endogenous explanation for these behavior patterns, and there is a lack of empirical data from the system. System dynamics provides a unique, effective methodology to study IT implementation.

System dynamics offers a methodological, iterative approach to analyze a system (Sterman, 2000:86). The first step is to articulate the problem clearly and specify the client (system manager) for whom the work is being accomplished (Sterman, 2000:86). Modeling can never capture all of the complexity of a system, so a specific problem must be identified so the appropriate structural boundary can be explored (Liberatore et. al., 2000:186; Sterman, 2000:89). Modeling a specific problem allows the researcher to identify and better frame the problem being studied by providing information that leads to exploration of certain areas and exclusion of others (Liberatore et. al., 2000:186). Modeling gives decision-makers insight into the causal structure of the system and helps them understand how actions in one area may have formerly unforeseen impacts in another (Sterman, 2000:85). Once the problem is identified, the client specified, and the proper background in the problem gained (through interviews, literature research, client conversations, expected problem time horizon, etc.), hypotheses about the system can be proposed.

In concert with the client, the researcher proposes a set of graphs that show how important metrics from the system are expected to behave over time. These graphs embody the reference mode of the system (since the researcher refers back to them when formalizing the structure of the system). Using the reference mode graphs as a guide, the researcher outlines the causal structure of the system (Sterman, 2000:102). The researcher must focus only on the important, aggregated influences surrounding the problem and resist being pulled into the "dark forest" of all influences present within the system. The causal diagram is a useful tool for outlining the feedback structures present within the system by showing the causal links among variables using arrows running from a cause to an effect (Sterman, 2000:102). Once the reference mode and causal diagram are completed and agreed upon, the researcher can take this dynamic system hypothesis and move to the next step in the process, namely formulation.

Formulating and simulating the dynamic hypothesis is done in the virtual world. Simulation in the virtual world allows the modeler to test various management strategies quickly and efficiently without having to endure longitudinal studies composed of empirical data. The goal of system dynamics simulation is not precise prediction of numerical metrics -- the behavior pattern over time and magnitude of difference between simulations elucidate how the system should respond given specified initial conditions and management interventions. To assure the model functions properly, the researcher must test it.

Testing begins when the first formalized variable is entered into the computer. Each variable must correspond to something meaningful in the real world (Sterman, 2000:103). To be meaningful, variables must have a certain degree of aggregation, but not so much that they lose explanatory power in the framework of the model. Usually in social system experimentation, most of the variables are "soft." That is, a precise measurable number cannot be associated with the variable. Even though precise, measured numbers are not included in a model, the goal of system dynamics is not obscured by this complication. Simulation does not produce precise, predictive output (only behavior patterns and level of magnitude differences); hence, exact parameterization of the model is not necessary.

Validation from these tests differs from statistical validation. System dynamics validation assists the client in gaining confidence in the model. Strictly speaking, the model is validated to the extent the client uses it to make decisions influencing the system. In more quantitatively precise modeling efforts, some degree of confluence of simulation data and empirically observed data is useful, but in social system modeling efforts (since there are usually no applicable metrics in the real world) there is no need for precise numerical agreement between empirical and simulation numbers. The important validation comes from aligning the simulation behavior pattern with either historical or hypothesized behavior patterns from the real world, which allows the manager to use the model in a meaningful way.

Literature Associated with GeoBase Implementation System

The desire to understand the natural system requires the researcher to gather relevant, aggregated concepts from many different fields of study. System dynamics allows the researcher to combine these concepts into aggregate variables in the system. Applicable areas of study for this research effort include: diffusion of innovations, IT and innovation adoption, and organizational change, among others, which all include different approaches managers can take to intervene in these portions of the system. The remainder of his literature discussion will focus on the aggregate concepts of operating capability, adoption, integration, and organizational inertia. The literature discussion will include some commentary on how each of these concepts pertains to the IT implementation model.

Operating Capability.

Operating Capability represents the technology and technological system management portion of GeoBase. One of the initial milestones for GeoBase is arrival at initial operating capability (IOC). GeoBase assists and is managed for three discrete customers: users, doers, and viewers. The users are those who require access to the common installation picture (CIP) and need a full GIS to manipulate it. Doers are the data maintainers. Each organization using GeoBase will be responsible for maintaining some piece of the data. A dedicated GeoBase management team will maintain the data in the CE squadron. Viewers are those who require infrequent access to the CIP and do not require substantial GIS manipulation tools. They would operate mainly from a web-based viewer. Arrival at IOC will occur when all of the hardware, software, and management elements are in place to satisfy all of these GeoBase customers.

Getting the hardware, software, and management teams in place will take time and will require consistent funding. GeoBase management personnel will continue improving the system over time, so arriving at IOC will not end the investment in technology and operating capability. The database, the most important technical component of a GIS (personnel being the most important), will always need continual updating, not to mention its expensive genesis. The long-term investment in this portion of GeoBase will always require strict management control – advocating funding and managing the database and technical. As the initial hurdles are passed, the manager's level of time and effort in this portion of the GeoBase system will diminish, but he will still need to continually work at keeping this element in place and functioning properly.

GeoBase Technical Issues in the Organization Environment.

GeoBase is an enterprise-wide GIS. An enterprise-wide GIS is "a single, organization-wide data resource" (Geo InSight, 1999). The role of a GIS in an organization is more than simply automating a few tasks for the sake of efficiency. The introduction and adoption of GIS by an organization is an opportunity to introduce fundamental change in business operations. Organizational GIS adoption forces organizations to reorganize how they collect, maintain, and use data and information. These changes should lead to improved operational effectiveness and efficiency (Geo InSight, 1999).

An enterprise GIS database allows users to have immediate and easy access to up-to-date information and assures that database construction is done in the most efficient manner possible. The enterprise GIS database eliminates redundant collection and storage of information. An enterprise GIS integrates GIS data for all units of the organization participating in the GIS program (Geo InSight, 1999).

For an enterprise GIS database to function properly, all users must cooperate, both for the collection and entry of data, and in application development in a shared data context. Generally, this causes some individual applications to work less efficiently, but the overall benefit to the organization outweighs this distraction. For the overall organization to benefit, more emphasis must be placed on excellent data maintenance and user services to offset perceived individual loss of control that accompanies data sharing initiatives (Geo InSight, 1999).

The GIS database is the most important technical portion of the GIS. The GIS database "can account for up to 60% to 80% of the GIS development costs" (Geo InSight, 1999). Not only are initial database development costs high, but continuing costs for operation and maintenance are also dominated by the data. In addition to understanding that database development takes substantial time and money, users and managers must appreciate that GIS is a new technology and its adoption usually involves some level of uncertainty that can cause time delays, on-going change in the development program, and the need to resolve unforeseen problems (Geo InSight, 1999).

For a database to remain relevant over a long period of time, database information must include metadata (data about data). Metadata describe the "content, quality, condition, and other characteristics of data" (Geo InSight, 1999). Since data, once created, can travel almost instantaneously through a network and be used for a multitude of tasks, metadata allow different users to decipher what a piece of data means. With rotating personnel, this becomes even more important, so incoming people can understand what has been collected in the past and not have to "recreate the wheel", so to speak. For long-term GIS sustainment, metadata can provide a degree of continuity that otherwise would not exist.

Written plans, if followed, provide an effective management tool for a GIS development program. A GIS Implementation Plan can resolve some of the uncertainty associated with GIS development. An Implementation Plan describes the "organizational

GIS scope and objectives, management framework, task descriptions, schedule, budget, and administration" (Geo InSight, 1999). The Implementation Plan also provides a framework for all GIS hardware, software, network, and data considerations. The database design specified in the Implementation Plan governs the main database and all "children" databases and applications that are based on individual business process requirements. A Training Plan should also be developed that provides "a formalized, long-term strategy that outlines who should be trained, the subjects and topics covered, sources of education and training, forums, when training is appropriate in the implementation process, and training intervals and length" (Geo InSight, 1999). Changes to the training plan can be added as new requirements surface (Geo InSight, 1999).

GIS is an innovation that, when integrated into organizational processes, forces major changes in organizational behavior. Since the development period for an enterprise GIS can be lengthy, managers must be patient and take an active role in the development process. Personnel must be trained and educated on how to use GIS and managers must manage the change process to allow organizational adoption to occur. If personnel learn how to effectively share and utilize data differently than they have done in the past, a GIS can bring major improvements in organizational effectiveness and efficiency.

Adoption.

Adoption is the most human portion of the GeoBase innovation system. There are many issues involved in adoption, including many inputs from the field of organizational change, IT innovation perceptions, and management intervention recommendations. The first section, change process management, will focus the adoption discussion that follows.

Change Process Management.

A number of researchers have proposed change process management interventions for organizational managers. In the change literature, process issues focus on management actions taken to implement changes within an organization and how employees respond to such efforts (Armenakis & Bedeian, 1999:295). Kotter recognizes that a successful change progresses through various stages that can take a considerable amount of time to complete (Kotter, 1995:59). Skipping steps in the process only provides an illusion of successful change implementation and never produces desired long-term performance results (Kotter, 1995:59). Substantial mistakes in any of the process stages can have a devastating impact, slowing momentum and negating past efforts (Kotter, 1995:60).

Kotter (1995:61) identifies eight stages that must be sequentially completed and sustained by change agents for any substantial change effort to be successful:

1) Establish a sense of urgency (identify and discuss crises, potential crises, or major opportunities),
2) Form a powerful guiding coalition (assemble a group with enough power to lead the change effort and have them work as a team),
3) Create a vision (where is the organization now and where does it want to be in the future),
4) Communicate the vision (using every communication vehicle available and through guiding coalition example, promote the change effort),
5) Empower others to act on the vision (remove obstacles, change inhospitable organizational structures, promote good, nontraditional ideas, etc.),
6) Plan for and create short-term wins (visible performance improvements as a result of the change),
7) Consolidate improvements and produce more change (get rid of policies and structures inconsistent with the change vision), and
8) Institutionalize new approaches (articulate connection between new behaviors and organizational success).

For GIS-specific change programs, there are a number of policy issues that must be addressed early in the GIS planning process. GIS is still an evolving technology, so personnel involved with the implementation process (managers, users, and GIS staff) may have varying expectations of what GIS can accomplish. GIS development is a long-term process, hence pay-offs from the technology usually take a long time to materialize. Geo InSight Inc., a leader in GIS implementation management, identifies several factors associated with successful GIS implementation (Geo InSight, 2001):

- Emphasize advantages of GIS to individual users and entire organization
- Require high level of competency by all participants
- Ensure high level of management commitment from all management levels in the organization
- Require participation in team building and team participation within and between departments
- Ensure minimum data quality and access for all users
- Require development team to set realistic expectations
- Minimize time between user needs assessment and availability of useful products
- Develop positive attitude toward change within organization
- Ensure level of technology is appropriate for intended users
- Conduct highly visible pilot project that is successful

How Perceptions of Change Progress through a Process.

For general change, Isabella proposes a four-stage model of how change targets perceive change. Isabella proposes the first step in a change is anticipation. Anticipation occurs when individuals assemble rumors and pieces of information into a perceived reality (how they view the change and the state of the organization based on rumors). Confirmation occurs when events are standardized into a conventional frame of reference used to establish logical associations reflecting understandings that have worked in the past. Culmination results from a comparison of conditions before and after the change where the frame of reference created in the confirmation stage is adjusted based on how the change actually unfolded. The final stage, aftermath, occurs when change targets review and evaluate the consequences of a change (Isabella, 1990).

Jaffe et al. propose a four-stage model focused on how change targets react to change. The first step is denial, which occurs as employees refuse to believe that a change is necessary or that it will be implemented. Resistance follows when individuals withhold participation, attempt to postpone implementation, or try to convince decision makers that the proposed change is inappropriate. Exploration occurs when employees experiment with new behaviors and test their effectiveness in achieving promised results. If exploration produces a positive view of the change, commitment to the change takes place as change targets embrace the proposed change (Jaffe et. al., 1994).

Kotter's change implementation model parallels the general effects of the change models of Isabella and Jaffe et al. Isabella describes the stages through which an individual progresses as change unfolds and Jaffe et al. provide a title for each stage. Hence, during anticipation, employees are likely to experience denial. At confirmation, employees may resist the change. Armenakis et al. propose that individuals will experience denial and resistance throughout the change process if they are not adequately prepared for the introduction of change at the outset of the change effort (Armenakis et. al., 2000). During culmination, when organizational members compare past and present conditions as a result of the change, they are exploring. Aftermath occurs when change targets decide the extent to which they will commit to the change (Armenakis & Bedeian, 1999). These models give the change agent an idea of what change targets experience during a change effort and outline some practical strategies and tactics to ease the transition through each step of the process.

Adoption and Diffusion of Innovations.

Since this research recognizes the importance of change induced by an IT innovation, the relevant points from the research literature that focuses on innovation adoption and diffusion, which is highly correlated with change process management, will be discussed. An innovation is "an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (Rogers, 1995:11). GeoBase is a new concept for many people in Air Force organizations, since the program is in its infancy, so it would currently qualify as an innovation. Successful introduction of an innovation into an organization requires two main processes. First, the individual user must adopt the innovation. Rogers defines adoption as a "decision to make full use of an innovation as the best course of action available" (Rogers, 1995:21). Second, the organization must adopt the innovation through a diffusion process. Rogers defines diffusion as "the process by which an innovation is communicated through certain channels over time among the members of a social system" (Rogers, 1995:5).

Rogers describes the stages through which an individual progresses as he evaluates an innovation for adoption or rejection (Figure 5).

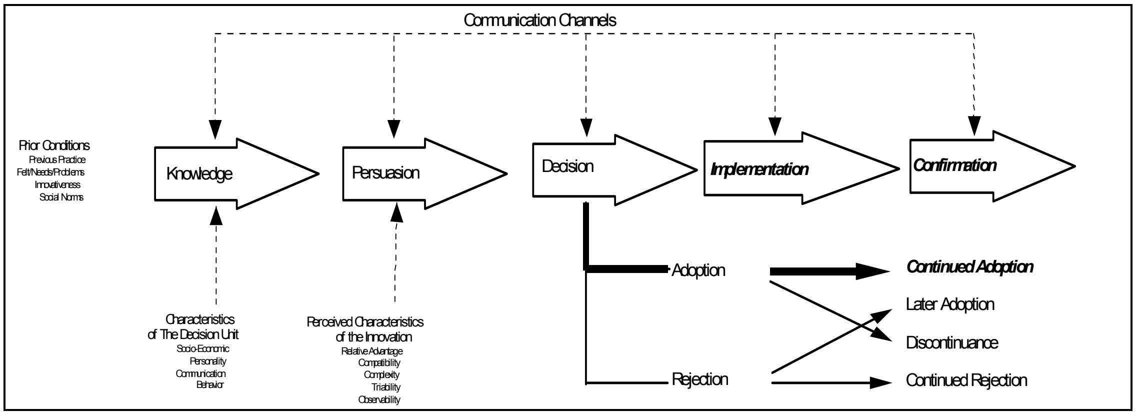


Figure 5: Stages in the Innovation-Decision Process (Rogers, 1995:163)

In the model shown in Figure 5, the potential adopter first gathers information about an innovation, which generates knowledge. The potential adopter's mental model (or paradigm), which is typically formed as a result of both personal and organizational culture, frames the way he views an innovation. Factors involved with the potential adopter's mental model include previous practice, needs and problems, level of innovativeness, social norms, socio-economic characteristics, personality, and communication behavior. Positive or negative persuasion occurs as the potential adopter either forms positive or negative perceptions about the innovation based on its perceived characteristics (relative advantage, compatibility, complexity, triability, and observability). Relative advantage is "the degree to which the innovation is perceived as being better than its precursor" (Moore & Benbasat, 1991:195). Compatibility is "the degree to which an innovation is perceived as being consistent with existing values, needs, and past experiences of potential adopters" (Moore & Benbasat, 1991:195). Complexity is "the degree to which an innovation is perceived as being difficult to use (Moore & Benbasat, 1991:195). Triability is "the degree to which an innovation can be experimented with before adoption" (Moore & Benbasat, 1991:195). Observability is "the degree to which the results of an innovation are observable to others" (Moore & Benbasat, 1991:195). If the potential adopter forms a positive perception of the innovation based on these characteristics, he will probably make the initial decision to adopt. If the potential adopter perceives the innovation lacking overall in these characteristics, then the initial decision will be to reject. Initial adoption leads to implementation, where the adopter actually begins using the innovation. Initial rejection forces the potential adopter to reevaluate the innovation as more knowledge is gained. Over time, confirmation will either reinforce the initial decision (continued adoption) or degrade the initial decision to adopt (discontinuance) if the innovation does not perform as desired. Discontinuance can be separated into two categories: replacement discontinuance (rejection in order to adopt a better idea that superceded it) or disenchantment discontinuance (rejection as a result of dissatisfaction with innovation performance). If the potential adopter initially rejected the innovation, later confirmation of the innovation may induce the potential adopter to adopt or, if the innovation continues to not meet the potential adopter's needs, he will continue to reject the innovation (Rogers, 1995).

In Cullis' research, the innovation-decision process is adjusted to show how GIS is implemented at the individual level (Figure 6). The environment, information system, and development process combine to determine the extent of GIS use for an individual. Based on the individual experiences with the GIS, the GIS user is either satisfied or dissatisfied. If the user is satisfied, the user will continue to adopt GIS. On the other hand, if the user is dissatisfied, he will discontinue use of the GIS. The user progresses through three phases in this model: the decision phase, the implementation phase, and the confirmation phase.

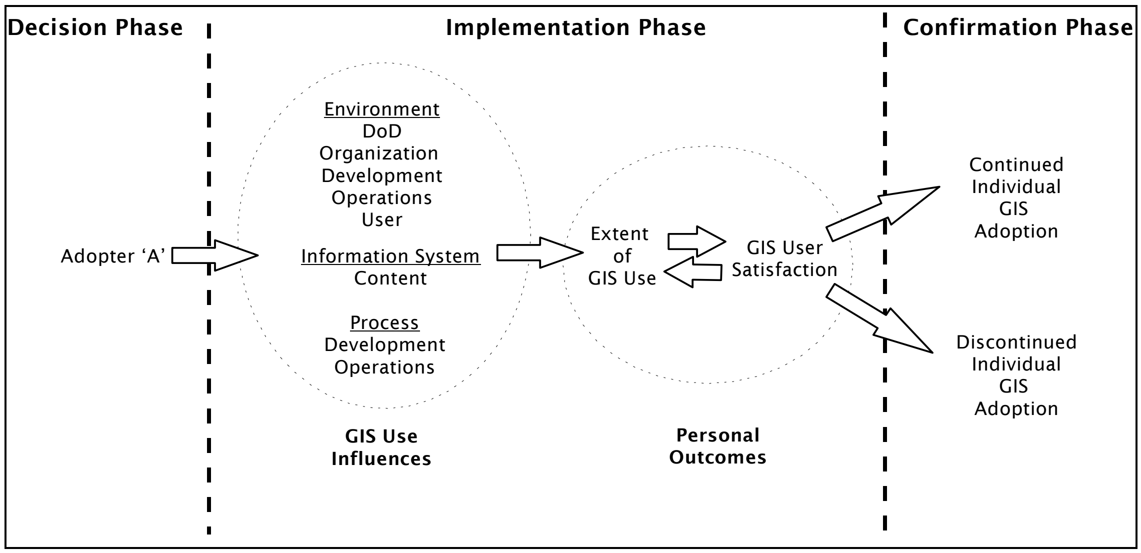


Figure 6: The GIS Implementation Research Model (Cullis, 2000:9)

During the process of adoption and implementation, users may re-invent the innovation to better suit their needs. Re-invention is defined as "the degree to which an innovation is changed or modified by a user in the process of its adoption and implementation" (Rogers, 1995:174). In previous research, investigators treated re-invention as "noise" in the adoption process. Researchers erroneously perceived adopters as passive acceptors of an innovation instead of active modifiers and adapters of new ideas. Later, researchers found that re-invention often occurs at the implementation stage -- providing impetus to measure adoption at the implementation stage rather than trying to measure the intention to act on the innovation (Rogers, 1995).

Re-invention causes innovations to change over time and across different adopters. Researchers and diffusion agencies typically frown on re-invention because it is difficult to measure performance and it distorts the original technology. Adopters, on the other hand, generally think favorably about re-invention. Re-invention provides a wider body of alternatives besides adoption or rejection; modification or selective rejection of innovation modules may also be appropriate. Implementation problems by individuals or organizations are unpredictable, so changes in innovations that make them more compatible with the individual or organization can be desirable. Re-invention also decreases discontinuance since re-invented innovations better fit the conditions of the individual or organization; innovations and organizations may engage in a kind of mutually influencing interaction, as the innovation and organization move closer to one another (Rogers, 1995).

Innovation Diffusion.

Individual adoption eventually can lead to organizational adoption if the innovation is effectively diffused throughout the organization. For diffusion of an innovation to occur, it must be spread throughout an organization beginning from a source and carried through a channel. A source is “the individual or institution that originates a message” (Rogers, 1995:194). A channel is “the means by which a message gets from the source to the receiver” (Rogers, 1995:194). Researchers categorize communication channels as either (1) interpersonal or mass media in nature, or (2) originating from either local or cosmopolite sources (Rogers, 1995).

Mass media channels are a means of transmitting messages (radio, television, newspapers, etc.) to reach a large audience rapidly, create knowledge and spread information, and lead to changes in weakly held attitudes. Interpersonal channels involve face-to-face exchange between two individuals and can be effective at changing strongly held attitudes and providing a two-way exchange of information. Mass media channels are relatively more important at the knowledge stage and interpersonal channels are more important at the persuasion stage in the innovation-decision process (Rogers, 1995).

Cosmopolite communication channels "are those from outside the social system of study" (Rogers, 1995:196). Interpersonal channels can be either local or cosmopolite, whereas mass media channels are almost always cosmopolite. Cosmopolite channels are relatively more important at the knowledge stage and local channels are more important at the persuasion stage in the innovation-decision process (Rogers, 1995).

The innovation decision period is the "length of time required for an individual or organization to pass through the innovation-decision process" (Rogers, 1995:197-198). The time elapsing from awareness to knowledge of an innovation decision for an individual is measured in days, months, or years. This is the gestation period during which the new idea ferments in an individual's mind. Rogers describes the rate of awareness knowledge, rate of adoption, and length of the innovation decision period for Iowa farmers adopting a weed spray by year (Figures 7 & 8) (Rogers, 1995). Rogers suggests that the decision to adopt is not instantaneous, but may take a long period of time to develop, especially for the laggard portion of the potential adopter pool.

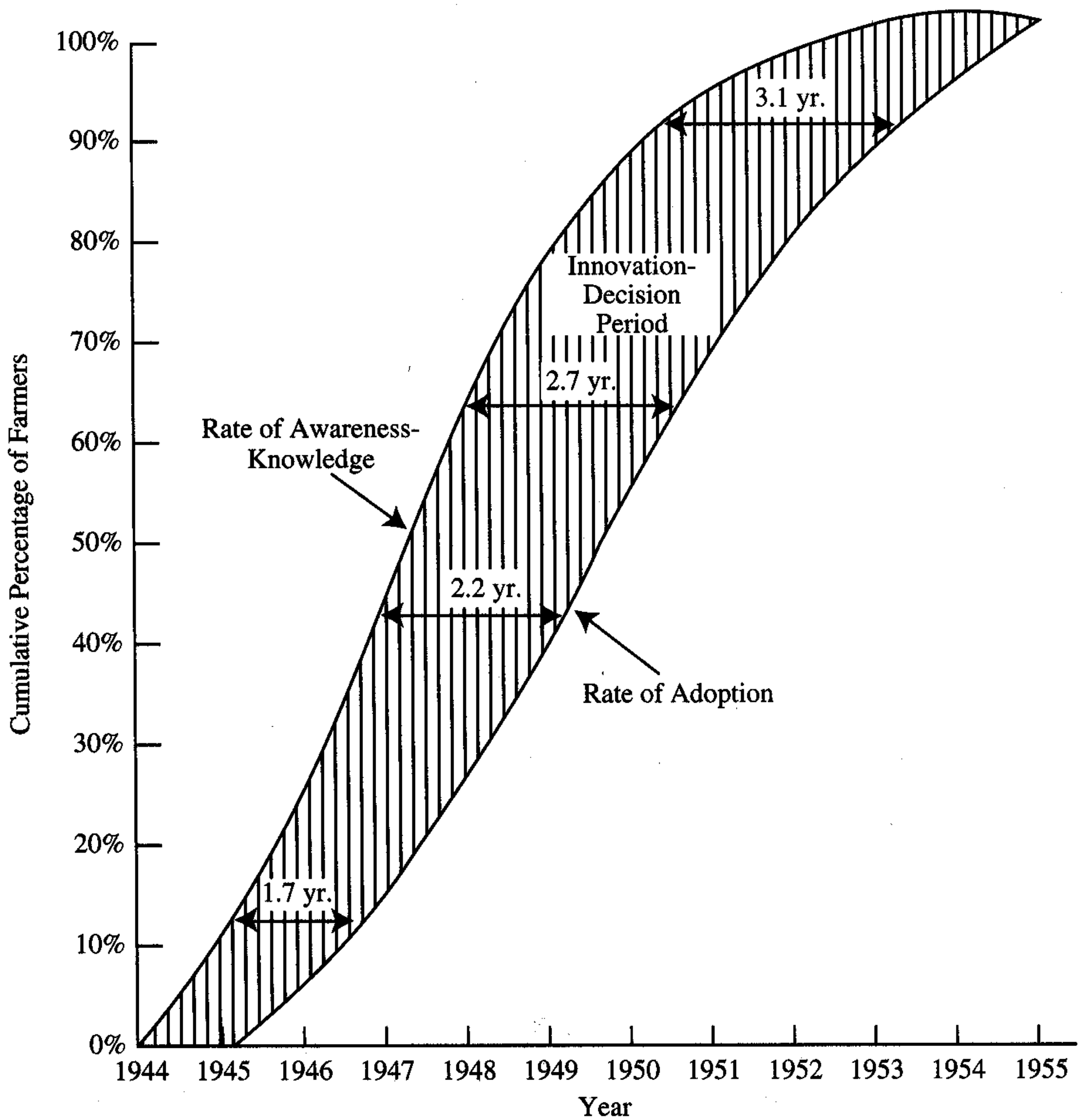
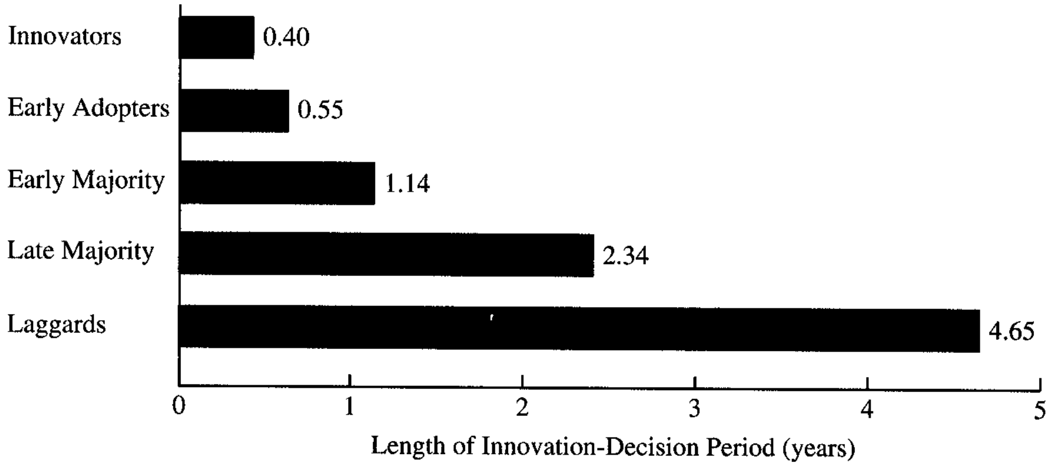


Figure 7: Rate of Awareness Knowledge, Rate of Adoption, And Length of the Innovation Decision Period for Iowa Farmers Adopting a Weed Spray by Year (Rogers, 1995:200)



Source: This figure is based on data from 148 Iowa farmers, gathered by Beal and Rogers (1960).

Figure 8: Innovators Have Shorter Innovation-Decision Periods than Laggards in Adopting 2,4-D Weed Spray (Rogers, 1995:201)

As mentioned earlier, diffusion is "the process by which an innovation is communicated through certain channels over time among the members of a social system" (Rogers, 1995:5). The four main elements of this definition include: innovation, communication channels, time, and the social system. Rogers describes the diffusion process by graphing the percentage of adopters versus time in Figure 9. Rogers suggests that an innovation diffusing throughout an organization follows an s-shaped curve as a result of differences between the innovative behaviors of personnel within the organization. Innovative personnel would tend to adopt an innovation earlier than non-innovative personnel. Innovative personnel would tend to fall into the early adopters group and non-innovative personnel would tend to fall into the laggard or late adopters group. Different innovations would also follow different s-shape behavior pathways, based on the perceptions of the innovation by potential adopters. Better perceptions would lead to faster diffusion and lower perceptions would lead to slower diffusion.

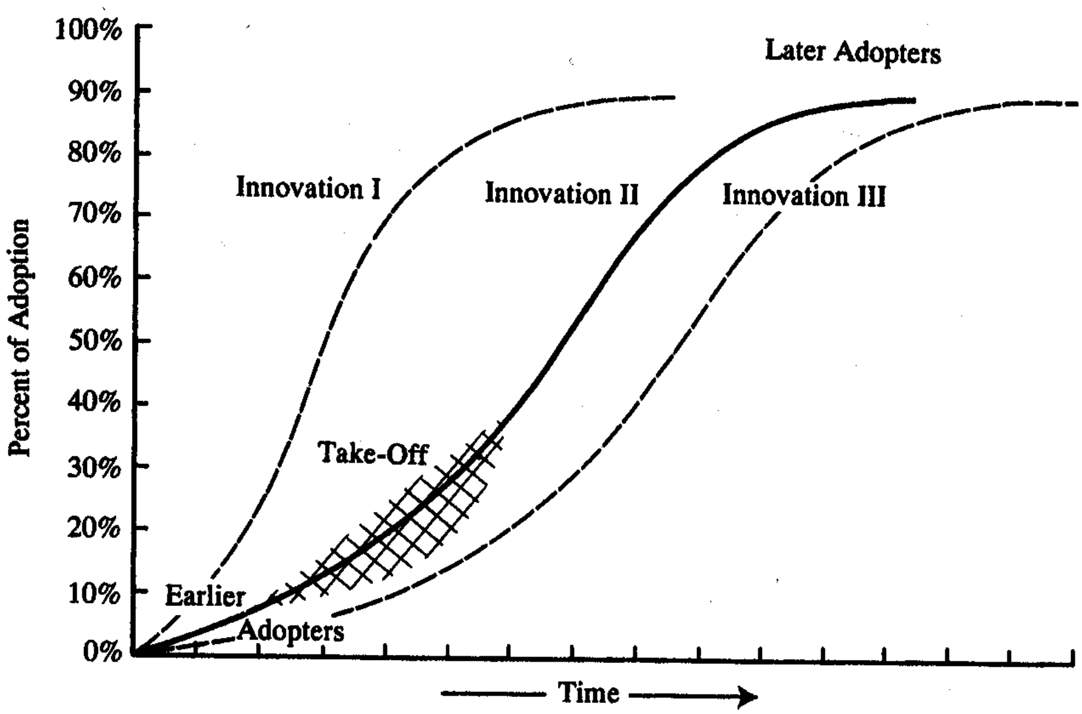


Figure 9: Innovation Diffusion (Percent of Adopters versus Time) (Rogers, 1995:11)

A social system is defined as "a set of interrelated units that are engaged in joint problem-solving to accomplish a common goal" (Rogers, 1995:23). The scope of the social system can encompass individuals, informal groups, organizations, and/or subsystems. Each element in the social system must be distinguishable from other units, but all elements cooperate to the extent of solving a common problem to reach a common goal. This sharing of common objectives binds the system together (Rogers, 1995).

There are a number of factors that affect diffusion within a social system. The system structure, system norms, opinion leader and change agent roles, types of innovation-decisions, and consequences of the innovation all contribute to how effectively an innovation diffuses.

System structure is defined as the "patterned arrangements of the units in a system" (Rogers, 1995: 24). Structure lends regularity and stability to human behavior in the system and allows researchers and managers to predict group behavior with some accuracy – thereby reducing uncertainty. The social structure within a typical government organization system would consist of hierarchical positions, giving individuals in higher-ranked positions the right to issue orders to lower-ranked individuals.

In addition to this formal social structure, an informal structure of interpersonal networks also links a system's members. Rogers defines these as communication structures, defined as "the differentiated elements that can be recognized in the patterned communication flows in a system" (Rogers, 1995:24). Communication structures are often tied together through cliques of homophilous individuals. Homophily is defined as "the degree to which two or more individuals in a system talk with others who are similar to themselves" (Rogers, 1995:24). A complete lack of a communication structure in a system would consist of system members having the same probability of communicating equally with each member of the system. The structure of a social system can facilitate or impede innovation diffusion in a system (Rogers, 1995).

System norms also affect innovation diffusion. Norms are defined as "the established behavior patterns of the members of a social system" (Rogers, 1995:26).

They define the tolerable range of behavior and serve as a behavioral guide for members in a social system. Norms can operate on a national, religious, organizational, or local level and must be considered when undertaking any diffusion action (Rogers, 1995).

Opinion leaders are also important members of a social system during diffusion processes. Opinion leadership is defined as "the degree to which an individual is able to influence other individuals' attitudes or overt behavior informally in a desired way with relative frequency" (Rogers, 1995:27). Opinion leadership is earned and maintained by an individual's technical competence, social accessibility, and conformity to the system's norms; not by their ranked authority (though they typically have somewhat higher social status than their peers). When a system is accepting of change, opinion leaders can be quite innovative, but when the system's norms are opposed to change, the behavior of the opinion leaders also opposes change (Rogers, 1995).

Opinion leaders are always at the center of interpersonal communication networks, consisting of "interconnected individuals who are linked by patterned flows of information" (Rogers, 1995:27). The opinion leader can serve as a social model whose innovative behavior can be imitated by other members of the system. However, if opinion leaders deviate too far from system norms, they can lose credibility and become an obsolete influence (Rogers, 1995).

A change agent differs from an opinion leader in that they are usually heterophilous from their clients. A change agent "is an individual who influences clients' innovation-decisions in a direction deemed desirable by the change agency" (Rogers, 1995:27). The change agent typically seeks to gain the adoption of new ideas, but may also try to quell diffusion and prevent adoption of undesirable new ideas. Since change agents are usually heterophilous from their clients, they have problems effectively communicating the innovations they are promoting. Hence, change agents should attempt to enlist opinion leaders to spread the innovation message.

Figure 10 is an example of a diffusion network of school superintendents in Allegheny County, Pennsylvania. The innovator superintendent (I) was the first to adopt a modern math innovation, but since he was not linked through the interpersonal network to any of the other superintendents, he had no influence on any of the other superintendents' adoption trends. The innovator was a social isolate, among other superintendents, who mainly interacted with cosmopolite friends and was disdained by his superintendent peers due to his innovative behavior. The gray-shaded area represents a clique of superintendents who interact more with each other than any of the outsiders. Within this group resided three opinion leaders (OL). After they adopted the modern math teaching techniques, others began quickly adopting to follow their examples. This diagram shows the powerful effect of opinion leaders in the communication network and how they can speed adoption (Rogers, 1995).

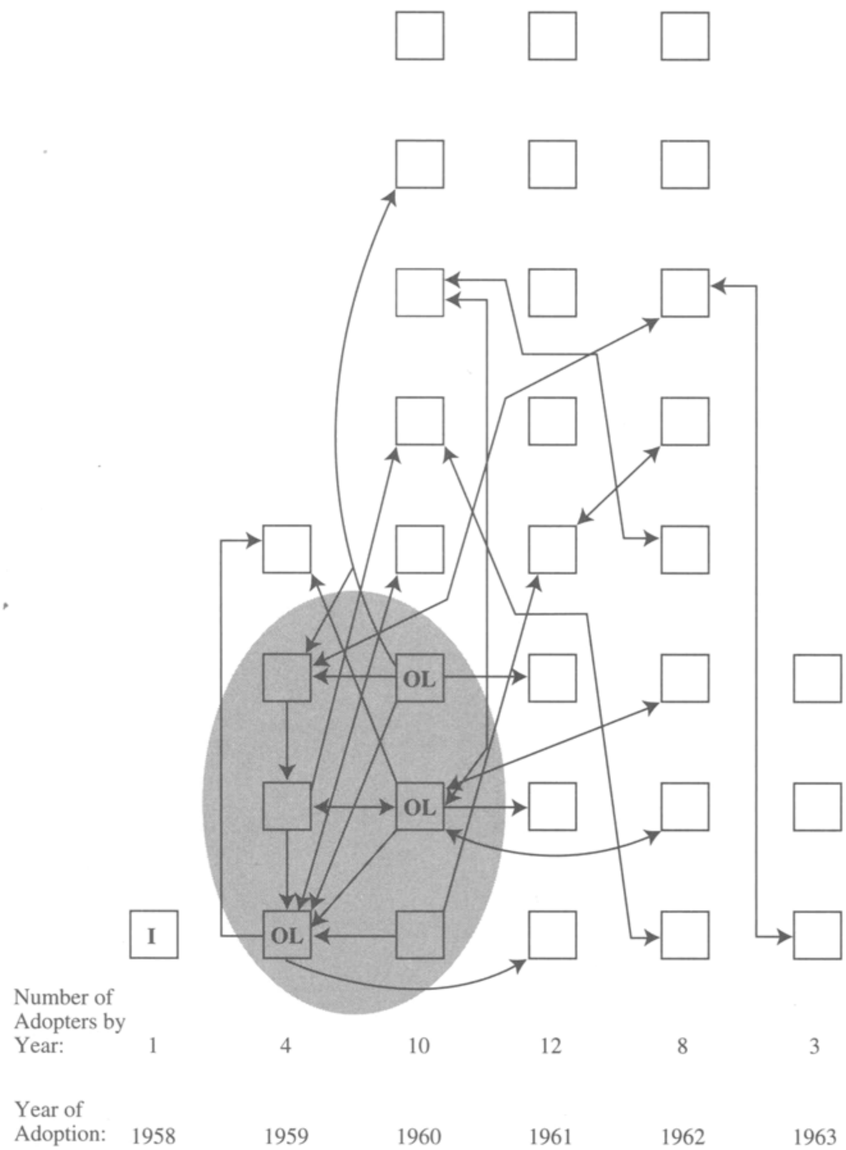


Figure 10: Opinion Leadership Patterns in the Diffusion of Modern Math Among School Superintendents in Allegheny County, Pennsylvania (Rogers, 1995:283)

There are three types of innovation decisions that can have a huge impact on the diffusion process. First, optional innovation-decisions "are choices to adopt or reject an innovation that are made by the individual independent of the decisions of the other members of the system" (Rogers, 1995:28). Even in this case, system norms and interpersonal networks can greatly influence this individual decision. Second, collective innovation-decisions "are choices to adopt or reject an innovation that are made by consensus among the members of a system" (Rogers, 1995:28). Once this decision is made, all members of the organization must conform to the system's decision. Third, authority innovation decisions "are choices to adopt or reject an innovation that are made by a relatively few individuals in a system who possess power, status, or technical expertise" (Rogers, 1995:29). The individual system member has little influence on these decisions – he or she must simply implement the decision. Ram and Jung have found that authority innovation decisions resulting in "forced" adoption are a poor way to manage innovative change. Their results suggest that even innovative individuals resist the innovation in the context of forced adoption. In these types of decisions, organizational members deal with forced adoption through the use of coping mechanisms such as complaining and seeking peer help (Rogers, 1995; Ram & Jung, 1991).

Consequences of an innovation provide the defining factor for long-term innovation sustainment. Consequences are "the changes that occur to an individual or to a social system as a result of the adoption or rejection of an innovation" (Rogers, 1995:30). Rogers identifies three types of consequences: desirable versus undesirable (functional or dysfunctional effects in the social system); direct versus indirect (changes occur in immediate response to an innovation or as a second-order result of the direct consequences); and anticipated versus unanticipated (depending on whether changes are recognized and intended by members of the social system or not). Change agents usually introduce innovations into a system where the results will be desirable, direct, and anticipated. However, innovations often have undesirable and indirect consequences for a system's members (Rogers, 1995).

Information Technology Adoption.

The literature focused on adoption of information technologies (IT) by individuals and organizations provides a solid background on how perceptions of IT innovations influence adoption. Research in this area has been a major topic of research over the past 36 years (Moore & Benbasat, 1991:193). Understanding how to effectively implement IT successfully has proven difficult, with efforts producing mixed and inconclusive results (Moore & Benbasat, 1991:193). Recent research has focused on how potential IT users perceive the information technology and how those perceptions influence its adoption and ultimate diffusion (Davis et. al., 1989:983; Moore & Benbasat, 1991:193; Cullis, 2000:2; Agarwal & Prasad, 2000:295; Fisher et. al., 2000:284).

In the study conducted by Agarwal and Prasad concerning the adoption of the C programming language by COBOL programmers, multiple factors were uncovered that were correlated with successful software adoption. They used three beliefs, found to be the most important in innovation adoption-implementation studies (Tornatzky & Klein, 1982) that influence employee attitudes for technology acceptance: perceived usefulness (relative advantage), perceived ease of use, and perceptions of compatibility. Relative advantage "captures the extent to which a potential adopter views the innovation as offering an advantage over previous ways of performing the same task" (Agarwal &

Prasad, 2000:298). Ease of use "encapsulates the degree to which a potential adopter views usage of the target innovation to be relatively free of effort" (Agarwal & Prasad, 2000:298). Compatibility is "the degree to which an innovation is perceived as being consistent with the existing values, needs, and past experiences of potential adopters" (Agarwal & Prasad, 2000:298). These factors shape employee attitude, which accounts for 72% of the variance in usage intentions.

In the case of the COBOL programmers, those having greater prior technical knowledge and less organizational tenure had more positive perceptions of C than those with more perceived job security. The group with greater prior technical knowledge and less tenure found it easier to make the transition to the new C language development environment, thus improving their perceptions of C (Agarwal & Prasad, 2000).

Though organizational tenure and prior technical knowledge are not factors that can be directly affected in the short term, training is a management intervention that can help produce desired adoption results. In this organization, many managers expected employees to take the responsibility of reskilling themselves through non-structured training. However, the results of the study found that unstructured training experiences did not have a significant effect on any of the beliefs relevant to attitude, whereas formal, structured training was more fruitful in this regard (Agarwal & Prasad, 2000).

People with perceived job insecurity exhibited strong negative relationships with beliefs about the innovation. The researchers found it is very important for management to create and foster an organizational climate where the threat of layoffs and powerlessness in the workplace is not imminent. Perceived job insecurity leads to feelings of uncertainty, which is detrimental to innovation adoption and may result in other undesirable effects such as reduction of effort and diminishing productivity (Agarwal & Prasad, 2000). The effects of A-76 studies on Air Force organizations are not specifically explored in this model, but it seems reasonable to conclude that organizations undergoing A-76 actions would develop an innovation-unfriendly culture.

The researchers also found that managers should devote attention to motivating their personnel by positively highlighting the relative advantage and compatibility aspects of new technologies as opposed to only focusing on programs that are easy to learn and use (through design and educational programs). For long-term routinization of the technological innovation, adjustments to work processes may be necessary so that mutual adoption can occur within the organization (Agarwal & Prasad, 2000). Short term success in technology adoption can be had through forced adoption by management mandate, however, negative long-term effects of this method have been well documented (Ram & Jung, 1991). Figure 11 presents a synopsized view of the relevant factors leading to the intent to use the C language. Voluntariness acted as a control variable in the research.

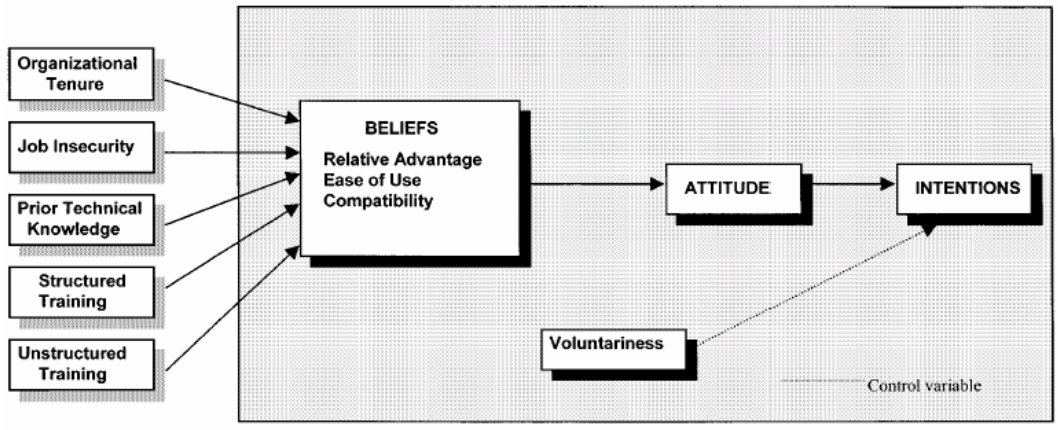


Figure 11: Research Model for C Adoption by Information System Professionals (Agarwal & Prasad, 2000:297)

Technology Acceptance Model.

The Technology Acceptance Model (TAM) also posits useful information to better predict, explain, and increase user acceptance of computer technology. Davis et al. address the ability to "predict peoples' computer acceptance from a measure of their intentions, and the ability to explain their intentions in terms of their attitudes, subjective norms, perceived usefulness, perceived ease of use, and related variables" (Davis et al., 1989:982). TAM, shown in Figure 12, postulates that computer usage is determined by the behavioral intention to use (BI), which is determined by the person's attitude toward using the system (A) and perceived usefulness (U) according to the relationship BI = A + U (Davis et al., 1989).

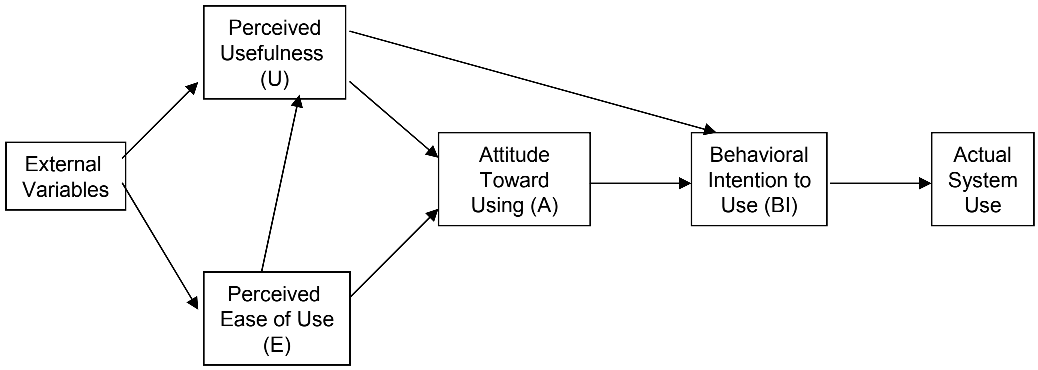


Figure 12: Technology Acceptance Model (TAM) (Davis et al., 1989:985)

The A-BI relationship implies that people form intentions to perform behaviors toward which they have positive affect. The U-BI relationship is based on the idea that, in organizations, people form intentions toward behaviors they perceive will increase job performance, beyond whatever positive or negative feelings they have for the behavior. The desire to improve performance is a result of the ability to achieve extrinsic rewards, such as pay and promotions, based on enhanced performance (Davis et al., 1989).

Davis et al. also found that people's computer use can be predicted reasonably well from their use intentions. Perceived usefulness strongly influenced people's use intentions, while perceived ease of use had a small but significant impact on use intentions, although the effect from perceived ease of use subsided over time. Attitudes only partially mediated the effects of these beliefs on use intentions (Davis et al., 1989).

GIS Adoption on DoD Installations.

Cullis specifies the common factors influencing GIS adoption based on the GIS use influences shown in Figure 6. Based on Cullis' research findings, Figure 13 illustrates how 52 variables influencing GIS adoption were collapsed into twelve groups under three GIS use influences. The three GIS use influences include: environment, process, and GIS subsystem. There are six groups in the environment use influence, including: external environment, organizational environment, and four user groups (user benefits, GPS and remote sensing knowledge, relative advantage of GIS, and the extent of GIS training). There are two groups under the process use influence, including: GIS use access and the analog-to-digital conversion. There are four groups under the GIS subsystem use influence, including: utility of GIS hardware, confidence in database quality, ease of applying GIS, and GIS linkages. The dependent variables in this model include GIS user satisfaction and extent of GIS Use.

Based on the results of Cullis' research, he proposed four recommendations for GIS adoption (Cullis, 2000:17-20):

1) Develop a strategic plan for achieving GIS success on defense installations.
2) Seek out resistance to GIS initiatives and treat it as a signal needing response.
3) Focus on the GIS end user and not solely on GIS technologies
4) Assemble a "toolkit" to share the "way ahead."

Cullis' first recommendation focuses on change management, operational and job redesign, development of a long-term perspective with clear goals and objectives, and the use of an integrated GIS management approach. His second recommendation specifies user coordination and stakeholder involvement are vital to successful GIS development initiatives. His third recommendation focuses on developing realistic expectations of what the technology can do and what to expect during the implementation process. The key is to prepare users and leaders for change and follow the change process throughout the effort. His fourth recommendation recognizes the investment already made in GIS across DoD installations and how all can utilize these investments. Providing a DoD GIS clearinghouse would help others at any point along the GIS implementation pathway (Cullis, 2000).

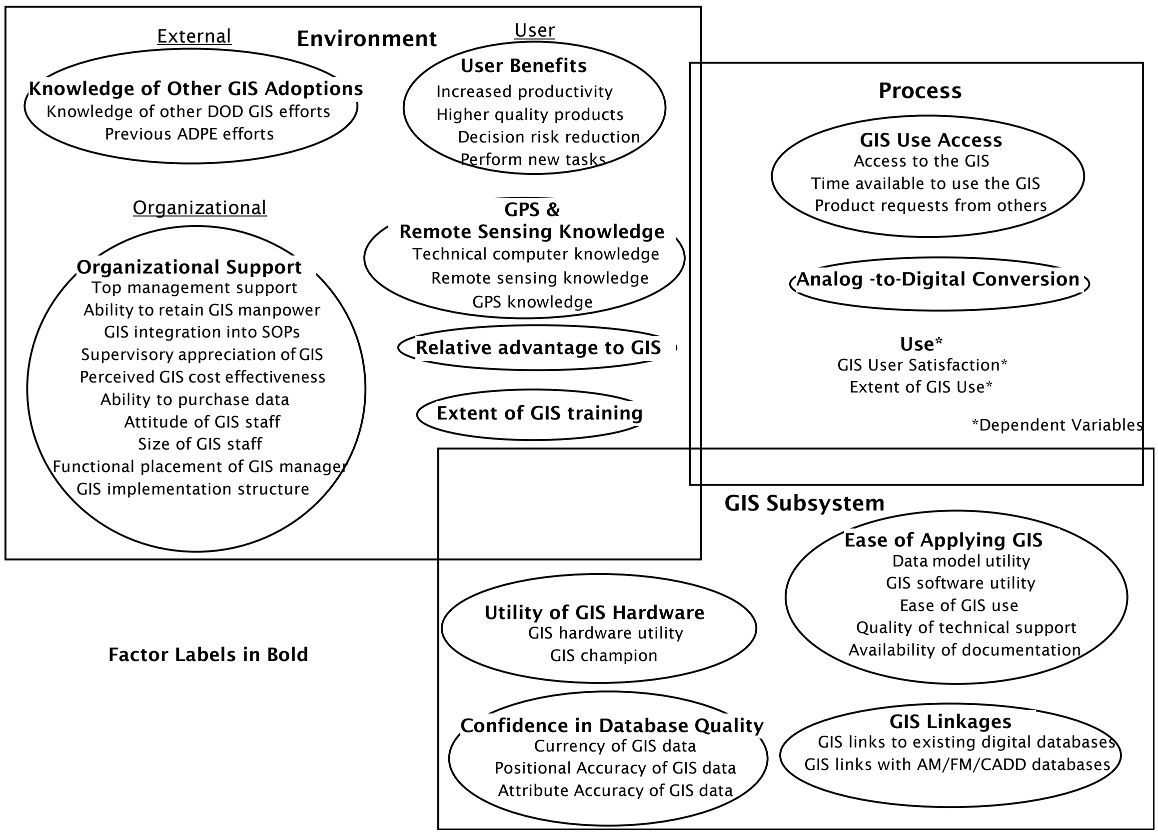


Figure 13: Common Factors Influencing GIS Adoption Responses (Cullis, 2000:9)

<u>Modeler's View of Adoption in GeoBase Implementation System.</u>

For this research effort, the members of the organization who are capable of using the GeoBase innovation in their work functions comprise the pool of potential adopters. Adoption (moving from the potential adopter pool to the adopter pool) requires buy-in from potential adopters on three levels. First, the potential adopter must adopt the GIS technology that drives GeoBase. Second, the potential adopter must agree to work within the new data framework for the organization, meaning the intercommunication, database control, and data sharing protocols that are required. Third, the potential adopter must choose to become a force for integrated business process change. The potential adopter must research his business processes and find ways for GeoBase to fit-in and improve the process performance. These individuals define the pool of potential adopters in this system.

Based on Rogers (1995) research, adoption is expected to follow an s-shaped behavior pattern over time as a result of innovative and laggard characteristics of potential adopters. Innovative personnel will tend to adopt earlier and laggards will tend to adopt later. Both organizational personnel and managers will go through the stages of change discussed by Isabella (1990) and Jaffe et al. (1994) during this s-shaped adoption growth period.

There are two main processes at work in organizations to move this diffusion process forward: direct management action using change process techniques and interpersonal communication channels. Direct management influence using the change process techniques discussed by Kotter (1995) and others (Geo InSight, 2001; Armenakis et al., 2000) focus on moving personnel from the potential adopter pool to the adopter pool by direct management action. Change process techniques are necessary at the beginning of a change implementation effort until the adopter pool builds to a point where passive, interpersonal communication channel processes (Rogers, 1995) can take over. Managers can have some influence on these interpersonal communication channels by gaining buy-in from opinion leaders (thereby strengthening the diffusion by interpersonal communication channels power of the IT innovation) and organizing communication forums.

There are also overarching IT innovation perception characteristics that will control the rate of adoption, based on potential adopter perceptions and organizational culture. These perceptions will generally be higher in organizations more accepting of IT innovations (positive IT organizational culture) and lower in organizations less accepting of IT innovations (poor IT organizational culture). These perceptions include the concepts of relative advantage, ease of use, and compatibility as discussed earlier (Tornatzky & Klein, 1982).

Figure 14 provides an overall view of all of these concepts as they relate to the adoption portion of the IT implementation model. Chapter 4 includes more information on how these influences interact in the adoption portion of this model.

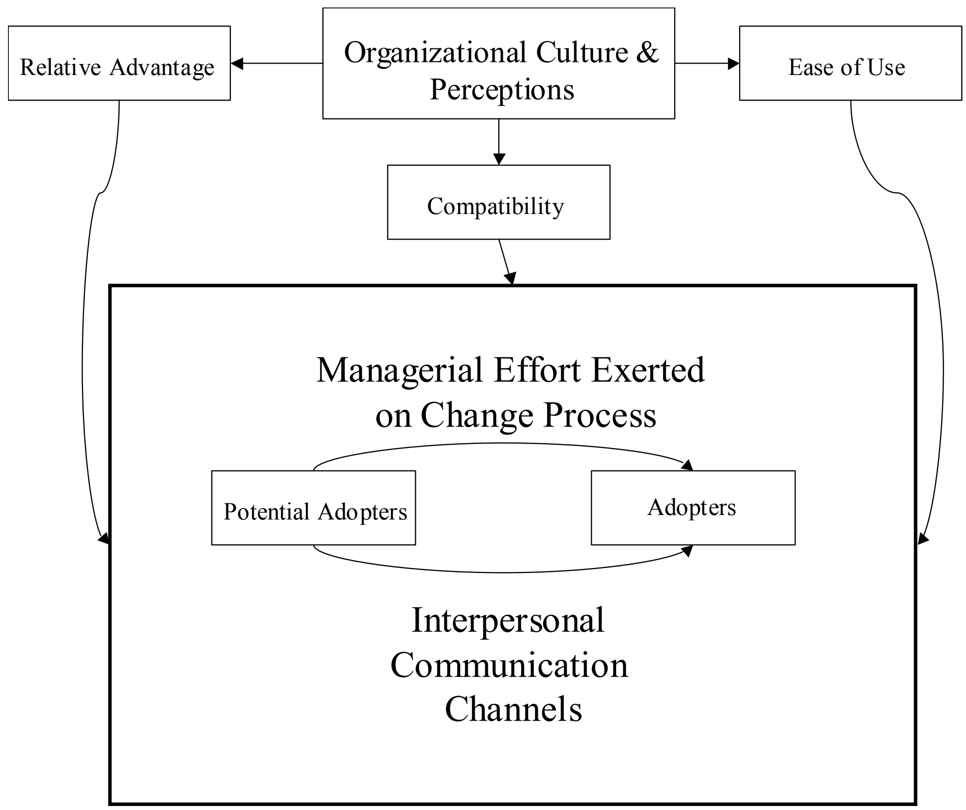


Figure 14: Modeler's View of Adoption Process

Integration.

The word integration is defined as combining technical hardware, technical software, and social system components into the business processes of the system.

GeoBase is more than simply an information technology (IT) integration effort (though this is a required element); it also aims to transform information behavior. Personnel must learn to share and spatially enable information. This level of change is categorized as second-order change. Second-order change requires more than mere incremental change – it requires personnel to move outside of existing parameters and frameworks and redefine how business is accomplished in their organizations (Cunningham, 1999:32). People often do not know what type of information is available in an organizational setting – instead of spending extra time trying collect new information, it would be much easier to have a general database of metadata for personal reference to check if required information already exists. When personnel share information, as uncomfortable and risky as this may be, for the good of the whole organization, it enables everyone involved in organizational business processes to accomplish their jobs much more efficiently.

Organizational business process efficiency can be dramatically improved with the addition of meaningful IT capability. As GeoBase adoption continues to grow, adopters will begin to think inductively about technology. Instead of deductively saying, "I have a problem. What IT innovation is out there that can help me solve it," people can now inductively say, "Here is this IT innovation. What can I use it for to help me improve my business processes?"

Over time, GeoBase will arrive at initial operating capability (IOC). However, this is not the end of the GeoBase implementation process. Personnel must be initially trained on how to use the innovation and make the commitment to adopt, then they can begin finding innovative uses for it. Integrating technology into business processes is done much more effectively by the personnel operating within the process than by outsiders looking in. Cosmopolitan teams of insiders and outsiders are usually the most effective at reengineering business processes with new IT innovations (Hammer & Champy, 2001). Integration, in this context, is more than introducing a new technology into an organization and expecting people to use it. Managers must assist personnel through a process of personal discovery. If managers can help their personnel progress through this adoption process by alleviating roadblocks and other distractions, then subordinates will begin to buy-in to the GeoBase initiative and find ways to integrate it into their business processes. GeoBase integration, in this model, is a very aggregated term. GeoBase integration is more than merely increasing the technological capabilities of IT or focusing solely on individual or group adoption of technology; it is about changing how the organization deals with information sharing and IT capability and using these enhancements to make the business processes of the organization dramatically more efficient. This type of second-order change takes time, but with proper management, personnel will adjust and all will benefit.

For the GeoBase initiative to maximize its potential in the organization, managers and adopters must find ways to integrate it into their business processes. There are a number of ways to do this. If organizations already understand their business processes and only require business process enhancements to moderately improve performance, they may find ways to integrate GeoBase technology without having to rethink the way business is done in general. This approach is akin to continuous improvement (kaizen). However, this research proposes that for significant gains in organizational effectiveness to occur, many of the fragmented processes alive in the Air Force organizations today must be reengineered.

A typical civil engineer (CE) squadron (or any organization in the Air Force) provides an illustrative example of a reengineering opportunity. Most Air Force organizations are structured around fragmented functionality. Most CE Squadrons are composed of an engineering flight, environmental flight, maintenance engineering flight, etc. However, most of the products that organizations produce for a customer are the result of a process. A new building construction process for a customer has elements of engineering, environmental, maintenance engineering, and other CE-internal and CE-external inputs that run across existing functional units. Obstacles to communication often reside between functional units, which produce time delays, quality problems, and missed information. Under the current system, a new building may not be adequately designed with customer requirements in mind, project delays can multiply due to coordination delays, and certain environmental considerations may not be taken into account, resulting in environmental compliance problems. Moving from a functional organizational model to a process-oriented model would bring more value (less expensive, faster, better quality) to the products the customer is interested in. Instead of the organization being solely comprised of functional units, the creation of a new building process team, with membership in the process team based on product value-added input, could revolutionize the way business is done for great gains in time, cost, and quality. IT innovations, such as GeoBase, can become process enablers and allow these value enhancements to realistically materialize.

Often, reengineering is thought to be synonymous with organizational downsizing. It is true, oftentimes, that fewer personnel are a result of reengineering, but the goals of reengineering are not based on this factor alone. Some basic concepts from the business process reengineering literature will be discussed to hopefully clear up some of this confusion and show how the GeoBase initiative can have a dramatic impact on organizational performance in the form of efficiency, effectiveness, and lower costs, resulting in a better product for the customer.

Business Process Reengineering.

One of the major aspects of integration, as defined in this research, is the concept of business process reengineering. Reengineering is defined as "the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service, or speed" (Hammer & Champy, 2001:35).

The definition for reengineering contains four key words: fundamental, radical, dramatic, and processes. The word fundamental is emphasized because it forces organizational personnel to ask basic questions about how they operate. Asking fundamental questions forces personnel to look at the basic way they do business – why do we do things the way we do? Often, underlying assumptions that dictate how business gets done are based on erroneous, obsolete, or inappropriate rules. At the heart of reengineering is the premise that old rules can be destroyed and new rules can be created that replace the *what is* with *what should be* (Hammer & Champy, 2001:35-36).

The word radical refers to the concept of getting to the root of the problem and avoiding merely superficial changes. With reengineering, personnel can cast off the old and bring in a completely new way of doing things. Reengineering is about business reinvention – not business improvement, enhancement, or modification (Hammer & Champy, 2001:36).

The word dramatic refers to the concept of making quantum leaps in performance rather than marginal or incremental improvements. A need to improve process performance by 10% does not provide the impetus for reengineering – other methods such as incremental quality programs or exhorting personnel can dig an organization out of a 10% hole. Reengineering should be used when magnitudes of enhanced performance are needed (Hammer & Champy, 2001:36-37).

The last word, processes, is the most important in the definition of reengineering. Most managers do not think in terms of processes. Instead, they tend to think in terms of tasks, jobs, people, and structures. A business process is defined as a "collection of activities that takes one or more kinds of input and creates an output that is of value to the customer" (Hammer & Champy, 2001:38). The fragmentation of processes in organizations can be traced back to Adam Smith and his seminal work, *Wealth of Nations*, written in 1776 (Hammer & Champy, 2001:13). Smith determined that for organizations to be their most productive, work must be broken into its most simple tasks and each task assigned to a specialist – this division of labor was a very effective way to operate under the old rules of business efficiency where mass production was the key factor in success. In fact, management bureaucracy is the glue that holds together the fragmented business processes that division of labor created. In today's world however, customers, competition, and change itself have gone through such a metamorphosis that the old rules of division of labor do not usually work well. In today's world, customers want products that suit their individual needs, not those meant for the general population. With the number of competitors in the marketplace today, organizational survival is predicated on who will satisfy the new demands of customers. Technology growth has taken change from the every-so-often event to the norm – organizations must adapt to this level of change to be successful in today's world.

A major focus of business process reengineering is to put the fragmented pieces of processes back together to allow organizations to function productively in today's context (Hammer & Champy, 2001). The business process reengineering concept may have been derived from research in non-government companies, but the lessons learned apply as much to them as to government organizations, such as the Air Force.

Information technology plays a crucial role in business process reengineering, but one that is commonly misunderstood. Information technology is an essential enabler for reengineering, but merely throwing computers and technology at a problem does not cause it to be reengineered. Most managers are good at thinking deductively, which is to say they are good at defining a problem and seeking solutions to it. However, successful application of information technology to reengineering requires inductive thinking. Inductive thinking is the ability to first recognize a powerful solution and then seek the problems it might solve, possibly problems the organization does not know it even has (Hammer & Champy, 2001).

Even when thinking inductively about information technology, managers often make the mistake of viewing information technology through the lens of their existing processes. Instead of looking for ways that information technology can merely improve the way things are currently done, managers should look for ways that information technology can allow them to do things they are not already doing. Reengineering spawns innovative thinking – it exploits the latest capabilities of technology to achieve entirely new goals (Hammer & Champy, 2001). This research proposes this is the key to integration – allowing the information technology innovation to enter and change the business processes of the organization to achieve dramatic improvements in system performance.

It is difficult for managers and organizational personnel to continually think inductively about technology and implementing changes that offer more uncertainty – people get comfortable with their level of competence and tend to stop learning. A few issues related to individual and organizational learning will be discussed to lay the foundation for the rest of the integration discussion.

A System's View of Mental Models and Learning.

In order to adopt an innovation and act as a force for innovation integration, the potential adopter must go through a learning process. System dynamics can help us understand how this process progresses as a feedback loop. "We make decisions that alter the real world; we gather information feedback about the real world, and using the new information we revise our understanding of the world and the decisions we make to bring our perception of the state of the system closer to our goals" (Sterman, 2000:14). In addition to the process described above, decisions are also a result of a decision rule or policy, which come from institutional structures, organizational strategies, and cultural norms (Sterman, 2000: 16). These are all affected by our mental models, which are "deeply held images of how the world works" (Kim, 1993:39). Figure 15 is an illustrative example of this feedback loop conditioned by our mental model.

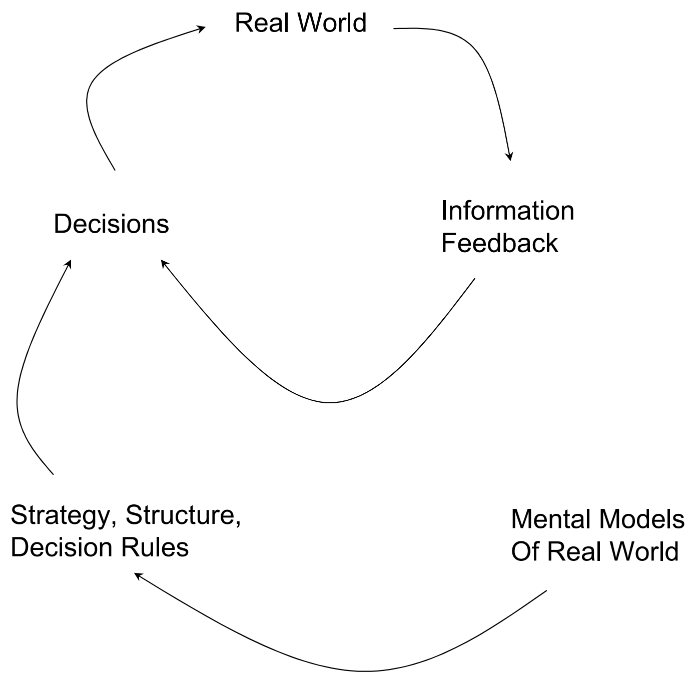


Figure 15: Single-loop Learning (Sterman, 2000:15)

The type of learning process pictured in Figure 15, commonly referred to as single-loop learning, helps an individual change a particular decision he or she might make, but to actually change how they think about a given problem requires double-loop learning (associated with second-order change).

Figure 16 illustrates the difference between these two types of learning processes for an individual. Single-loop learning, though information from the environment is still obtained and taken into account in the decision process, relies on the same mental model of the real world. When substantial change or a significant paradigm shift is introduced into a system, the mental model of the individual must change to accommodate this adjustment; hence double-loop learning is required.

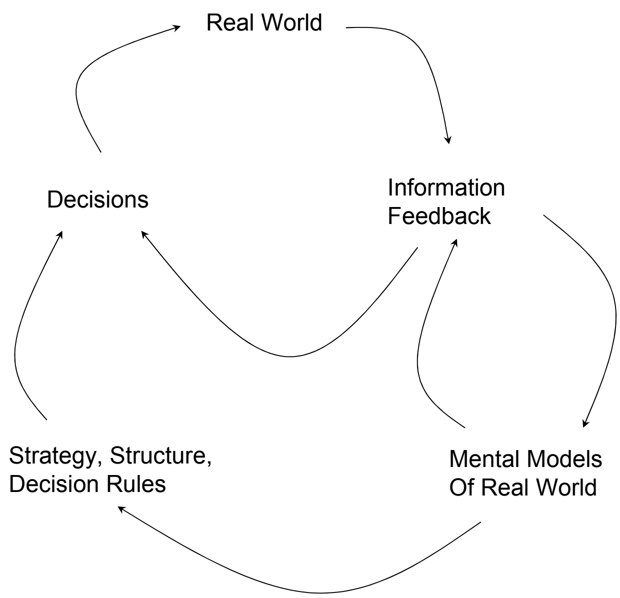


Figure 16: Double-loop Learning (Sterman, 2000:19)

Mental models differ from the commonly held belief of how static memory operates because mental models filter what an individual sees and does (Kim, 1993:39). Mental models are similar to the source code for a computer's operating system, acting as the manager and arbiter of gathering, storing, using, and deleting new information. However, they are also a step higher, since they are also like the source code programmer – they can rewrite the source code and choose between different sets of code (Kim, 1993:39).

Kim (1993) breaks learning into two types: operational (required steps to complete a task) and conceptual (why things are done the way they are in the first place). Mental models are an important part of how an individual learns. To illustrate the link between mental models and learning, consider the following analogy. Imagine the task of driving a vehicle home from work. Usually, each person has a favorite return route. This belief system is our framework that guides our choice between a route with the least stoplights and the one with the most scenic views. Once we have decided on a route, we execute this routine whenever we want to return home – as if on autopilot. If there is road construction or something that blocks this route, we have to rethink our criteria of what represents the best route home and select a new one. This is the model of individual learning – a cycle of conceptual and operational learning that informs and is informed by mental models (Kim, 1993).

Cunningham introduces some important concepts from the writings of Peter Drucker to give further understanding of individual and organizational learning. Drucker wrote about his experiences in Japan and compared their learning paradigm to the western learning paradigm.

Some of the specific references to the Japanese emphasis on learning include (Cunningham, 1999:47):

- the idea of 'continuous learning';
- every employee (including managers) attended training sessions;
- learning was seen as part of regular, scheduled work;
- training sessions were not, as a rule, run by trainers but by the employees;
- experts (for example, industrial engineers) would assist in learning sessions but not take the lead or dominate;
- learning did not focus on just one skill at a time – people learned about all the work in the unit: they did not focus on one person or one job but on the whole unit or the whole plant;
- training sessions were oriented to developing new, creative ways of doing things.

Japanese culture fostered a Zen-based learning tradition where learning was seen as a perpetual process of self-improvement (Cunningham, 1999:48). Japanese workers understood the concept of a learning curve to mean unending learning – ever expanding knowledge and abilities (Cunningham, 1999:48). On the other hand, the western view of a learning curve is an approach to steady state behavior pattern (Cunningham, 1999:48). Figure 17 could represent the Japanese view of learning as opposed to Figure 18, which represents the western view of learning.

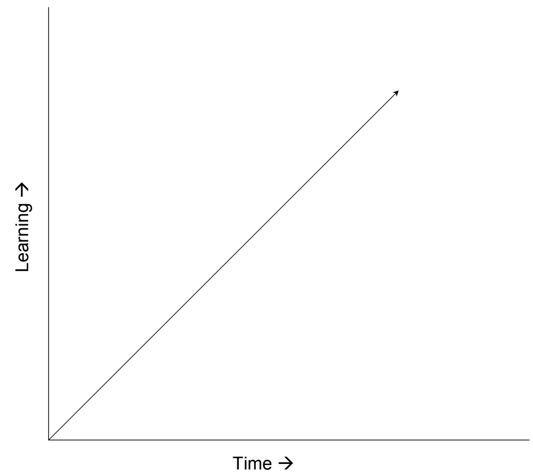


Figure 17: Possible Japanese Model of Learning

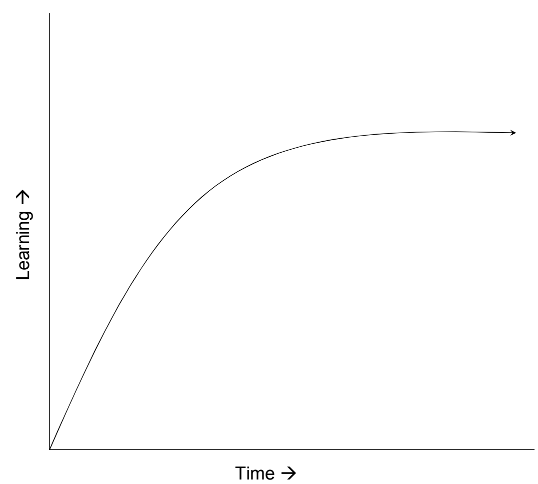


Figure 18: Western Model of Learning (Cunningham, 1999:48)

In the Western model, learning is a temporary nuisance that is cured by the individual leveling-out into competent performance (and, by implication, ceasing significant learning until the next promotion requires increased learning). The economic and production success of the Japanese following WWII (specifically in the 1970s) is partially attributable to this learning paradigm. Japanese companies that have moved into North America and Europe have shown that the indigenous workforce can learn in similar ways to the Japanese, hence this type of paradigm shift is possible and useful for studying how western organizations can increase their learning capacity and make marked improvements in productivity and knowledge creation (Cunningham, 1999:47-48).

Cunningham also notes that both societies had troubles making the transition to double-loop learning. The Japanese were very efficient within their existing way of thinking, but had problems dealing with second-order change (Cunningham, 1999:48). It is uncomfortable moving away from existing mental models (which is essentially change), hence the difficulties inherent in double-loop learning. Often in change initiatives, there is a substantial amount of individual and organizational resistance to change (Isabella, 1990:34; Armenakis et. al., 2000:327). This research proposes that resistance to continued learning is one of the major compensating influences on IT integration. From the discussion of individual learning and the complexities of changing mental models of the real world (double-loop learning), one can see why it is difficult to undergo IT-induced second-order change. If it is difficult for individuals to undergo double-loop learning and second-order change, how much more difficult is it for organizations composed of multiple individuals to do the same? Since this research focuses on achieving GeoBase integration within an organizational setting, as opposed to a lone individual, it is necessary to examine how individual learning and knowledge is transferred from individuals to the organization for its continued improvement.

Learning Organizations.

There is a large body of research that focuses on identifying how to create a "learning organization" (Garvin, 2000; Kim, 1993; Cunningham, 1999; Beer & Eisenstat, 1996; Romme & Dillen, 1997). A learning organization can be defined as "an organization skilled at creating, acquiring, and transferring knowledge, and at modifying its behavior to reflect new knowledge and insights" (Garvin, 2000:80). Romme and Dillen point out that "the gap between individual and organizational learning is perhaps the biggest barrier in moving toward learning organizations" (Romme & Dillen, 1997:77). System dynamics modeling can be especially useful in understanding and alleviating this gap between individual and organizational learning since it offers "a number of resources for reducing fragmented learning, involving situations in which individuals learn but the organization as a whole does not" (Romme & Dillen, 1997:77). The work of Kim clarifies how individual and collective mental models interact and operate as a transfer mechanism between individual and organizational learning (Kim, 1993:44).

Specifying the transfer mechanism between individual and organizational learning uncovers the process through which individual learning embeds itself into an organization's memory and structure (Kim, 1993:37). An organization's memory is composed of manuals, procedures, symbols, rituals, myths, physical office layout, and all of the current individual memories of its employees (Romme & Dillen, 1997:73). All organizations are made-up of individuals; organizations can learn independent of any one individual, but not independent of all individuals (Kim, 1993:37).

Organizational learning is more complex and dynamic than a mere amalgamation of individual learning (Kim, 1993:40). As individuals have their own mental models, organizations have what Kim calls shared mental models – "shared assumptions that protect the status quo" (Kim, 1993:41). Organizational culture is defined much the same way as shared mental models. Organizational memory is composed of everything that is retrievable, but a static definition is not very useful when trying to understand how organizations learn (Kim, 1993:43). Only the parts of an organization's memory that are relevant for organizational learning are those that make-up active memory (portions that outline what an organization gives heed to, how it acts, and what experiences it chooses to remember) (Kim, 1993:44). These active memory portions explicitly or implicitly define both individual and shared mental models (Kim, 1993:44). When the shared mental model precludes people from easily exchanging information, little learning is possible. One of the methods Kim recommends for overcoming shared mental model complications, leading to organizational learning, is to make them explicit (Kim, 1993:46). Making mental models explicit is one of the learning management methods discussed in the next section.

<u>Individual and Organizational Learning Management Interventions.</u>

Kim identifies that the "mental models in individuals' heads are where a vast majority of an organization's knowledge (both know-how and know-why) lies" (Kim, 1993:44). Since mental models are composed not of reality, but perceptions of reality, then fundamental to learning is a shared mental model (Kim, 1993:46). If one could accurately and easily articulate what composes his or the organization's mental model, then most learning problems could be overcome. However, organizational learning problems stem from the fact that mental models are a mix of both what is learned explicitly and absorbed implicitly – hence communicating them is difficult (Kim, 1993:46). Mental models are usually highly dynamic and nonlinear phenomena, so tools such as system dynamics become effective to help elucidate much of this complexity through causal loop diagrams and computer modeling and simulation (Kim, 1993:46). As mental models are made explicit and actively shared, a base of shared meaning in the organization widens and the organization's capacity for effective coordinated action increases (Kim, 1993:48). Making mental models explicit is one way to close the gap between individual and organizational learning and fosters an environment where a learning organization can flourish.

The process of making mental models explicit also aids how individuals communicate within an organization. Garvin recognizes the first step in creating a learning organization is fostering an environment that is conducive to learning (Garvin, 2000:91). Managers must give employees the opportunity to learn – if they are rushed or overwhelmed with pressing tasks, the possibility of organizational learning is depressed (Garvin, 2000:91). It follows from this analysis that employees must take advantage of the learning time given to them or nothing constructive will occur.

Garvin also identifies the need to open up boundaries and stimulate the exchange of ideas between functional units within and without the organization (Garvin, 2000:91). Autonomous groups within organizations have a tendency to isolate themselves and view the function of the organization only from their perspective (Romme & Dillen, 1997:75).

Their mental model perceptions are framed in such a way that they are unable to view events from the perspective of other elements within the organization. The "not invented here" syndrome must be replaced by "enthusiastic borrowing" when innovative and positive ways of doing business are discovered outside one's own group (Garvin, 2000:86).

When knowledge and skills are linked to specific people or groups within an organization and not shared and distributed to others, the danger of deterioration creeps in. Deterioration is the "breakdown of the organization's capacity to learn" and reverses any organizational gains from learning (Romme & Dillen, 1997:69). As people possessing unshared knowledge transfer out or leave the organization, deterioration increases (Romme & Dillen, 1997:75). Garvin argues for the creation of "learning forums" where information can be freely exchanged among members of differing groups in a supportive and open environment (Garvin, 2000:91). Hoarding information and unhealthy inter-group competition is reduced in these pro-learning environments (Cunningham, 1999:50). These types of forums foster double-loop learning, especially when forum activities require employees to wrestle with new knowledge and consider its implications (Garvin, 2000:91). In terms of GeoBase integration, since the Air Force is at the initial stage of development, there are many business processes that remain unaffected by GeoBase improvements. However, one of the GeoBase objectives is to <u>significantly</u> improve mission processes (Department of the Air Force, 2000b:7). For significant improvements, business process reengineering is a proven commodity; for minor improvements, continual improvement programs are applicable. Business process integration can be aided through a cross-functional information exchange forum where double-loop learning can be exercised.

Cunningham proposes a practical approach to both individual and organizational learning that increases inter-group communication, fosters the proper organizational learning environment and culture, and allows individuals to "own" their learning process (Cunningham, 1999). This approach, called self managed learning (SML), aims at achieving long-term results and emphasizes the need for organizational buy-in with the support of top management (Cunningham, 1999:xi-xii). Garvin identifies that education and training programs are powerful tools for transferring knowledge, but for them to add value to the organization, they must be linked explicitly with implementation (Garvin, 2000:88). Cunningham seems to recognize this important element since his approach is devoid of standardized training or instruction modules, since these are typically too generalized and ineffective at motivating people to learn about their own behavior and thinking (Romme & Dillen, 1997:76).

Instead of solely using training sessions (though these may be a part of the approach), Cunningham has employees participate in training or self-educational activities based on individual learning contracts, in which a number of goals have been agreed upon by the employee and manager over, for example, the next four to nine months (Cunningham, 1999:177-180). These learning contracts are established in a learning set, composed of a group of preferably five individuals (including a set manager) from different backgrounds and positions within the organization (Cunningham, 1999:182-194). Knowledge and skills acquired in these learning sets are spread throughout the organization by merit of the eclectic group of individuals present within the set (Cunningham, 1999:182-194). Learning contracts allow the individual to "own" his learning and knowledge creation process and learning sets disperse space and facilities to learn collectively, building a learning culture throughout the organization over time (Cunningham, 1999:182-194). Integration of set learning with daily tasks is also stimulated by this approach since individuals can discuss pertinent individual issues during the set meeting and get different perspectives on these issues (Cunningham, 1999:182-194). Knowledge retention is increased when paired with operational exercise (Romme & Dillen, 1997:76). An approach, such a Cunningham proposes, that, to some degree, unshrouds individual and shared mental models and increases inter-group communication is of most benefit for the learning organization to reduce learning fragmentation (link between individual and shared mental models is poorly maintained (Kim, 1993:46)) and deterioration.

Organizational Resistance to Change.

When people become comfortable in their surroundings and feel competent in their jobs, they tend to resist a lot of increased learning (Cunningham, 1999). People also resist change – it creates uncertainty and forces them to adjust their ways of operating. In the aggregate integration concept resides the concept of organizational resistance. This research views organizational resistance in the integration context as both resistance to continued learning and resistance to change.

Second-order change forces individuals to change their mental models through double-loop learning processes (Sterman, 2000; Kim, 1993). This is uncomfortable, as was discussed in a previous section, so individuals tend to resist changes that force double-loop learning. If managers are able to effectively intervene and assist individuals change their learning paradigms, then much of this resistance disappears (Kim, 1993). The focus of change process management is to communicate to personnel why the change is necessary and assist them in reducing their own uncertainty, thus decreasing their change resistance.

This research proposes that the limits to the level of IT integration in an organization are naturally caused by the level of organizational resistance present in the organization. Integration is probably the most aggregated concept in this model because it takes many different concepts, such as business process improvement and reengineering, learning, and organizational resistance, and brings them under one heading. However, the summarizing concept in this research, which brings together all of the concepts discussed to this point is that of organizational inertia.

Organizational Inertia.

Organizational inertia, in this model, is an overarching concept that "encompasses personal commitments, financial investments and institutional mechanisms supporting the current way of doing things" (Huff et al., 1992:55). The three main aggregate variables discussed in the model to this point (operating capability, adoption, and integration) capture the concepts embedded in the definition of organizational inertia by Huff et al. Personal commitment is at the heart of adoption, financial investments are associated with operating capability, and institutional mechanisms could also be described as the business processes of the organization. When most people in the organization accept the innovation (and probably stop referring to it as an innovation) as the way certain things get done, this indicates it has probably been effectively integrated into some of the business processes of the organization. This acceptance as status quo also indicates a level of positive organizational inertia has been developed.

Organizational inertia is linked with the concept of organizational memory. Organizational memory is composed of everything in the organization that is retrievable; this includes all of the written documentation in the organization, the experiences and knowledge of personnel, manuals, procedures, symbols, rituals, and myths (Kim, 1993:37; Romme & Dillen, 1997:69). As an organization lavishes time and resources upon an innovation and as adopters buy-in to the innovation and seek to integrate it into the organizational business processes, organizational memory increases, thereby increasing organizational inertia.

It is important to understand that organizational inertia can be either positive or negative. Positive organizational inertia would tend to support further integration, support adoption, and continue increasing operating capability. Negative organizational inertia, on the other hand, would tend to decrease integration, decrease adoption, and decrease operating capability.

Positive organizational inertia stores the positive continuance practices of the organization as they relate to the innovation. For long-term innovation sustainment, the organizational memory must accumulate positive experiences and pass them on to others in the organization. In contrast, negative organizational inertia stores the negative continuance practices of the organization and leads to long-term innovation rejection.

Organizational inertia is also, to a large degree, determined by the context within which the organization functions. Referring back to Figure 3, there were four main items that were exogenous in the GeoBase system and defined the context of the system:

funding, top level support, organizational culture, and innovation meeting needs. HAF GIO provides a portion of the context for the squadron-size GeoBase system through Air Force-wide GeoBase leadership and funding. In this model, HAF GIO helps define the organizational context the GeoBase system manager functions in. This influence, in this model, is derived mostly from top leadership support and funding. The organizational culture is also very important. If an organization is innovative, perceptions of innovations will be better and adoption will tend to increase more quickly. If an organization is rigid, or unkind to innovation and change, it will tend to prevent or reduce adoption. Another important concept in the organizational context is whether the innovation is meeting both personal and organizational needs or not. If both the individual user and organization's needs are being met as a result of innovation use, innovation integration will be supported over the long-term. If not, organization inertia will not support continued integration.

The upcoming discussion focuses on literature examples, some using the system dynamics approach, which help to provide a better understanding of organizational inertia. The reader should not expect to see all of the factors discussed in this section to be included in the formalized model, since the literature research is guided by wholly different questions.

Contextual Issues in Organizational Inertia.

Contextual issues in organizational change play a major role in organizational inertia. Contextual factors focus on forces or conditions existing in an organization's internal or external environments. External conditions could include things such as governmental regulations and technology advances, whereas internal conditions could include the degree of specialization or work specificity required by existing technology and experiences with previous changes (Armenakis & Bedeian, 1999:295).

Fox-Wolfgramm et al. analyzed the effects of the Community Re-Investment Act (CRA) on two Texas banks and how the banks reacted to these regulatory changes in their environments. One bank was labeled a *defender* bank and the other a *prospector* bank, given their previous methods of operating. Changes as a result of CRA on these two banks required the defender bank to go through second-order change, whereas the prospector bank went through first-order change. The second-order change required of the defender bank was inconsistent with its envisioned identity and image, so the change was ultimately rejected. On the other hand, the changes required of the prospector bank were sustained because they were consistent with its envisioned identity and image. As a result of this work, Fox-Wolfgramm et al. proposed that to be sustainable, change must be consistent with an organization's current identity or envisioned identity and envisioned image (Fox-Wolfgramm et al., 1998:118). Likewise, for GeoBase to be sustainable, it must fit in with the organizational identity and image, which are determined by the organizational culture.

Huff et al. developed and simulated a characterization of how organizations move between state sustaining strategic renewal and the more radical changes that significantly alter organization activity over time. Their argument juxtaposes inertia (commitment to current strategy) and stress (dissatisfactions that signal the need for renewal). Huff et al. model differing evolutionary processes that simulate differing renewal paths and the interaction of cumulative stress and inertia that naturally develops in organizations over time (Huff et al., 1992).

Organizational inertia will grow over time as basic business task demands are met. Successfully meeting demands leads to more detailed and routinized policies and procedures to increase reliability. As managers find the organization's new strategy satisfactorily meets current conditions, and as they make decisions following its prescription, the new strategy is further supported. As the new strategy is more strongly implemented, even individuals who are not completely convinced of its benefits are motivated by self-interest to find ways to mark their stake in the status quo. This escalating commitment to current strategy, at the organizational level, can be thought of as organizational innovation adoption (Huff et al., 1992).

Resistance to further frame changing renewal in the organization arises due to the difficulties associated with reconfiguring increasingly complex organizational activities surrounding the current strategy. Major strategy renewal efforts would resubject the organization to the inefficiencies and uncertainties of new innovation. Managers are more motivated to work with what they have inherited, since commitments become less easy to change and administrative mechanisms make it easier to predict satisfactory results (Huff et al., 1992).

In the period immediately following adoption of a new strategy, organizational inertia is low; but as time goes on, inertia and the associated resistance to changing a satisfactory strategy will tend to follow the classic 's-shaped' adoption curve (shown in Figure 19). Despite the prediction that inertia will increase, escalating commitment is not always inevitable. New personnel, transferring champions, and eliminated institutional repositories of organizational memory can cause dampened or stepped reduction in inertia over time (Huff et al., 1992).

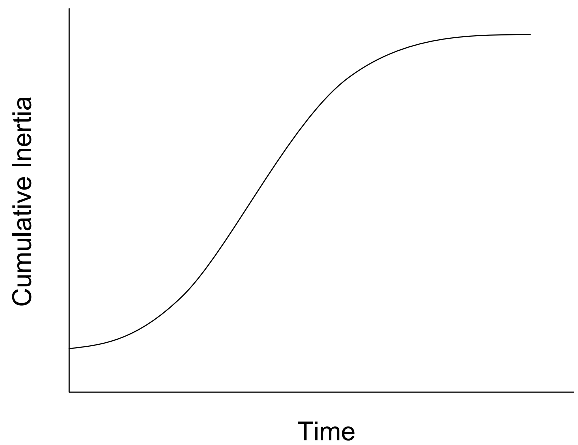


Figure 19: Cumulative Inertia Surrounding Current Strategy (Huff et al., 1992:57)

Even though the forces of inertia generally gain strength over time, the grounds for significant strategic renewal are always present as well. Poor performance, technological advances, internal reorganizations, and new leadership can make past strategic positions less appropriate. "Organization stress" is a "summarizing concept that expresses ways in which current strategy is not satisfactory; it reflects the dissatisfactions of individual actors and imperfections in the fit between the organization and its environment" (Huff et al., 1992:58).

Stress is always present because no strategy is perfect – it will increase if strategy implementation falls short of expectations. Stress also increases because the environment in which the organization functions is dynamic. As opportunities develop and new technologies and ideas become available, the inadequacies of current strategy are compounded. Stress accumulating over time is likely to lead more and more people in the organization to perceive the benefits of major strategic renewal, in contrast to the processes that increase commitment to current strategy.

Stress tends to dissipate over time as attention to and memory of specific stressful events fade (Figure 20). These stress adjustment processes are all aspects of an important form of organizational renewal called homeostatis, defined as "the tendency of a system to maintain internal stability owing to the coordinated response of its parts to any situation tending to disturb its normal condition or function" (Huff et al., 1992:58). However, not all problems can be satisfactorily resolved within one strategic framework. It is unlikely that homeostatic efforts can completely counteract dissatisfaction over time when large stressors enter the system. Cumulative stress, which makes major strategic change more likely to be sought and accepted, is usually associated with specific stressful events (Huff et al., 1992).

Figure 20: Cumulative Stress with Homeostasis (Huff et al., 1992:59)

Stress and inertia are interdependent; therefore, their effects upon major strategic change decisions must be evaluated simultaneously. Larger stressors (and short time horizons) will usually generate major strategic change (second-order change); while smaller inconveniences lead to more incremental efforts (first-order change) (Huff et al., 1992).

Sastry also developed a simulation model for analyzing the dynamics of organizational change. Sastry formalized a theory of organizational change by Tushman and Romanelli (Tushman & Romanelli, 1985), in which organizations undergo occasional dramatic revolutions or punctuations to overcome organizational inertia and set a new path for the organization to follow. Sastry cites the need for his research because "critics of the existing research argue that, too often, the causal structures of the theories are not fully specified" (Sastry, 1997:237). Sastry also points out that his model does not treat the organization as a black box, but as a collection of functions carried out be personnel who are influenced by organization culture, norms, and practices and who in turn influence these organizational phenomena (Sastry, 1997).

Sastry uses a system dynamics approach in his research for three reasons. First, system dynamics "highlights feedback processes, or circular causal relationships in which variables influence and, in turn, respond to each other" (Sastry, 1997:240). Second, "an explicit representation of behavioral decision making is central to [his] approach" (Sastry, 1997:240). Sastry recognizes that decision makers are subject to bounds on their rationality as imperfect knowledge and expectations take time to update. As a result of using a system dynamics approach, lags inherent in collecting, assembling, and interpreting data and in taking action are represented explicitly. Third, "system dynamics distinguishes between state variables, such as the organization's number of employees or its inertia, and variables that represent rates of change, such as the rate of hiring and laying off or the increase in inertia per unit of time" (Sastry, 1997:240). Sastry specifies that this distinction is important because state variables, which represent properties of the organization that have been accumulated over the organization's history and characterize the system, cannot be changed instantaneously. Also, because system dynamics models approximate continuous-time processes, rather than step-by-step discrete processes, they are able to capture ongoing processes and simultaneous procedures that influence one another and can be used to explore the effects of time lags likely to be at work in an organizational setting (Sastry, 1997).

Sastry's model focuses on four organizational variables modeled as state variables: inertia (i.e., resistance to environmental reassessment and change in social and structural relationships); strategic orientation (i.e., what business a firm is in and how does it compete); performance (i.e., consistency of activities and organizational efficiency as perceived by top managers); and pressure for change (i.e., environmental changes that render an original strategic orientation ineffective).

Figure 21 is a simplified causal diagram for Sastry's model. Each internal variable is locked into a causal relationship with other variables. For example, as organizational inertia increases, the ability of the organization to change decreases (an inverse relationship represented by the minus sign on the causal connecting arrow from *Inertia* to *Ability to change*). As the ability of the organization to change decreases, the ability to change strategic orientation also decreases (a relationship shown by the plus sign on the causal connecting arrow from *Ability to change* to *Change in strategic* *direction*). If the reader follows the arrows that form a loop (arrows must loop in the same direction), the loop is either self-reinforcing or compensating. A self-reinforcing loop has either none or an even number of inverse (minus) causal arrows. A compensating loop always has an odd number of inverse (minus) causal arrows. In Figure 21, there are three self-reinforcing loops (loops labeled with a "P") and one compensating loop (loops labeled with an "N"). The model of punctuated change is fairly simple, containing only four state variables. However, it is difficult to simulate mentally since it contains feedback and nonlinear relationships. System dynamics modeling software acts as a differential equation solver and allows the modeler to perform these complex simulations after the model has been formalized in the computer's memory.

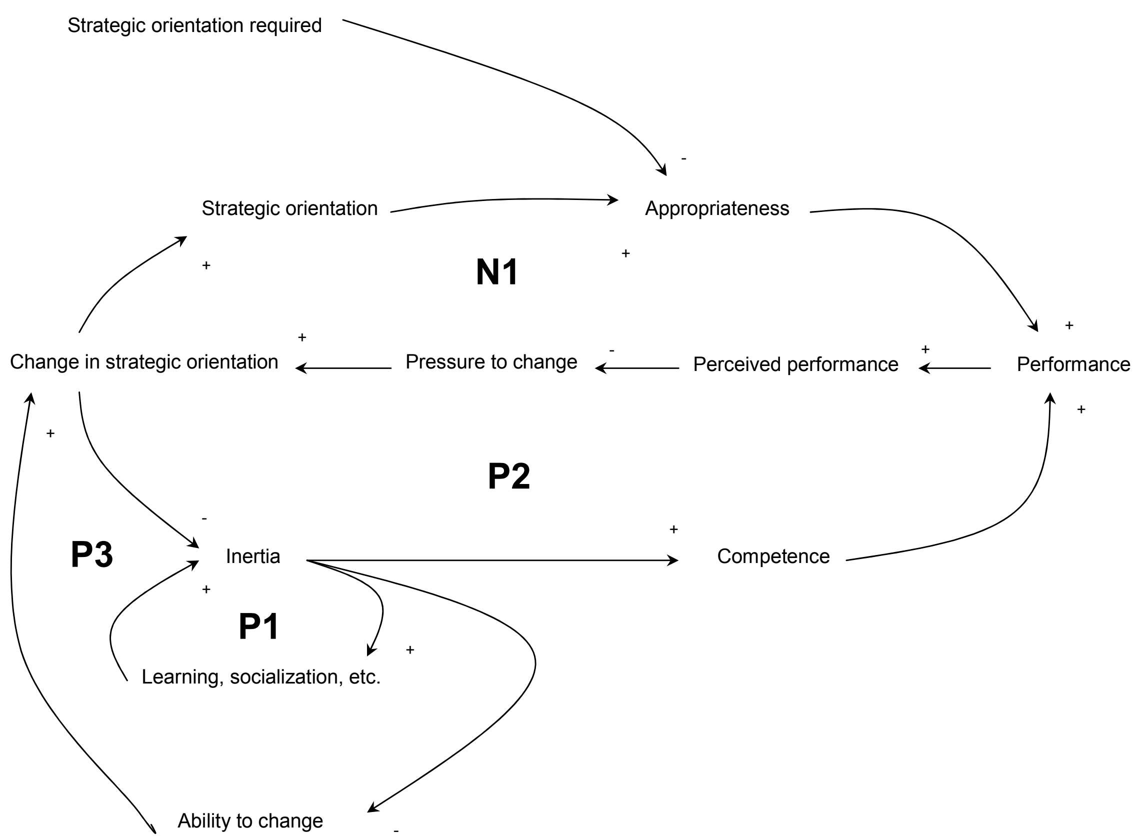


Figure 21: Simplified Causal Diagram of the Punctuated Change Theory (Sastry, 1997:244)

As long as the organization does not change its strategic orientation, inertia builds up over time through continuous social and structural processes, "as webs of interdependent relationships with buyers, suppliers, and financial backers strengthen, and as commitments to internal participants and external evaluating agents are elaborated into institutionalized patterns of culture, norms, and ideologies, the organization develops inertia" (Tushman & Romanelli, 1985:177). Sastry modeled inertia as a stock (state variable) representing the "degree to which these networks and relationships are solidified and the extent to which organizational culture is developed" (Sastry, 1997:247). Like other stocks, at time *t*, inertia is simply the integral of all previous changes in inertia, plus its initial value, I_o. The inertia stock is simply the difference between the rate of increase of inertia and the rate of decrease of inertia.

Using similar formalization techniques for each of the stocks and after testing his model, Sastry was able to simulate how this organizational system would operate over time. After simulating the model, Sastry found that if a new change effort followed too soon after a previous change, the organization did not have an opportunity to rebuild destroyed competence. This finding suggested for the organization to succeed, organizational leaders must, under some conditions, prevent change from taking place, even when it appears to be indicated (i.e., even when both organization-environment fit and performance are low). Usually this situation occurs right after a major reorientation, since this is the period when competence is lowest. In order to prevent too much change from taking place, the organization needs to suspend its responses to signals of poor performance and fit. To add this logic to his model, Sastry included a trial period routine, which represented an organizational policy of suspending the practice of monitoring, evaluating, and responding during the trial period (Sastry, 1997).

Empirical evidence from General Electric (GE) supports this finding. GE Chief Executive Officer (CEO) Jack Welsh implemented a new strategic orientation at GE and wrote in a 1991 shareholder letter, "parts of the organization needed to just sit there…like popcorn kernels in a warm pan" (Sastry, 1997:263). The waiting period eventually spawned improvements as, "suddenly, things began to pop here and there, with big ideas, process breakthroughs" (Sastry, 1997:263). Without a specific period of "soft initiatives," Welsh suggests, GE would not have achieved the performance gains of the early 1990s (Sastry, 1997).

Additionally, Sastry found that for organizations to survive constantly changing environments, they must undergo regular reorientations spaced far enough apart to maintain a level of competence. In his model, with the trial period routine and constantly changing environment, overall performance was much better than earlier versions of the model (Sastry, 1997).

Management Interventions.

The GeoBase implementation system focuses on four major management interventions: change process management, learning management, reward system management, and continuity management. These aggregated management intervention constructs all have been discussed to some extent throughout each of the sections of Chapter 2, but only change process management and learning management have received specific references in this chapter. The discussion of the aggregate management interventions will be completed by briefly discussing reward system management and continuity management.

<u>Reward System Management.</u>

Reward system management can take a few forms. Since personnel are motivated by personal gain, based on whatever the individual values, that manager should set up a system that rewards based on individual values. Managers should focus on rewarding ideas that come to fruition and assist GeoBase integration. These rewards may come in the form of money (something like the Air Force idea program), time-off, certificate awards and decorations, or whatever the personnel in the organization value. Rewards may not even be tangible – it could be that individuals value learning a new skill that has potential value in the public and/or private sectors or simply enjoy having the manager's positive attention placed on them. Whatever it may be, the manager must be able to effectively sell these rewards to the potential adopter to motivate the potential adopter to adopt the GeoBase innovation.

Continuity Management.

Elements of continuity management are present in most of the management interventions – since each assists the accumulation of organizational memory and, thus, inertia. In this context as a management intervention, continuity management focuses on passing the accumulated memory of the organization to others in the system to prevent disjointed organizational knowledge. When knowledgeable personnel leave the system and do not pass their knowledge on to others, the organization loses as a whole. Each organization has some degree of natural continuity – personnel will typically create a continuity file and include some helpful hints for the next person filling the position. There is also a repository of recorded organizational information that usually sits untouched on the shelves of the organization. The system manager can either allow the natural level of organizational continuity to dominate how knowledge is created, stored, and possibly read, or he can take a more active role in this process.

Managers can create programs that focus on "assembling a 'toolkit' to 'share the way ahead'" (Cullis, 2002:20). This toolkit would possibly consist of user information on GIS-related technology and any other useful applicable information associated with successful integration. This is a good program and can create good long-term continuity, but the fact that personnel typically do not take a lot of time to read historical documents makes this a somewhat weak pathway to increase integration in the unit over time. It is also important to understand that organizational memory contains both good and bad experiences, so if the IT innovation is not meeting organizational and personal needs, there would probably be a limited amount of positive recorded information that would be passed on.

Other Management Interventions.

The other management interventions include change process management and learning management, which were discussed earlier in Chapter 2.

Summary of Literature Review

A wide breadth of literature has been discussed. This discussion has been structured to assist the reader understand the development of the system dynamics model, which is forthcoming. The high degree of aggregation in each of these concepts allows the research to focus on the portions of the system that will substantially change behavior patterns over time. As a result, the modeler can avoid getting lost in the "dark forest of variables" that every system has and be able to analyze the system without rambling. The next portion of the thesis document, namely Chapter 3, will outline the system dynamics approach and how to navigate through it properly. Chapter 4 will delve into very specific information associated with the literature review in Chapter 2 while following the Chapter 3 methodology.

III. Methodology

General View of the Modeling Process

The system dynamics approach can be generalized into five main steps: problem articulation, formulation of dynamic hypothesis, formulation of a simulation model, testing, and policy design and evaluation. Table 1 presents each of these steps with some additional explanation of meaning.

Even though the modeling process appears to be a step-wise progression through various steps, it is more complex than that. Figure 22 shows an iterative, as opposed to a linear, progression through the steps. The modeler begins the modeling process with specific questions and a problem. As the modeler researches the problem in more detail and works with the client to better understand the system, the problem and/or questions about the system may change. Throughout the process, the modeler must question, test, and refine until both modeler and client are satisfied with the product (Sterman, 2000).

The modeler progresses through the iterative modeling process, but does so in a dynamic environment. Figure 23 shows the iterative modeling process, conditioned by the dynamic environment of the real world. Modeling itself is embedded in a larger cycle of learning and action taking place in dynamic organizations. Environmental context changes can change the way the modeler views the system. With updated information, these changes in the real world force changes in the modeler's mental model. The dynamic world in which we live and within which organizations operate will always require adjustments to models – such is the world we live in. "Modeling is not a one-time activity that yields The Answer, but an ongoing process of continual cycling between the virtual world of the model and the real world of action" (Sterman, 2000:89).

Table 1: Steps of the Modeling Process (Sterman, 2000:86)

Modeling Step	Elements of the Step
Step 1: Problem Articulation (Boundary Selection)	**Theme selection**: What is the problem? Why is it a problem? **Key variables**: What are the key variables and concepts we must consider? **Time horizon**: How far in the future should we consider? How far back in the past lie the roots of the problem? **Dynamic problem definition (reference modes)**: What is the historical behavior of key concepts and variables? What might their behavior be in the future?
Step 2: Formulation of Dynamic Hypothesis	**Initial hypothesis generation**: What are the current theories of the problematic behavior? **Endogenous focus**: Formulate a dynamic hypothesis that explains the dynamics as endogenous consequences of the feedback structure. **Mapping**: Develop maps of causal structure based on initial hypotheses, key variables, reference modes, and other available data, using tools such as causal loop diagrams.
Step 3: Formulation of a Simulation Model	**Specification** of structure, decision rules **Estimation** of parameters, behavioral relationships, and initial conditions **Tests** for consistency with the purpose and boundary
Step 4: Testing	**Comparison to reference modes**: Does the model reproduce the problem behavior adequately for your purposes? **Robustness under extreme conditions**: Does the model behave realistically when stressed by extreme conditions? **Sensitivity**: How does the model behave given uncertainty in parameters, initial conditions, model boundary, and aggregation?
Step 5: Policy Design and Evaluation	**Scenario specification**: What environmental conditions might arise? **Policy design**: What new decision rules, strategies, and structures might be tried in the real world? How can they be represented in the model? **"What if…"** analysis: What are the effects of the policies? **Sensitivity analysis**: How robust are the policy recommendations under different scenarios and given uncertainties? **Interaction of policies**: Do the policies interact? Are there synergies of compensatory responses?

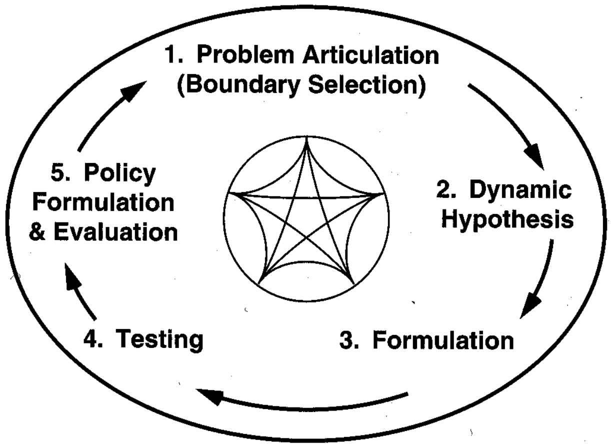


Figure 22: Illustration of Iterative Modeling Process (Sterman, 2000:87)

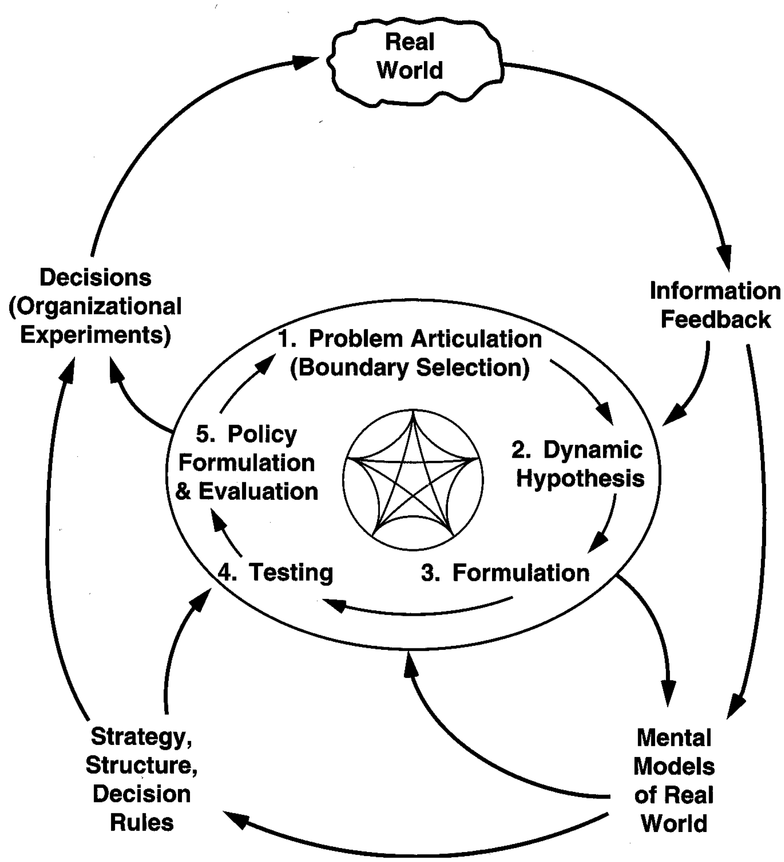


Figure 23: Modeling is Embedded in the Dynamics of the System (Sterman, 2000:88)

Step 1: Problem Articulation (Boundary Selection)

Theme Selection.

The modeler must first determine the problem that drives the research. The boundary of study is determined by the question that is posed at the forefront of the modeling process. The modeler must constrain his focus to only those portions of the system of study that pertain to the problem and questions. The incredibly high level of complexity that resides in most organizational systems forces the modeler to focus on the questions being asked; to do otherwise would open the way for overly complicated models that stifle system understanding and meaningful analysis.

The historical problems confronting IT implementation, which were recognized by the Headquarters Air Force Geo Integration Office (HAF GIO) as relevant for GeoBase implementation and sustainment, provided the impetus for this research effort. The research problem and questions (reference Chapter 1) were generated with this GeoBase implementation research opportunity in mind.

Key Variables.

To provide a link to the real world where implementation efforts are being conducted, the modeler required an expert client to advise as the research client. The following list comprises the requirements for the research client:

1. Client must have a good working knowledge of squadron systems where GeoBase implementation would occur.
2. Client must be associated with organizations at the forefront of the GeoBase implementation effort.
3. Client must commit to meet at least two times with the modeler to discuss hypothesized behavior and/or historical behavior patterns over time in the system.
4. Client must provide input on the substantial system variables that drive the agreed-upon behavior patterns.

The AMC GeoBase Implementation Officer and his staff met the client requirements, so they were specified as the research clients. The research problem and questions were coordinated with the research clients at the forefront of this effort to assure the model would be useful in addressing a problem they care about.

The modeler and clients discussed the important elements of the system that would determine the fate of GeoBase. Based on discussions with the clients and the literature, the general IT implementation model (Figure 3) was created, which specifies the major aggregate variables in the IT implementation system. The implementation actions of GeoBase managers and personnel, funding, and whether or not GeoBase would meet personal and organizational needs would define the long-term health of the IT innovation. Top-level leadership support, the quality of the GIS database, and the cultural fit between GeoBase and the organization are indicators if GeoBase is meeting organizational needs over time.

These issues would have a delayed effect on integration – the preparation for change that was currently going forward and the strong leadership support would push GeoBase implementation onward at the forefront, so if there were to be any ill effects from these sustainment issues, they would come later.

Time Horizon.

The time horizon "should extend far enough back in history to show how the problem emerged and describe its symptoms. It should extend far enough into the future to capture the delayed and indirect effects of potential policies" (Sterman, 2000:90). A short-term view would only dictate a time horizon of one year. Typically, a principal deficiency in our mental models is our propensity to think of cause and effect as local and immediate. In dynamically complex systems, cause and effect are distant in time and space. Most of the unintended effects of policy decisions leading to resistance involve feedbacks with long delays, far removed from the point of decision or the problem symptom (Sterman, 2000:91). Sterman recommends long time horizons as a "critical antidote to the event-oriented worldview so crippling to our ability to identify patterns of behavior and the feedback structures generating them" (Sterman, 2000:91).

The time scale for this GeoBase research effort is ten years. It takes time for significant change to take hold in organizations – Kotter described a company that quantified the amount of change from a transformation each year for seven years (Kotter, 1995:67). In order to adequately capture the potential of GeoBase integration and be able to take a long-term view, the client and modeler selected a ten-year time horizon for study.

Dynamic Problem Definition (Reference Modes).

In system dynamics modeling, the modeler must work from reference modes throughout the modeling process. The reference mode is a "set of graphs and other descriptive data showing the development of the problem over time" (Sterman, 2000:90). Figure 24 shows some examples of reference mode graphs, such as exponential growth, goal seeking (approach to steady state or exponential decline), s-shaped growth, oscillation, growth with overshoot, and overshoot and collapse. Each of these reference mode behavior patterns can be associated with something in the real world. For example, unchecked bacterial growth often displays exponential growth, whereas innovation diffusion often displays cumulative s-shaped growth behavior.

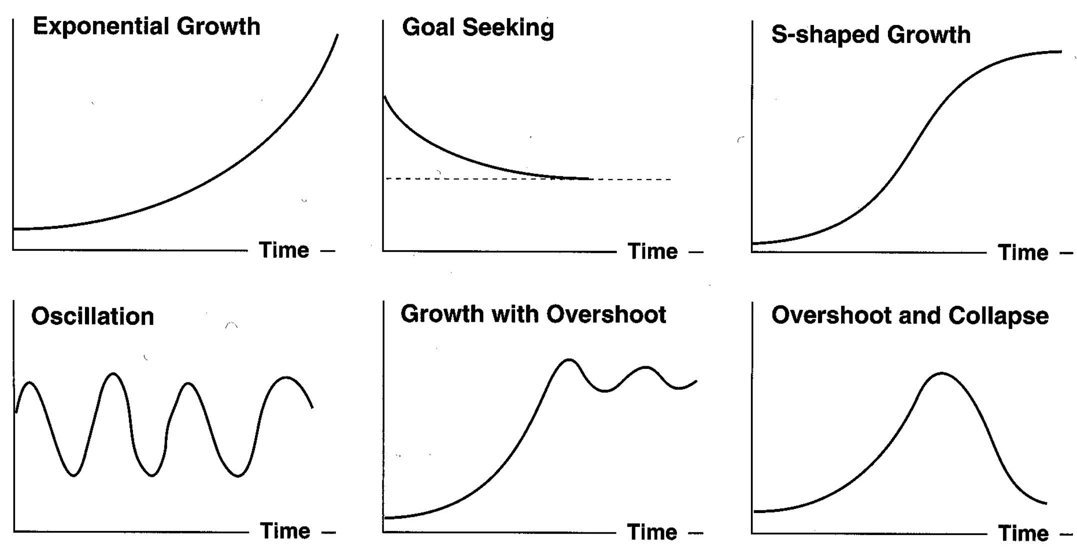


Figure 24: Examples of Reference Modes (Sterman, 2000:108)

Reference modes (named as such since the modeler refers back to them throughout the modeling process) help the modeler and client break out of the short-term event viewpoint (Sterman, 2000). The client focus on getting to initial operating capability (IOC) is an example of focusing on short-term goals. While arrival at IOC is an important part of the GeoBase implementation process, this research effort forces both the modeler and client to focus on the long-term integration effort that ultimately will determine GeoBase success.

Various reference mode graphs, which capture the behavior patterns of each aggregate variable over a specified time period, were proposed by the modeler and clients for each aggregate variable. The creation and rational behind each of the reference mode graphs for each aggregate variable is discussed in Chapter 4.

Step 2: Formulation of Dynamic Hypothesis

Initial Hypothesis Generation and Endogenous Focus.

With the problem well articulated at the forefront of the modeling effort, the modeler is prepared to develop a theory to account for the problematic behavior – namely, the dynamic hypothesis. This hypothesis is dynamic because it must explain the dynamic characterization of the problem in terms of the underlying feedback and stock and flow structure of the system. It is a hypothesis because it is always provisional – the modeler can always adjust or abandon the model as more information is gleaned from the real world (Sterman, 2000).

In defining the dynamic hypothesis, the modeler seeks an endogenous (arising from within the system) explanation for behavior. An endogenous explanation generates the dynamics of the system through the interaction of variables represented in the model. Typically, exogenous explanations (arising from outside the system boundary) do not adequately address system behavior. When exogenous variables are used, the modeler must question whether any of the endogenous variables have an impact on the exogenous variable. If so, the model boundary must be expanded to include the former exogenous variable and make it endogenous (Sterman, 2000).

The usefulness of modeling lies in the fact that it simplifies reality, creating a representation of reality we can comprehend. If modelers go about trying to model an entire system, this comprehensiveness would be just as complex as the real system and just as inscrutable. Hence, the art of modeling is knowing what to cut out of the model, based on the problem posed (Sterman, 2000). This research focuses on IT implementation; hence, the modeler can cut out portions of the more complex organizational system that do not significantly influence the IT implementation problem.

Mapping: Causal Loop Diagram.

Causal loop diagrams are tools for “diagramming the feedback structure of systems in any domain” (Sterman, 2000:102). Causal loop diagrams show the causal links among variables with arrows from a cause to an effect. Figure 25 shows the definitions, mathematics, and some examples of the link polarity of causal arrows. For example, an arrow with a (+) sign above it means if variable X increases, Y also increases. Likewise, if X decreases, Y also decreases. An arrow with a (-) sign above it means if variable X increases, Y decreases. Likewise, if X decreases, Y increases. As an example, if the number of deaths increases, the population decreases. This relationship corresponds to a (-) sign, as shown in Figure 25.

Symbol	Interpretation	Mathematics	Examples
$X \xrightarrow{+} Y$	All else equal, if X increases (decreases), then Y increases (decreases) above (below) what it would have been. In the case of accumulations, X adds to Y.	$\partial Y/\partial X > 0$ In the case of accumulations, $Y = \int_{t_0}^{t} (X + \ldots)ds + Y_{t_0}$	Product Quality $\xrightarrow{+}$ Sales; Effort $\xrightarrow{+}$ Results; Births $\xrightarrow{+}$ Population
$X \xrightarrow{-} Y$	All else equal, if X increases (decreases), then Y decreases (increases) below (above) what it would have been. In the case of accumulations, X subtracts from Y.	$\partial Y/\partial X < 0$ In the case of accumulations, $Y = \int_{t_0}^{t} (-X + \ldots)ds + Y_{t_0}$	Product Price $\xrightarrow{-}$ Sales; Frustration $\xrightarrow{-}$ Results; Deaths $\xrightarrow{-}$ Population

Figure 25: Link Polarity: Definitions and Examples (Sterman, 2000:139)

Each endogenous variable always has a causal link to another variable in the causal loop diagram. If a variable only has a one-way effect on another variable (and no other variable affects it), it is considered exogenous. The other purpose for the causal loop diagram is to show the feedback loops present within the system. Figure 26 shows the causal loop diagram notation. The positive, or reinforcing loop, denoted with an "R", is created by variables locked into a reinforcing behavior pattern. The natural behavior for this type of loop is exponential growth (Figure 27). The negative, or balancing (compensating) loop, denoted with a "C", is created by variables locked into compensating behavior. The natural behavior for this type of loop is exponential decay (Figure 28). A loop is considered a reinforcing loop is there is an even number of negative causal polarities within the loop structure. A loop is considered negative (compensating) if it has an odd number of negative causal polarities within the loop. Reinforcing loops tend to move a system out of balance by amplifying disturbances in the system and compensating loops tend to move a system toward an equilibrium point or goal.

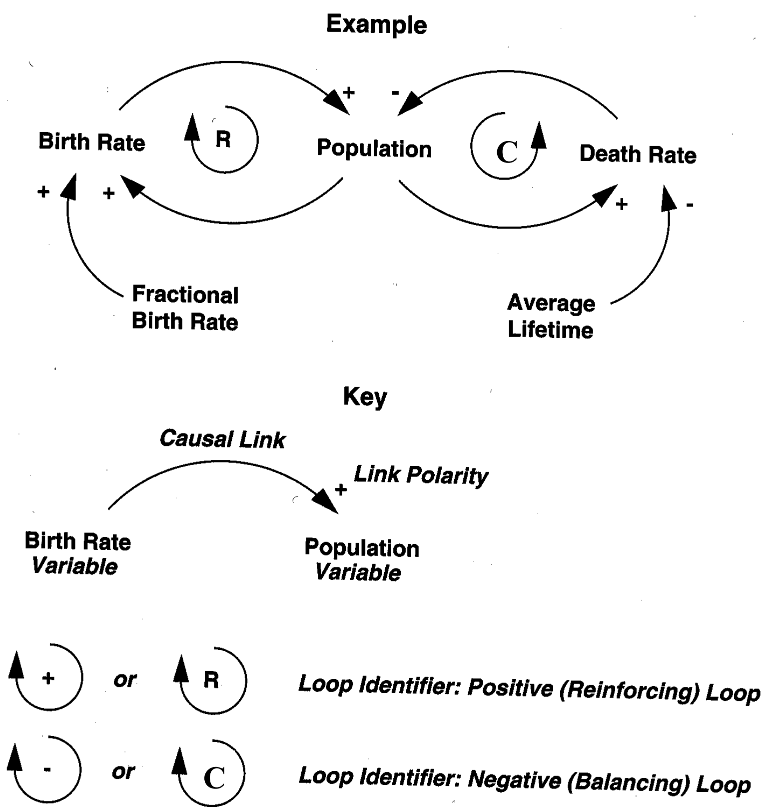


Figure 26: Causal Loop Diagram Notation (Sterman, 2000:138)

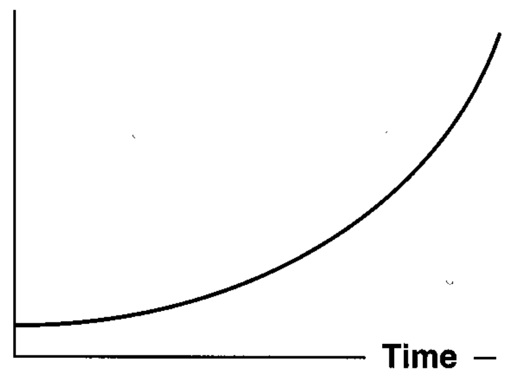


Figure 27: Exponential Growth (Sterman, 2000:108)

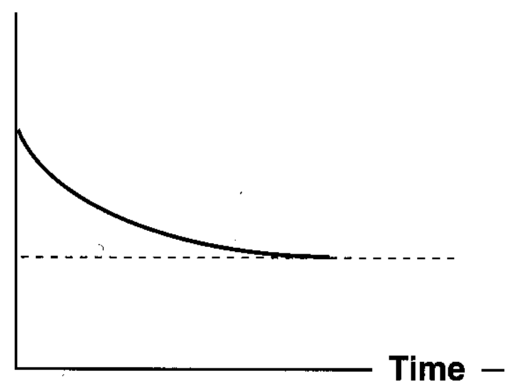


Figure 28: Exponential Decay (Sterman, 2000:108)

It is important that each arrow connecting variables in the causal loop structure represents a causal relationship as opposed to a correlated relationship, as is common in statistical analysis. As an example, if a statistical correlation exists between ice cream sales and murder, the modeler would not draw a causal arrow between these two variables. Instead, the modeler would find both ice cream sales and murder rise in the summer while in the winter they both fall as the average temperature fluctuates. A causal correlation might exist between temperature and ice cream sales and temperature and murder rate, but not between ice cream sales and murder rate (Sterman, 2000:142).

The modeler must also determine if there are delays between causal links. Delays are critical in the dynamics of a system. Delays give systems inertia, create oscillations, and are often responsible for the trade-offs between short and long term effects of policies (Sterman, 2000).

One of the more difficult concepts in causal diagram creation is choosing the right level of aggregation. There are many variables and influences in any system, especially human systems, so choosing the right way to combine concepts becomes important to prevent the model from becoming too unwieldy. The causal loop diagram is designed to communicate the central feedback structure of the dynamic hypothesis, not to be a detailed descriptor of equations. The modeler must balance being too complex with being too simple. The audience must be able to grasp the model logic to be able to evaluate its plausibility and realism, but the modeler must not obfuscate the model to the point where no one in the audience can decipher the overall feedback structure or how the loops interact (Sterman, 2000).

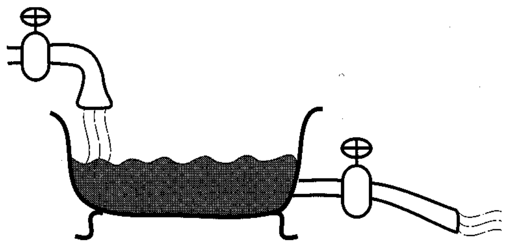
The modeler proposes a causal loop diagram based on the reference mode, time horizon, literature review, client meetings, and personal experience that provides an endogenous explanation of the system problem. Once the causal diagram is proposed and discussed, the modeler then can move to the formulation in the virtual world using a stock and flow model.

Step 3: Formulation of a Simulation Model

The formulation of the causal diagram in the virtual world is accomplished using a stock and flow diagram created using STELLA software. Causal loop diagrams are very effective at capturing the interdependencies and feedback processes of a system and can uncover mental models of the client and modeler, but they are not effective at capturing the stock and flow structure of the system. Stocks and flows, along with feedback, are the two central concepts of dynamic systems theory (Sterman, 2000).

Stocks and flows are critical in generating the dynamics of any system. Stocks are the accumulations in the system. They represent the state of the system and generate information upon which decisions and actions are based. Stocks provide systems with inertia and memory. Stocks also create delays in the system by accumulating the difference between inflows and outflows (Sterman, 2000). Flows push or pull units of stock per unit time into or out of a stock. Comparing system dynamics to mathematics, a stock would be considered as an integral and a flow would be a rate or derivative (Sterman, 2000:197). Figure 29 is an illustrative example of a stock and flow system.

Hydraulic Metaphor:



Stock and Flow Diagram:

Integral Equation:

$$\text{Stock}(t) = \int_{t_0}^{t} [\text{Inflow}(s) - \text{Outflow}(s)]ds + \text{Stock}(t_0)$$

Differential Equation:

$$d(\text{Stock})/dt = \text{Net Change in Stock} = \text{Inflow}(t) - \text{Outflow}(t)$$

Figure 29: Representations of Stock and Flow Structures (Sterman, 2000:194)

Figure 29 presents four different, but equivalent representations of the stock and flow structure using a hydraulic metaphor, stock and flow diagram, integral equation, and a differential equation. Once all of the relevant stocks and flows in the causal diagram have been specified in the virtual world, software, such as STELLA, acts as a differential equation solver. Through simulation in the virtual world, the modeler can uncover how a system performs over time and uncover much of the dynamic complexity of the system in the process.

In addition to stocks and flows, auxiliary variables also play a role in the formulation model. Auxiliary variables consist of exogenous constants or functions of stocks or flows. Figure 30 presents the varying symbols used by STELLA software in defining stocks, flows, constant auxiliary variables (exogenous constants), and auxiliary variables as functions of stock. Auxiliary variables also can serve as a unit conversion variable – translating a stock of A into a flow of B, or any number of conversion modifiers.

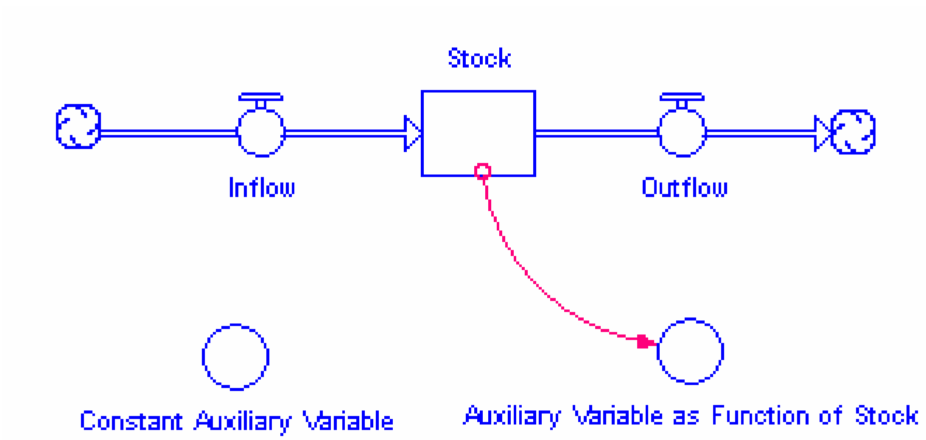


Figure 30: Various STELLA Symbols

Based on the reference modes and causal loop diagram, the modeler formulates the model in the virtual world. Each of the variables in the causal loop diagram must be represented on the stock and flow diagram, which must be structured to achieve the reference mode behavior pattern agreed upon by the clients and the modeler.

Once the model is formulated, the modeler must estimate parameters based on achieving the reference mode behavior patterns. Unless there is empirical data associated with the system, the modeler must focus on behavior patterns – only levels of magnitude and behavioral patterns are the focus of a system dynamics model, not specific quantified output. In the IT implementation system, there are no easily quantifiable metrics or data that are available. In this type of system, the modeler uses soft variables that capture how the system behaves over time. Soft variables are created to represent essential parameters in the model critical to the research question. Parameterization of all variables (hard and soft) is always an issue in realizing reasonable model behavior. The modeler can define how the initial conditions and levels in the model relate to the real world. Through initial testing, the modeler can determine if the model is consistent with the purpose and focuses on the model boundary specified in the problem statement.

Step 4: Testing

Testing allows the client and modeler to develop confidence in the model as a useful and relevant decision-making tool. Validation of the simulation model only exists to the degree the client uses it to make decisions about the system of study. As the model goes through and passes various tests, the client and modeler gain confidence in it. Where the model fails in the testing process, the modeler must make adjustments that can be either minor and easily fixable or major, requiring the modeler to move back to one of the earlier stages in the modeling process.

Sterman discusses seven main tests for the assessment of dynamic models: boundary adequacy test, structure assessment test, parameter assessment test, extreme conditions test, behavior reproduction test, behavior anomaly test, and sensitivity analysis test. Table 2 outlines these major tests and provides the purpose of the test (Sterman, 2000:859-861).

Table 2: Tests for the Assessment of Dynamic Models (Sterman, 2000:859-861)

Test	Purpose of Test
Boundary Adequacy	Are the important concepts for addressing the problem endogenous to the model?
	Does the behavior of the model change significantly when boundary assumptions are relaxed?
	Do the policy recommendations change when the model boundary is extended?
Structure Assessment	Is the model structure consistent with relevant descriptive knowledge of the system?
	Is the level of aggregation appropriate?
	Does the model conform to basic physical laws such as conservation laws?
	Do the decision rules capture the behavior of the actors in the system?
Parameter Assessment	Are the parameter values consistent with relevant descriptive and numerical knowledge of the system?
	Do all parameters have real world counterparts?
Extreme Conditions	Does each equation make sense even when its inputs take on extreme values?
	Does the model respond plausibly when subjected to extreme policies, shocks, and parameters?

Table 2 (cont): Tests for the assessment of dynamic models (Sterman, 2000:859-861)

Test	Purpose of Test
Behavior Reproduction	Does the model reproduce the behavior of interest in the system (qualitatively and quantitatively)?
	Does it endogenously generate the symptoms of difficulty motivating the study?
	Does the model generate the various modes of behavior observed in the real system?
Behavior Anomaly	Do anomalous behaviors result when assumptions of the model are changed or deleted?
Sensitivity Analysis	*Numerical sensitivity*: Do the numerical values change significantly…
	Behavioral sensitivity: Do the modes of behavior generated by the model change significantly…
	Policy sensitivity: Do the policy implications change significantly…
	…when assumptions about parameters, boundary, and aggregation are varied over the plausible range of uncertainty?

Once the model has been tested, using relevant tests and procedures as outlined in Table 2, and all parties in the modeling process are satisfied it meets their requirements, the modeler can then add management interventions that can lead to policies within the system.

Step 5: Policy Design and Evaluation

Once the model has been created and tested, the modeler can then begin formulating management intervention strategies that will most effectively drive the system in the direction deemed desirable by the client. The modeler should look at various possible environmental context situations that might arise and how policy interventions interact under varying conditions. The complexities associated with dynamic systems make it difficult for managers to understand what impacts their interventions will have in the system, so the modeler should explore management interventions under differing conditions and contexts.

A well-meaning manager can formulate a policy that appears to be beneficial in the short term, but after a while, the dubious long-term impacts may take hold. Changing environmental conditions and contexts can make initially good decisions seem bad. Even decisions that appear poor in the short term can have excellent long-term impacts. These are the types of questions and problems that system dynamics modeling can help solve. The value for the client in this type of modeling effort is a reduction of uncertainty for various policy actions and other management interventions. What are the best policies that will provide the manager with the most “bang for the buck” of his effort? What are the best policies under varying organizational environmental conditions? This research aims to assist managers in the organizational IT implementation system answer these questions.

IV. Results and Analysis

General Research Model

The system dynamics approach requires the modeler to uncover the significant, aggregated system components that influence the problem of study. As discussed in Chapter 2, the diagram depicted in Figure 31 shows how successful information technology (IT) implementation has three simultaneous, interrelated aggregate processes occurring in organizations: operating capability, adoption, and integration. Management intervention and organizational inertia endogenously affect each of these processes throughout the implementation process. The arrows in Figure 31 show how these influences are interrelated. During the overall implementation process, managers shepherd the innovation through the operating capability, adoption, and integration processes. Each of these processes will, in a successful implementation effort, build-up inertia over time.

All of the factors in the GeoBase implementation system are tied together in a loop. This looping structure provides an endogenous explanation for behavior and allows the system structure to dictate behavior as opposed to exogenous variables that externally dictate behavior. Fortunately, this problem has an endogenous explanation, so system dynamics can provide some insights into the system. The system boundary shown in Figure 31 separates endogenous variables (inside the boundary) from exogenous variables (outside the boundary). The exogenous variables are not affected by any of the endogenous variables, but they do have a one-way impact on the endogenous variables. The exogenous variables define the context within which a manager functions. The funding climate, organizational culture, top-level support, and whether or not the innovation will meet the needs of the organization are all exogenous influences in this model (since the IT implementation system manager has no direct control over them).

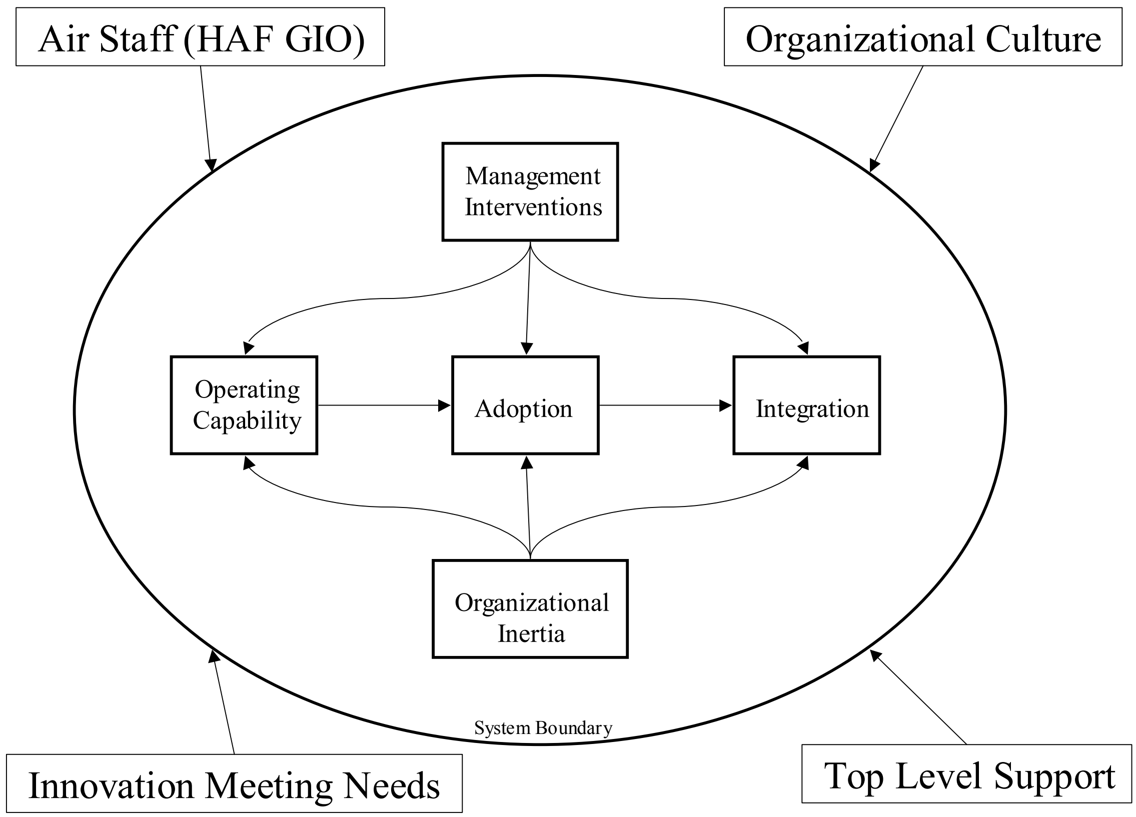


Figure 31: General GeoBase Implementation Model

Formulation of Dynamic Hypothesis

Since each endogenous variable exists somewhere in the loop, it is difficult to speak of one without speaking of another. For organizational clarity, the variables will be explained in the following order: operating capability, adoption, integration, organizational inertia, and the management interventions. Please reference Chapter 3 if there are questions about the symbols, arrows, etc. associated with the figures in this section. Chapter 2 contains an explanation of each of the aggregate model variables.

This section explains how the dynamic hypothesis was derived (reference mode behavior pattern and causal diagram) for each of the variables and how they interrelate.

Operating Capability.

The modeler and client agree that the desired behavior pattern for operating capability is a goal-seeking approach to steady state, as shown in Figure 32. Initially, the level of operating capability rapidly increases and begins tapering-off as it approaches the operating capability goal value (to what level the organization strives to improve its technological operating capability). The undesired, and more commonly seen, behavior pattern is a goal-seeking behavior pattern that falls off after a relatively strong start.

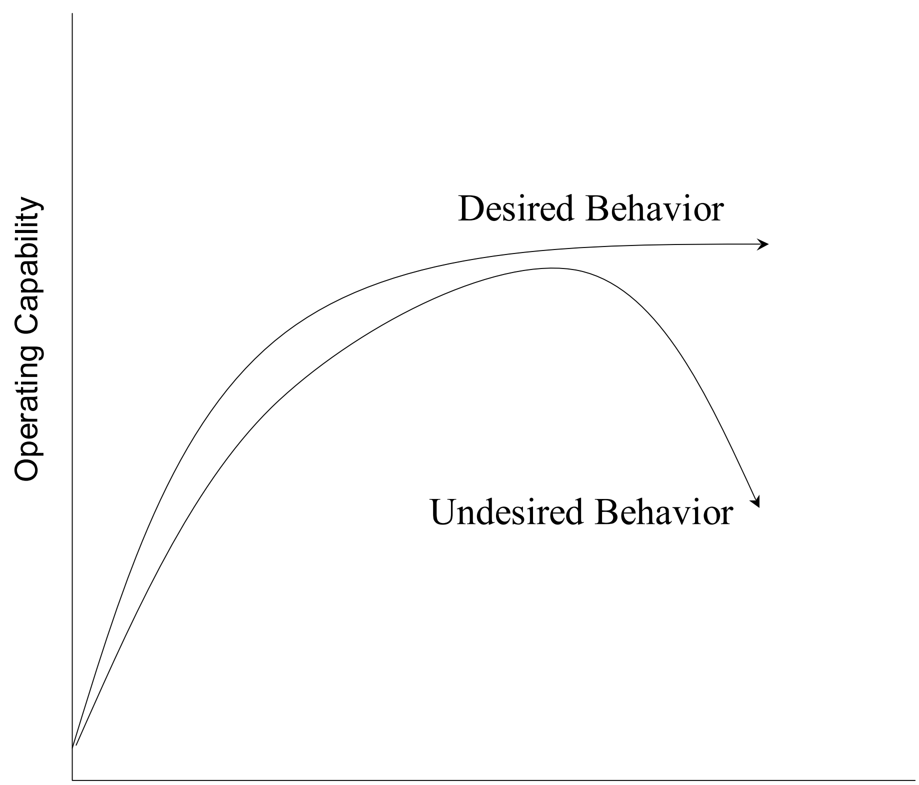


Figure 32: Desired and Undesired Reference Mode Behavior Patterns for Operating Capability: Goal Seeking Behavior Pattern

Once the reference mode behavior pattern is defined for a variable in the system, a causal diagram is proposed that provides the necessary structure that will generate the reference mode behavior pattern over time. Figure 33 presents the causal diagram for operating capability, which specifies the structure that is required to generate the desired behavior pattern shown in the reference mode for this variable (as pictured in Figure 32). Within the basic goal seeking structure there are five variables that drive the behavior behind operating capability: operating capability goal, management operating capability effort, funding, increasing operating capability, and operating capability. This structure will seek to attain the value of the operating capability goal after some period of time. One of the assumptions the model makes is that the operating capability goal is static, which is to say there will be no major jumps in technology capacity over the ten-year period of study that would cause the manager to drastically change the original operating capability goal. Operating capability goal and funding are exogenous within this structure, but do not dictate behavior. They only determine to what level and how rapidly operating capability will rise. In the presence of no funding, there will be no operating capability that accumulates in the system. Likewise, without an operating capability goal, there will be no operating capability that accumulates over time. On the other hand, with high values for operating capability and funding, the value for operating capability would rise higher and faster than with lower values for these two variables.

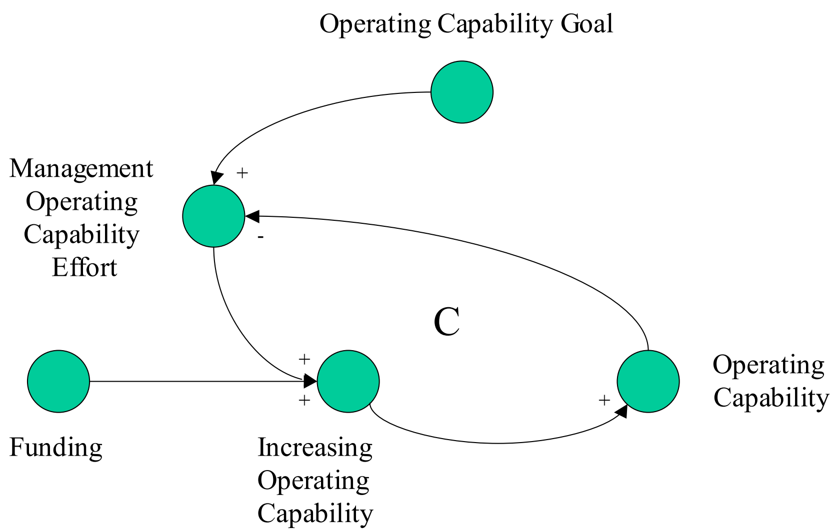


Figure 33: Operating Capability Causal Diagram: Goal Seeking Structure

For this undesired behavior pattern in Figure 32 to occur, there must be an additional compensating loop in the goal-seeking structure for operating capability to force it to decline after some initial build-up. Since the compensating loop does not take hold until a longer-term period of time, there must be delays in the system that force this behavior pattern. Later sections of Chapter 4 will discuss these delays.

Figure 34 presents the same figure in Figure 33, but with additional information on how operating capability interacts with other variables and how the additional compensating loop that drives the undesired behavior pattern functions in the system. If the reader refers to Figure 31, it is seen that operating capability affects two variables, adoption and management interventions, and is affected by two variables, management interventions and organizational inertia.

The additional relationships presented in Figure 34 allow the reader to see more specific connections between the variables. Notice there is only one arrow from the operating capability structure to management interventions. This variable is operating capability management effort and is tied to the management interventions aggregate variable. The operating capability variable is tied to the adoption aggregate variable. The additional compensating loop in Figure 34 relates organizational inertia and operating capability. This additional loop relates how the negative effects of organizational inertia can impact operating capability. This relationship will be more fully explained in the organizational inertia section.

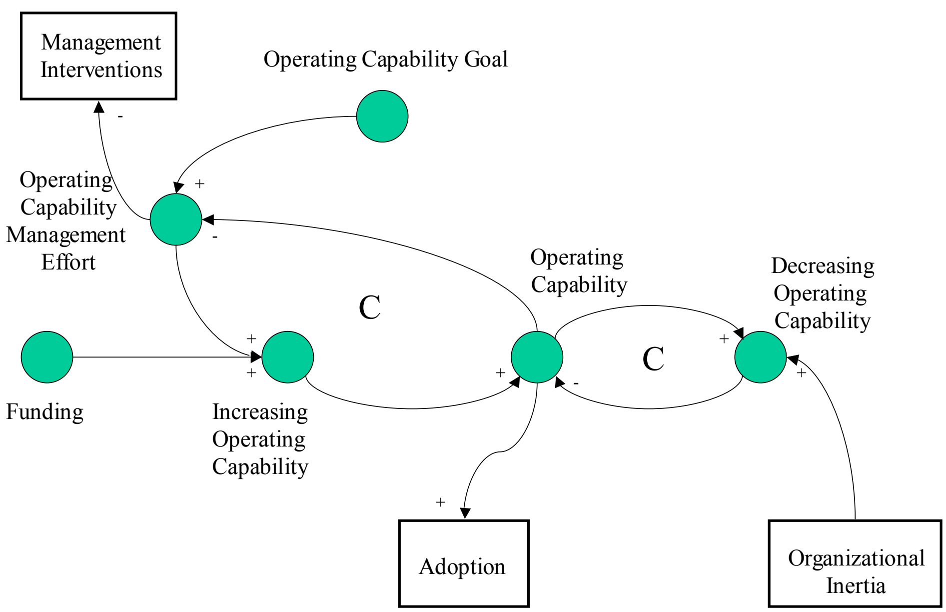


Figure 34: Operating Capability Causal Diagram with Additional Information on Undesired Reference Mode Behavior Pattern and Other Variable Relationships

Adoption.

Operating capability directly affects adoption, so this aggregate variable will be discussed next. Based on the research performed by Rogers (1995) and discussed at length in the Chapter 2 adoption section, adoption should follow s-shaped growth over time. Adoption follows s-shaped growth and eventually comes to static steady state. Hence, the structure that generates static steady state, s-shaped growth must be based on one variable drawing another down until nothing is left in the first variable. The concept of a pool of potential adopters transitioning to a pool of adopters fits this requirement.

Figure 35 presents the reference mode diagram for potential adopters, whereas Figure 36 presents the desired and undesired reference mode behavior patterns for adopters. The potential adopters reference mode shows inverse s-shaped behavior, since this variable drains over time. The desired adopter reference mode is s-shaped growth behavior, since this variable increases over time. The undesired adopter reference mode is initial s-shaped growth followed by a lagged decrease. According to Rogers, a successful cumulative innovation diffusion process follows an s-shaped curve over time until full adoption saturation occurs. This behavior pattern is like a goal-seeking pattern, with the goal being zero non-adopters. The reader should reference Chapter 2 for more information about this process.

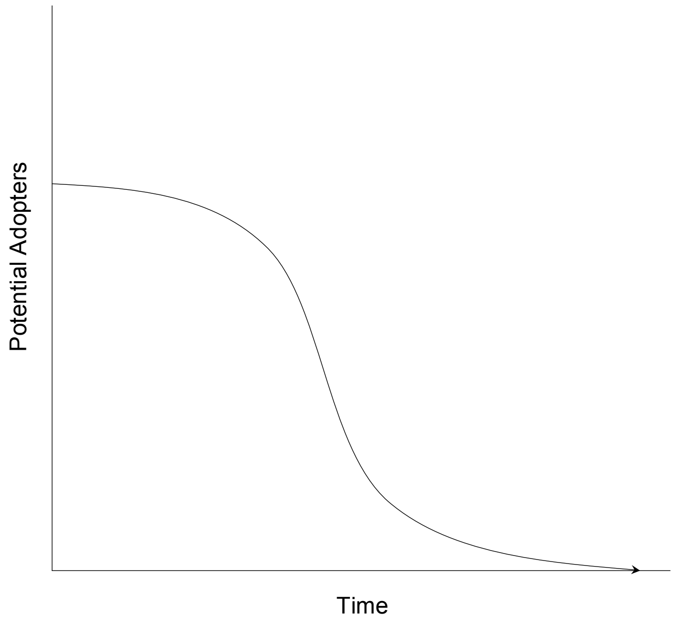


Figure 35: Reference Mode for Potential Adopters: Inverse S-Shaped Behavior Pattern

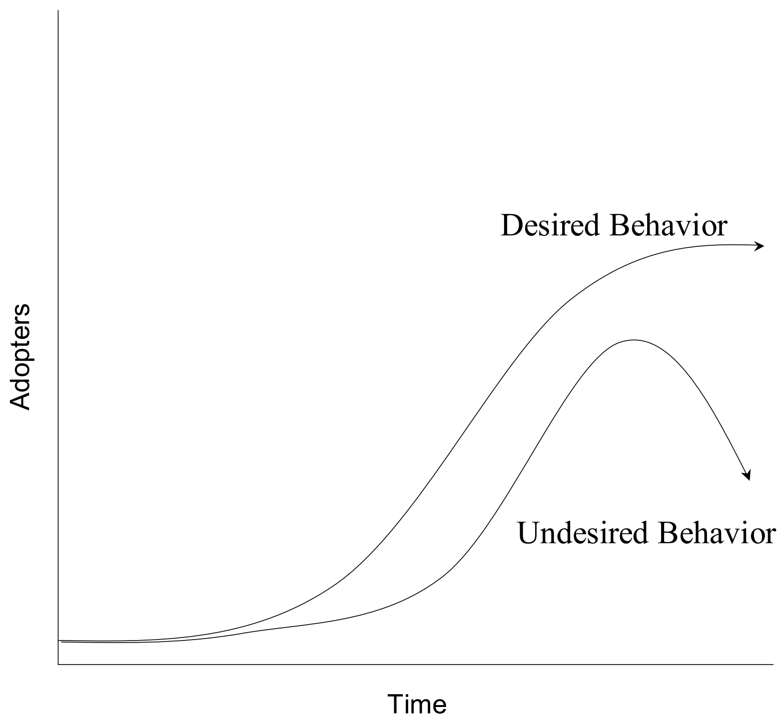


Figure 36: Desired and Undesired Reference Mode Behavior Patterns for Adopters: S-Shaped Behavior Pattern

Figure 37 presents the structure that links potential adopters and adopters into adopter s-shaped behavior. There is a compensating loop on the potential adopter side linking potential adopters to adoption rate. This means, as the adoption rate increases, this will drain the potential adopters pool more rapidly. There is a reinforcing loop on the adopter side of adoption rate. This means, as the level of adoption increases, the adoption rate will increase. The compensating loop runs through adoption from management effort, meaning the manager is the individual that keys initial movement from the potential adopter to the adopter pool. Once the adopter pool begins building up, the reinforcing loop running through adoption from communication channels will take over and move the remaining personnel from the potential adopters pool to the adopter pool. Three factors, relative advantage, ease of use, and compatibility, also govern the adoption rate.

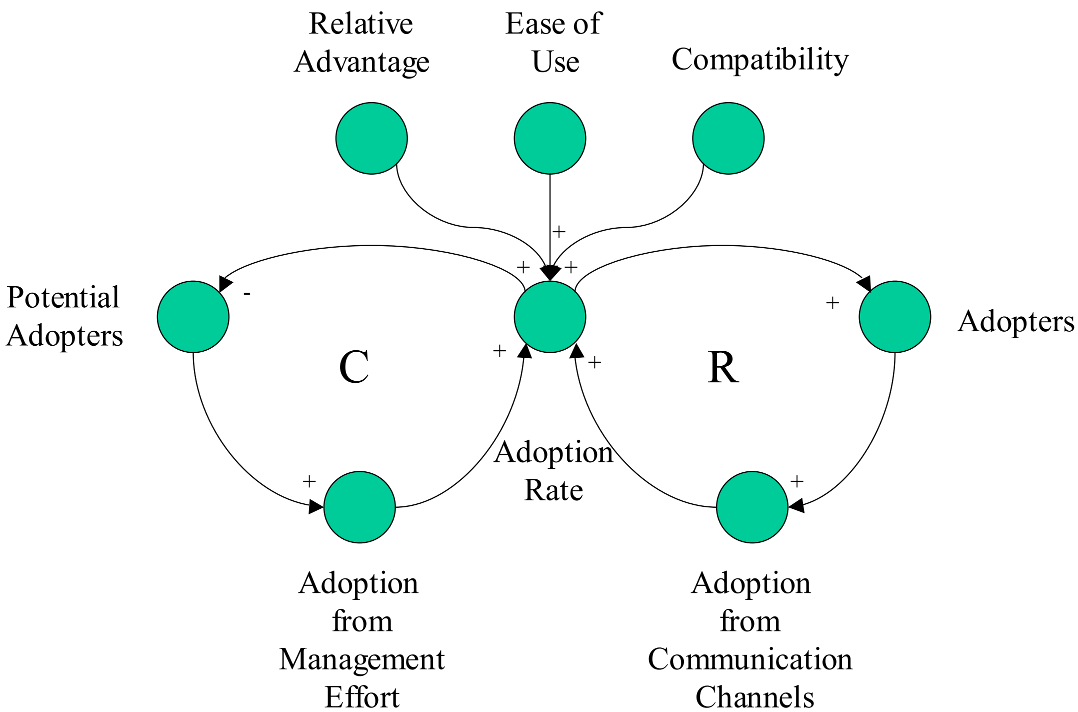


Figure 37: Adoption Causal Diagram: S-Shaped Growth Structure for Adopters

Once an individual becomes an adopter (moving from the potential adopter pool to the adopter pool), he or she can either continue to remain an adopter or decide to discontinue adopter status (based on either positive or negative organizational inertia -- discussed later). Positive organizational inertia will keep the adopter in the adopter pool. Negative organizational inertia will tend to drain the adopter pool as individuals discontinue use.

Potential adopters become adopters through two processes. The first process is aggregated as management effort. Managers can assist potential adopters move from the potential adopters pool to the adopters pool through change process management and reward system management. The second process involves diffusion through interpersonal communication channels. Managers have little direct influence on this feedback loop, but can strengthen it through learning management (increasing communication opportunities for personnel). The reader should reference applicable sections in Chapter 2 for more specific guidelines and sources for these variables.

The rate of adoption is regulated by the context of the perceived innovation characteristics (relative advantage, ease of use, and compatibility). The higher the combination of these factors are perceived to be, the faster the transition will be from the potential adopters pool to the adopters pool. High perceptions of the IT innovation reflect a positive IT organizational culture and low perceptions of the IT innovation reflect a poor IT organizational culture. The reader should reference Chapter 2's discussion on adoption for more information on these factors.

Figure 38 presents practically the same information shown in Figure 37, but adds how the adoption structure interacts with other aggregated variables in the system and how the undesired behavior pattern is generated. For the undesired behavior pattern to occur, there must be an additional compensating loop in the adopter s-shaped structure to force it to decline after some initial build-up. Since the compensating loop does not take hold until after a longer-term period of time, there must be delays in the system that enable this undesired behavior pattern to occur. Later sections of Chapter 4 will discuss these delays. The adoption rate is a function of the level of operating capability, as shown by the arrow drawn from operating capability to adoption rate. Management interventions, as discussed above, affect the adoption from management effort and adoption from communication channels variables. The level of the adopter pool affects integration. The additional compensating loop was added to the adopter variable to show

how negative organizational inertia can affect the pool of adopters. This structure assumes that once an individual becomes an adopter, they can either stay an adopter (if there is positive organizational inertia in the system) or else discontinue GeoBase adoption and leave the system (if there is negative organizational inertia built-up in the system).

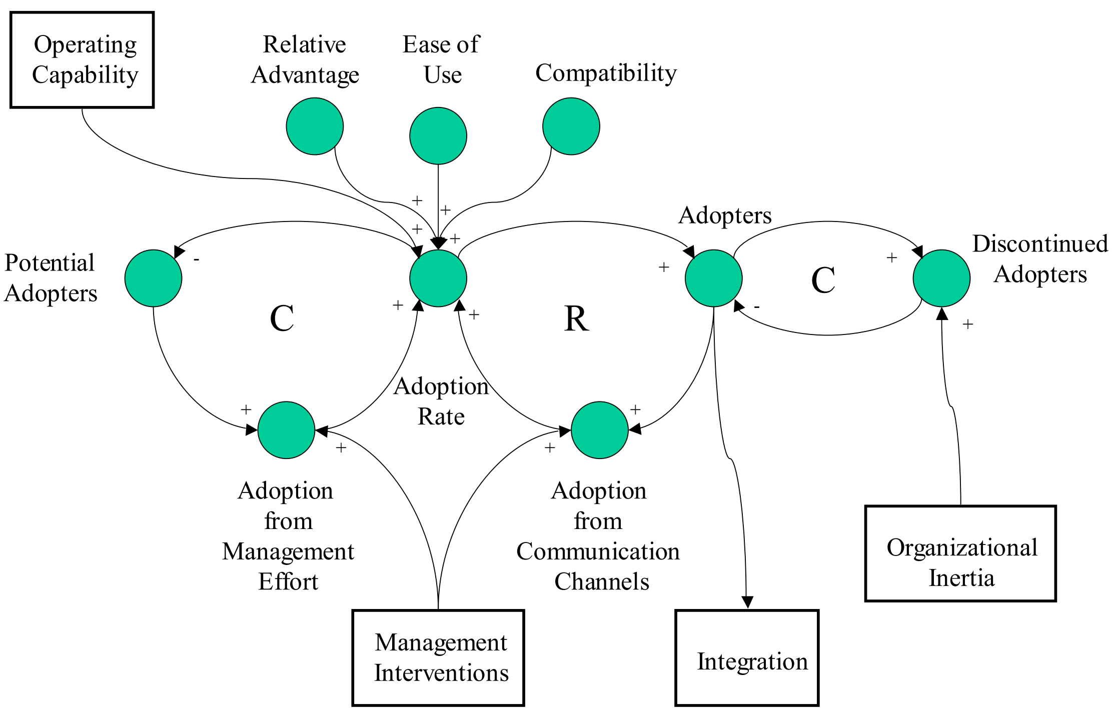


Figure 38: Adoption Causal Diagram with Additional Information on Variable Relationships and Undesired Behavior

Integration.

A major focus of this research effort is to better understand integration and what drives it for long-term sustainment. Integration reflects the level of change occurring in organizations as a result of an IT innovation. Kotter, a highly respected change process researcher, provides some empirical evidence that change typically follows an s-shaped behavior pattern over time. He states in a portion of his change research, "…in one of the most successful transformations that I have ever seen, we quantified the amount of change that occurred each year over a seven-year period. On a scale of one (low) to ten (high), year one received a two, year two a four, year three a three, year four a seven, year five an eight, year six a four, and year seven a two. The peak came in year five, fully 36 months after the first set of visible wins" (Kotter, 1995:67). The information contained in the preceding quote was tabulated and included as Table 3. Figure 39 graphically displays a portion of the data contained in Table 3 (level of change per year versus year). A straight line connects each discrete data point in Figure 39. Figure 40 also graphically displays a portion of the data contained in Table 3 (cumulative level of change per year versus year). Figure 40 connects each discrete data point with a smooth curve. It is interesting to note that the cumulative quantification of change in Kotter's research follows relatively closely an s-shaped behavior pattern over time, as shown in Figure 40.

Table 3: Kotter's (1995) Quantification of Change After a Transformation Over Seven Years

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Level of Change Per Year	2	4	3	7	8	4	2
Cumulative Level of Change Per Year	2	6	9	16	24	28	30

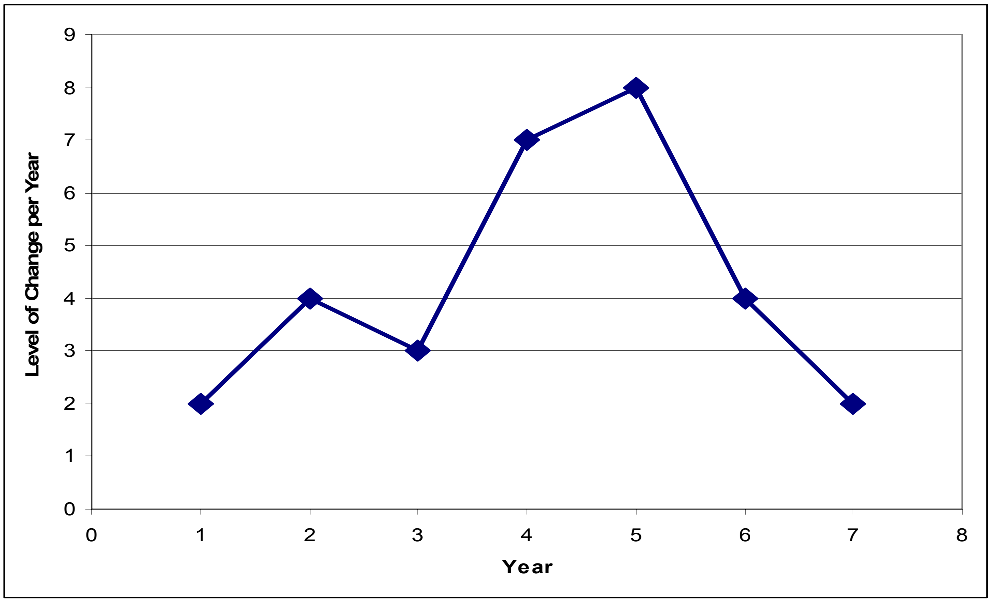


Figure 39: Kotter's (1995) Level of Change per Year versus Year

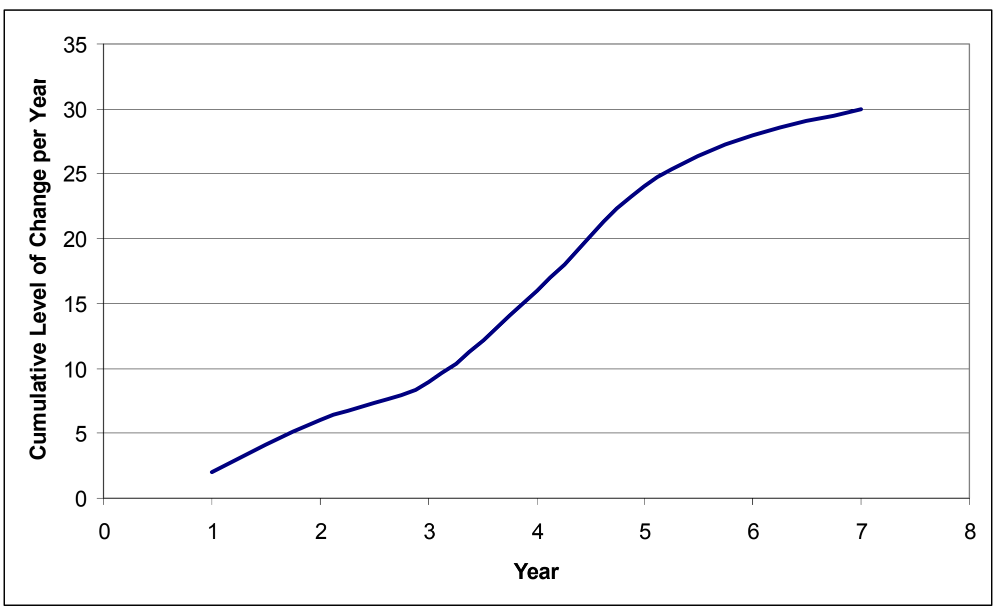


Figure 40: Kotter's (1995) Cumulative Level of Change per Year versus Year

Based on Kotter's findings, as well as client coordination, it is proposed that the desired behavior pattern for integration, a possible metric to quantify change as defined in this research effort, will most likely follow an s-shaped behavior pattern, as shown in Figure 41. The undesired behavior pattern for integration would consist of an initial s-shaped growth behavior pattern followed by a lagged decline.

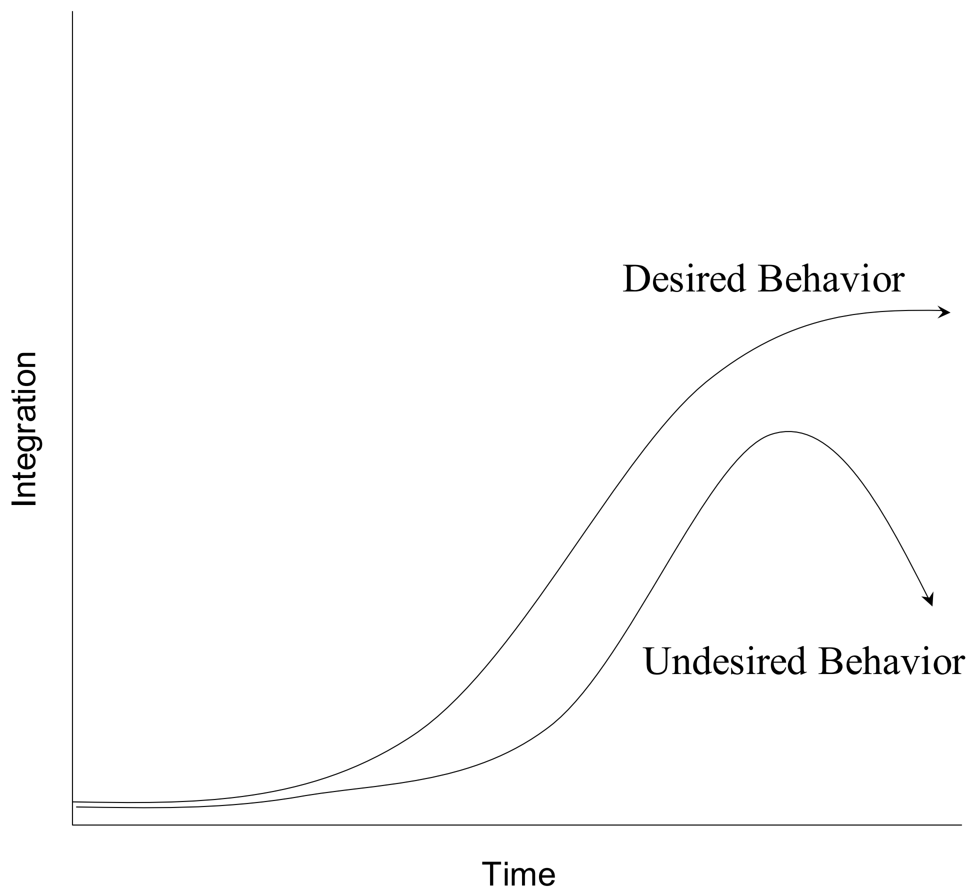


Figure 41: Desired and Undesired Reference Mode Behavior Patterns for Integration: S-Shaped Behavior Pattern

Figure 42 presents the causal diagram for integration. There is one reinforcing loop that will tend to increase integration and two compensating loops that will tend to decrease integration over time. The s-shaped structure shown in Figure 42 will produce the desired s-shaped behavior pattern shown in Figure 41. At the beginning, none of the loops are dominating integration, but eventually, the reinforcing loop will cause integration to exhibit exponential growth. When integration rises to a certain level, the compensating loops will begin to dominate and level-off integration until it comes to a dynamic steady state value.

The reinforcing loop in the integration structure is a result of GeoBase being added to the business processes of the organization. This can take place as either business process reengineering (when significant performance enhancements are necessary) or continuous improvement (when minor performance enhancements are required). It is a reinforcing loop because additions, in the form of either new GeoBase reengineered business processes or continuous improvement processes, to integration will increase ideas for further business process integration. There are two other items that also play a role in increasing integration. These include the number of adopters in the organization and how the continuity of the organization allows information about integration to be passed on to new personnel.

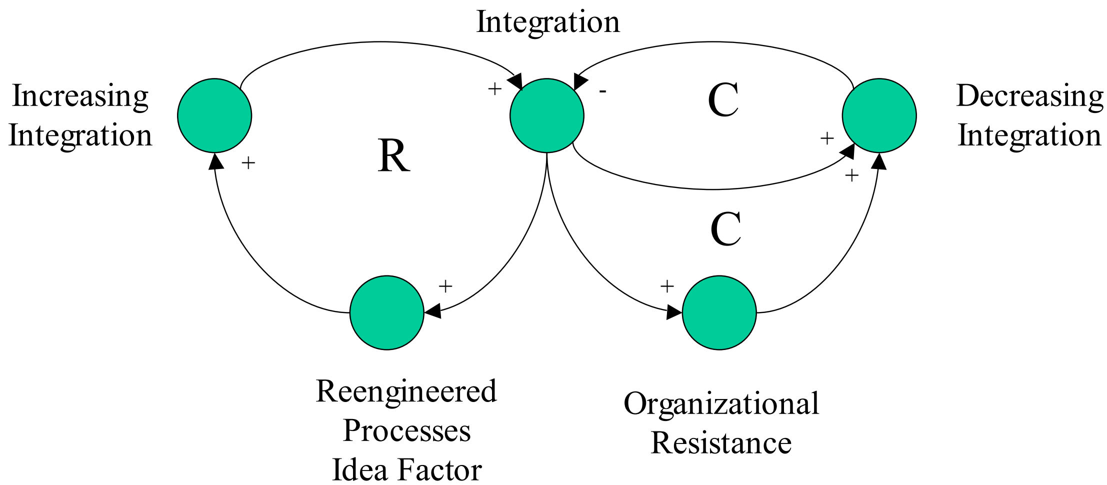


Figure 42: Integration Causal Diagram: S-Shaped Growth Structure for Integration

The s-shaped growth cycle shown in Figure 41 is self-perpetuating and continues to grow over time until dampened by compensating loops. Since unconstrained exponential growth is unrealistic, compensating loops must provide an impetus to level-off the integration curve and compensate for this growth. It is proposed that organizational resistance is the main cause for this compensating behavior.

Organizational resistance in this model aggregates two concepts from the literature: resistance to change and resistance to continued learning. People are inclined to resist change when it causes uncertainty in both their professional and personal lives. Many cognitive factors are associated with resistance to change – self-efficacy, job security, and motivation to move up in the organization, among many others. Personnel may also be cynical about proposed changes due to poor initial communication or a history of failed change efforts by management. The discussion of organizational resistance in Chapter 2 will provide more detail on this important concept in organizational change. The model's definition of organizational resistance takes all of these concepts into account, but also adds the propensity for personnel to congeal (from a learning perspective).

Cunningham's analysis of Drucker's writings about learning takes this point into account (reference discussion on learning in Chapter 2). Personnel tend to travel up the learning curve for a new job or task until they come to a point where they feel competent in their responsibilities. Typically, from that point on, they either stop or greatly reduce learning new concepts directly related to their job or task because they have become comfortable with their surroundings. This behavior could be referred to as congealing, or halting learning because of satisfaction with the status quo. These tendencies lie at the heart of the model's definition of organizational resistance. Organizational resistance is defined as the sum total of all the direct organizational resistance to change and resistance to continued learning. The model assumes the level of integration becomes the causal mechanism for organizational resistance. The model also assumes organizational resistance should correspond directly with the level of integration, since integration, in this model, represents the level of change associated with GeoBase taking place in the organization. When these loops are combined into the structure shown in Figure 42, s-shaped behavior is the result.

Figure 43 provides a new causal diagram with other influences from the system, in aggregated form, that play a role in integration and explain the undesired behavior pattern for integration. For this undesired behavior pattern to occur, there must an additional compensating loop in the integration s-shaped structure to force it to decline after some initial build-up. Since the compensating loop does not take hold until a longer-term period of time, there must be delays in the system that force this behavior pattern. Again, later sections of Chapter 4 will discuss these delays. Figure 43 shows there are three external aggregate variables that have an influence on integration. The variables with a direct causal effect on integration include adoption, management intervention, and organizational inertia. Integration also has a causal effect on organizational inertia. Figure 43 also includes another compensating loop involving abandoned reengineered processes factor. This loop helps explain how negative organizational inertia causes reengineered processes involving GeoBase to be abandoned when they are not improving performance (this also assumes personnel can cut GeoBase out of non-reengineered processes involving GeoBase). Reengineered business process abandonment explains the undesired behavior pattern shown in Figure 41 and provides the additional compensating loop that forces integration to decline.

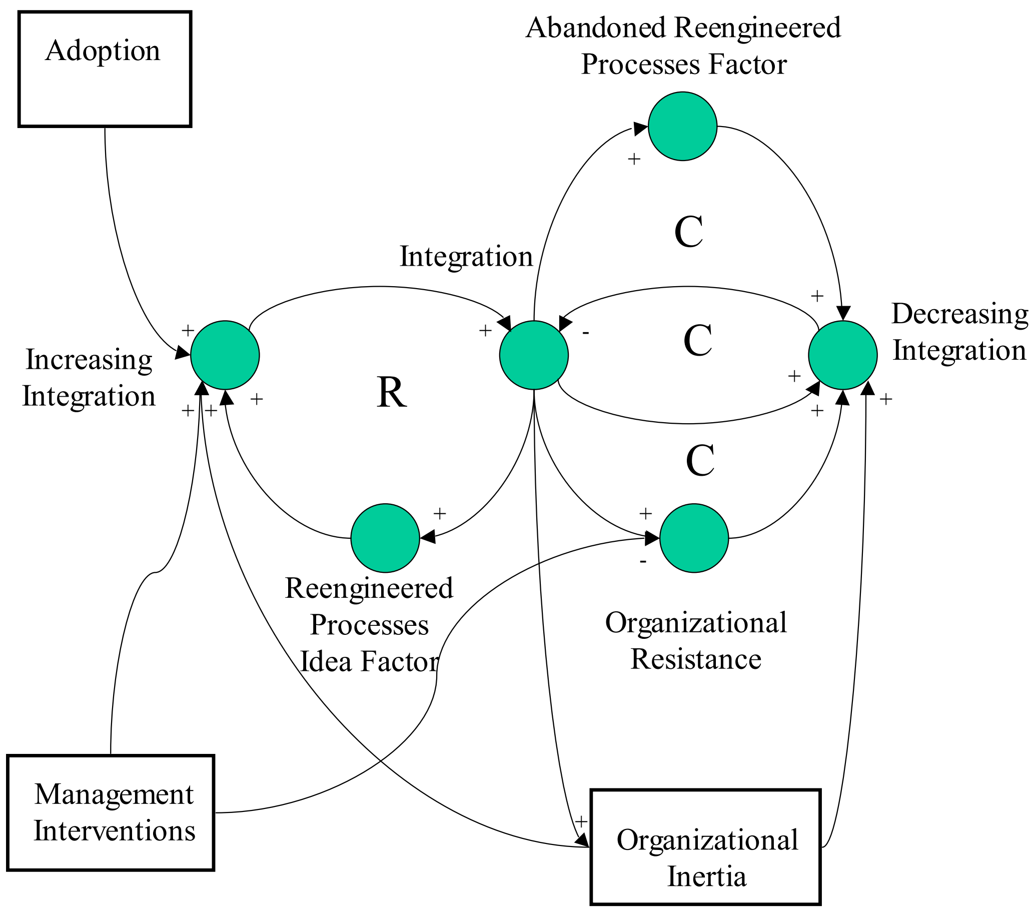


Figure 43: Integration Causal Diagram With Additional Information on Variable Relationships

Organizational Inertia.

The level of integration directly affects the level of organizational inertia in the GeoBase system, so organizational inertia will be discussed next. It is important to understand that organizational inertia can be either positive or negative. Positive organizational inertia would tend to support further integration, support adoption, and continue increasing operating capability. Negative organizational inertia, on the other hand, would tend to decrease integration, decrease adoption, and decrease operating capability. In this model, organizational inertia is partitioned into two concepts: continued use inertia (positive organizational inertia) and discontinued use inertia (negative organizational inertia).

Continued use inertia represents the positive continuance practices of the organization as they relate to GeoBase. For long-term sustainment of GeoBase, organizational memory must accumulate positive experiences within the system and pass them on to others in the organization. This concept encompasses the IT innovation meeting the needs of the organization. Three main factors affect continued use inertia in the GeoBase system: top level support, database quality, and culture fit. GeoBase integration will increase over time if these organizational inertia factors are together positive and personnel pass their knowledge on for the benefit of others in the organization through continuity processes.

As mentioned earlier, there are three main factors that affect organizational inertia in the GeoBase system: top level support, database quality, and culture fit. The first factor, top-level support, refers to the level of support from organizational leaders with high authority. Leaders can either be in favor of a change program or opposed to it. In reality, for any change program to have any hope of success, leaders must at least not be antagonistic towards it. They may have differing levels of support, from highly championing an effort, to openly antagonizing it. Most of the change literature recognizes the importance of top-level support in any change effort (Kotter, 1995; Armenakis & Bedeian, 1999; Armenakis et al., 2000; Cullis, 2000; Cunningham, 1999). The second factor, database quality, is fairly specific to the GIS portion of the GeoBase system. Aside from the personnel maintaining and using the GIS, the database is the most important technical component in any organizational GIS. Without reliable and updated database information, personnel will not be able to trust the output from the GIS, which will have a highly negative impact on the GeoBase system. A large portion of GeoBase operating capability is getting a quality database up and running and keeping it maintained properly. The database can range from very good to very poor. Positive inertia will result from a good database and negative inertia will result from a poor database. The third factor, culture fit, is probably the most aggregated of concepts among the organizational inertia factors. Organizations can either be considered rigid or innovative in general. In innovative organizations, the culture is usually supportive of new innovations that add to the organization's performance. Innovative organizations are usually communicative and supportive in general. On the other hand, in rigid organizations, the status quo rules and does not readily allow innovations to change the way things are currently operating. Rigid organizations are usually uncommunicative and unsupportive in general. The culture of the organization and how GeoBase fits-in to that culture, will, in large measure, determine long-term GeoBase sustainment. These three organizational inertia factors: top level support, database quality, and culture fit, provide the context for long-term GeoBase sustainment and define whether or not GeoBase is meeting the needs of the organization.

Discontinued use inertia represents the negative continuance practices of the organization as they relate to GeoBase. Organizational memory also applies to discontinued use inertia, since negative experiences with the technology will cause a depletion of GeoBase organizational performance. The same three organizational inertia factors affect discontinued use inertia as continued use inertia (top level support, database quality, and culture fit). When these sustainment factors are together negative, they have far reaching impacts on operating capability, adoption, and integration. As discontinued use inertia builds up in the system, operating capability will decline as the database is not properly supported throughout the organization, leading management to devote more of their time to keeping the database afloat, so to speak. As discontinued use inertia builds up in the system, adopters will become un-enamored with GeoBase and leave the pool of adopters. This model assumes that once an adopter leaves the adopter pool, he or she can never return (they leave the system). As discontinued use inertia builds up in the system, integration will also decline. As personnel find that GeoBase is not meeting their needs or improving business process performance, they will abandon or change business processes reliant on GeoBase.

Figure 44 presents how organizational inertia will tend to behave over time. This behavior pattern is referred to as accumulating behavior. This reference mode behavior pattern is the same for both desired and undesired behavior. For desired behavior, only positive organizational will accumulate in the system (continued use inertia). For undesired behavior, only negative organizational inertia will accumulate in the system (discontinued use inertia). Organizational inertia will accumulate either positive or negative inertia experiences, or both. It is also important to note that organizational inertia is directly dependent on integration. Hence, the accumulating behavior pattern for organizational inertia will have an element of the s-shaped behavior through this association.

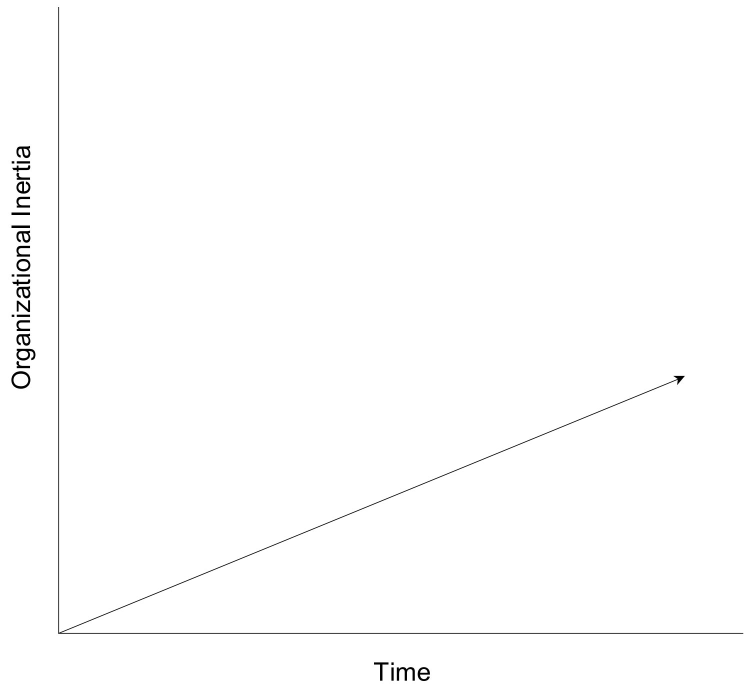


Figure 44: Reference Mode for Organizational Inertia: Accumulating Behavior Pattern

Figure 45 presents the accumulating structure causal diagram for organizational inertia, as separated into continued use inertia (positive organizational inertia) and discontinued use inertia (negative organizational inertia). The accumulating structure has no loops, since this structure simply accumulates without feedback from anything endogenous to itself. For a clearer picture of how continued use inertia and discontinued use inertia are separated, a Boolean identifier (continuing/discontinuing use Boolean determiner) is included that guides inertia to the positive or negative side based on the organizational inertia factors: top level support, database quality, and culture fit.

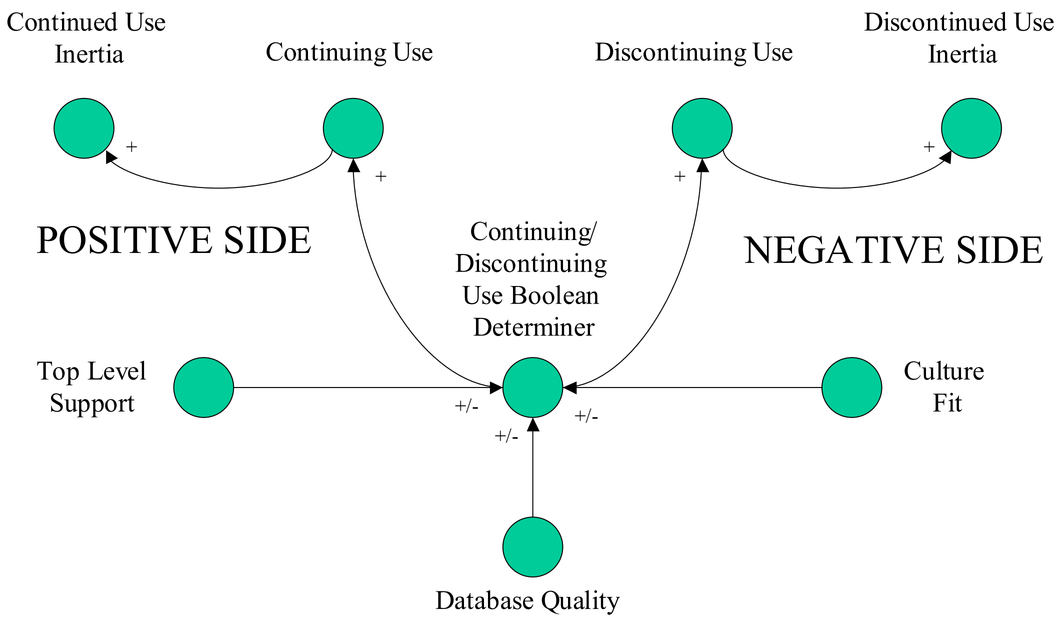


Figure 45: Organizational Inertia Causal Diagram: Accumulating Structure for Organizational Inertia

Figure 46 presents the organizational inertia causal diagram with impacts on and effects from other portions of the model. Organizational inertia has a strong influence on all aspects of the model. Hence, this model is created in such a way as to assume the system will naturally increase GeoBase integration and its supporting components, operating capability and adoption, over time. This natural increase defines the desired behavior patterns earlier discussed. This assumption supposes there is a natural level of positive continued use inertia driving integration, operating capability, and adoption upward. The explicit continued use inertia portion of the model assigned to organizational inertia represents a level of continued use inertia above and beyond what naturally exists in the system. Hence, the explicit continued use inertia portion in Figure

46 has a smaller direct influence when compared to discontinued use inertia. In the presence of discontinued use inertia, the system will readily decrease GeoBase integration and its supporting components, operating capability and adoption, much more rapidly than continued use inertia (explicitly included in the model) will increase them.

Discontinued use inertia affects operating capability, adoption, and integration. From previous causal diagrams, discontinued use inertia has a negative impact on each of the other aggregate variables. Since discontinued use inertia has a negative influence on each factor, the positive sign for the arrows running from discontinued use inertia to the other factors represent a positive influence on the compensating loops in the structures of the other systems. Continued use inertia also has an influence on the system, but it is constrained to the continuity processes affecting integration. Integration affects both continued use inertia and discontinued use inertia and they are derived from the level of integration, as discussed previously. Figure 46 is compatible with Figure 31 as well; organizational inertia affects three aggregate variables (operating capability, adoption, and integration) and is directly affected by integration alone.

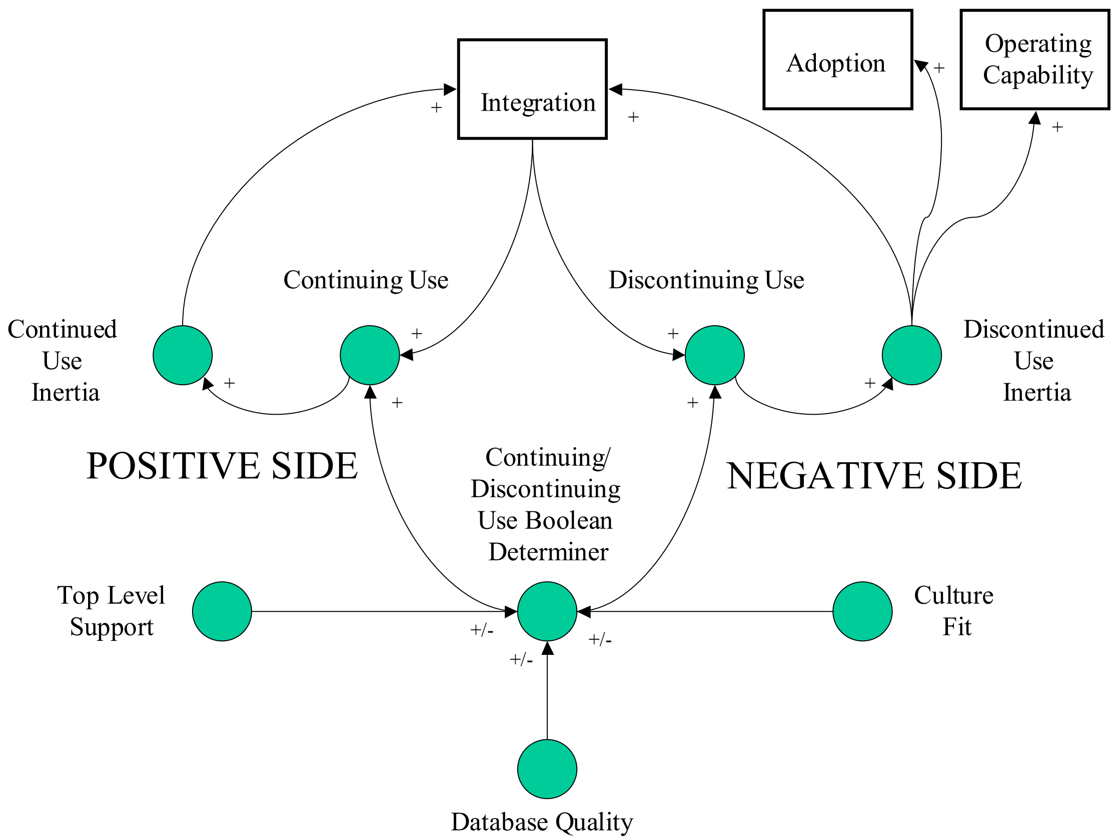


Figure 46: Organizational Inertia Causal Diagram with Additional Information on Variable Relationships

Management Interventions.

Management interventions include an assortment of the most common management strategies for dealing with a major change program, such as the GeoBase initiative, that are found in the literature. Possible management intervention programs include, in aggregated form, change process management, continuity management, learning management, and reward system management. The reader should reference Chapter 2 for a more detailed discussion on specific actions managers can take under the auspices of each of these management intervention aggregate variables. The most important concept in this portion of the model is to understand that a manager has a finite amount of time to devote to each intervention. What a wonderful world this would be if a manager could focus full attention on all of these interventions all of the time. Unfortunately, managers' time is limited, so they have to partition their time wisely to have the most impact on the GeoBase implementation system. These intervention strategies do not have an innate structure to them – they are part of a number of the loops in the system, but together do not have a pre-specified structure. Part of the value from system dynamics modeling is to include the base structure, then add management interventions that have an uncertain conclusion as to what constitutes the best way to manage the system. After simulating a variety of possibilities in the virtual world, the system manager should have better insight into how to manage the system depending on the organizational context he or she is working in.

The model makes the assumption up front that managers must focus a portion of their time on accumulating operating capability. Without operating capability, GeoBase would have no technological base to work from and the system would fail. With this assumption firmly grounded in the model, the operating capability management variable is part of the operating capability structure discussed earlier. Since discussing the management interventions without discussing the other aggregate variables in the system would be fruitless, all relevant variables in this portion of the model will be included. Figure 47 presents the management intervention variables with interactions with other system variables.

Figure 47 includes a number of variables and interrelationships. The first variable of note is management capacity. This variable represents the amount of time the manager can devote to GeoBase management. The model screens management talent from the model (manager charisma, experience, etc.), so the model presupposes the manager has enough talent to manage each program sufficiently. The maximum value this variable would attain would coincide with a manager being able to devote all of his or her time to GeoBase management. If the manager has other responsibilities, then this variable would diminish. The management allocator variable provides the capability for the model to allocate available time to the four management interventions (change process management, learning management, reward system management, and continuity management). Operating capability management is a must, so that value from the operating capability structure diminishes the available capacity for the other four management interventions previously mentioned. Recall operating capability management diminishes over time as GeoBase operating capability increases, so the manager, in a successful implementation effort, will generally have more time to devote to the other interventions over time.

Based on percentages of time spent on each intervention, the manager will partition time spent on each of the four management interventions. These interventions then affect various portions of the adoption and integration structures. Change process management will have an impact on the adoption and integration structures. Learning management will have an impact on the adoption and integration structures. Reward system management will have an impact on the adoption and integration structures. Continuity management will have an impact on the integration structure alone.

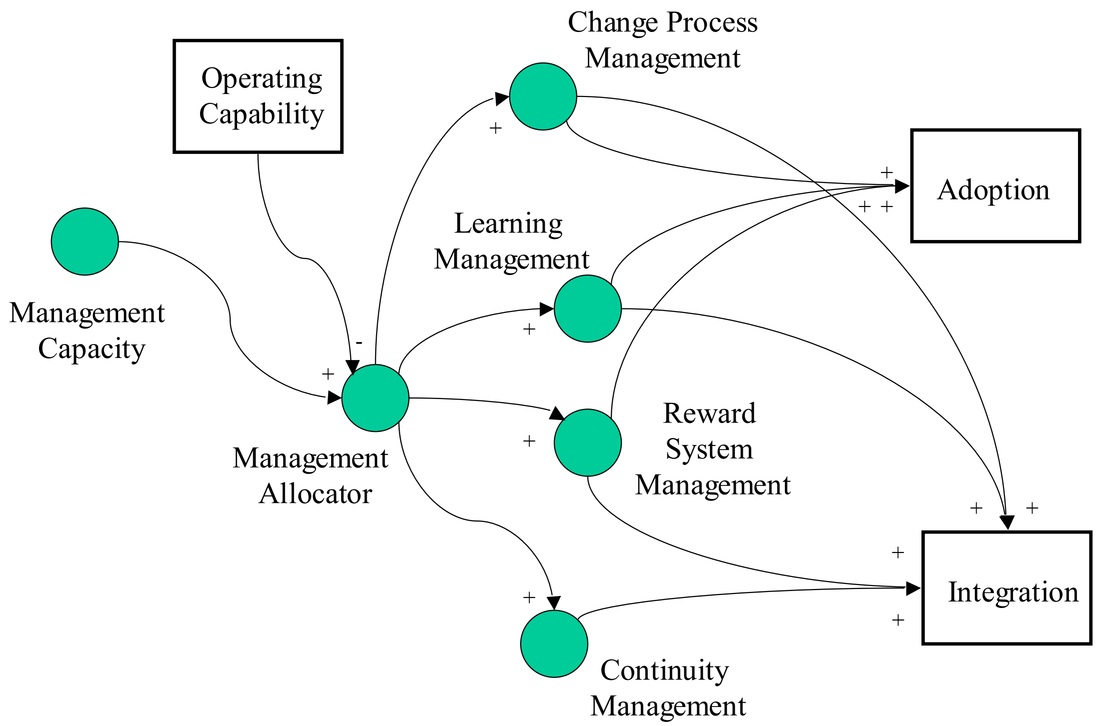


Figure 47: Management Interventions in Relation to Other System Variables

The reader may remember in Figure 31 that operating capability, adoption, integration, and organizational inertia occur in series. This concept is represented by the inclusion of main chain behavior between these variables (operating capability, adoption, integration, and organizational inertia). Main chain behavior allows the modeler to include delays in the system and cause variables to lag one another. With main chain behavior between variables, the adjusted reference mode is shown in Figure 48. The main chain behavior shown in Figure 48 forces organizational inertia to lag integration, integration to lag adoption, and adoption to lag operating capability.

Figure 49 presents the combination of all of the various structures discussed to this point, with the exception of the management interventions, locked into main chain structural relationships. The main chain behavior in Figure 49 is represented by the arrows connecting Operating Capability (OC) and Adoption Rate, Adopters and Increasing Integration, and from Integration to the Organizational Inertia variables Continuing to Use (Cont to Use) and Discontinuing Use (Discont Use).

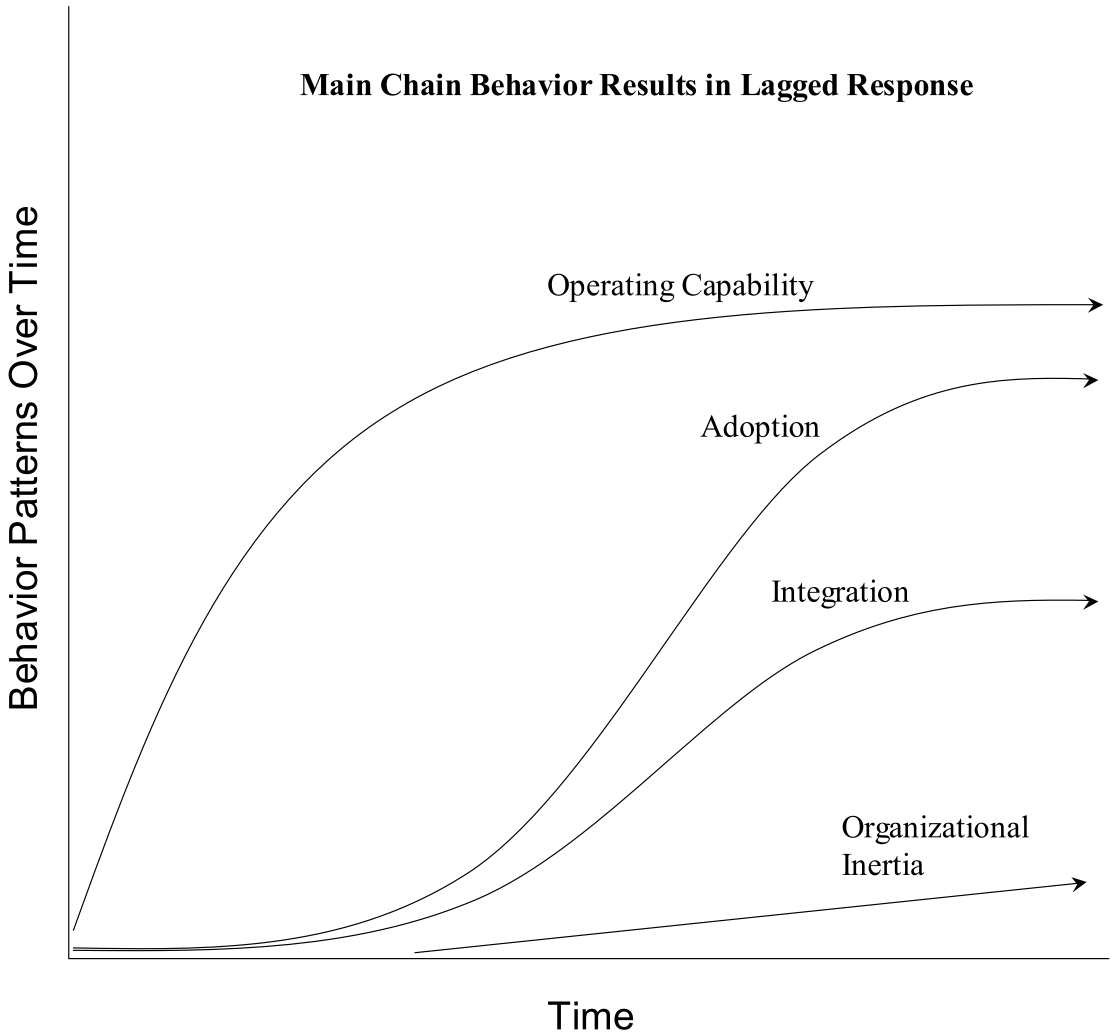


Figure 48: Desired Reference Mode for Main Chain Behavior Between Variables (Operating Capability, Adoption, Integration, and Organizational Inertia)

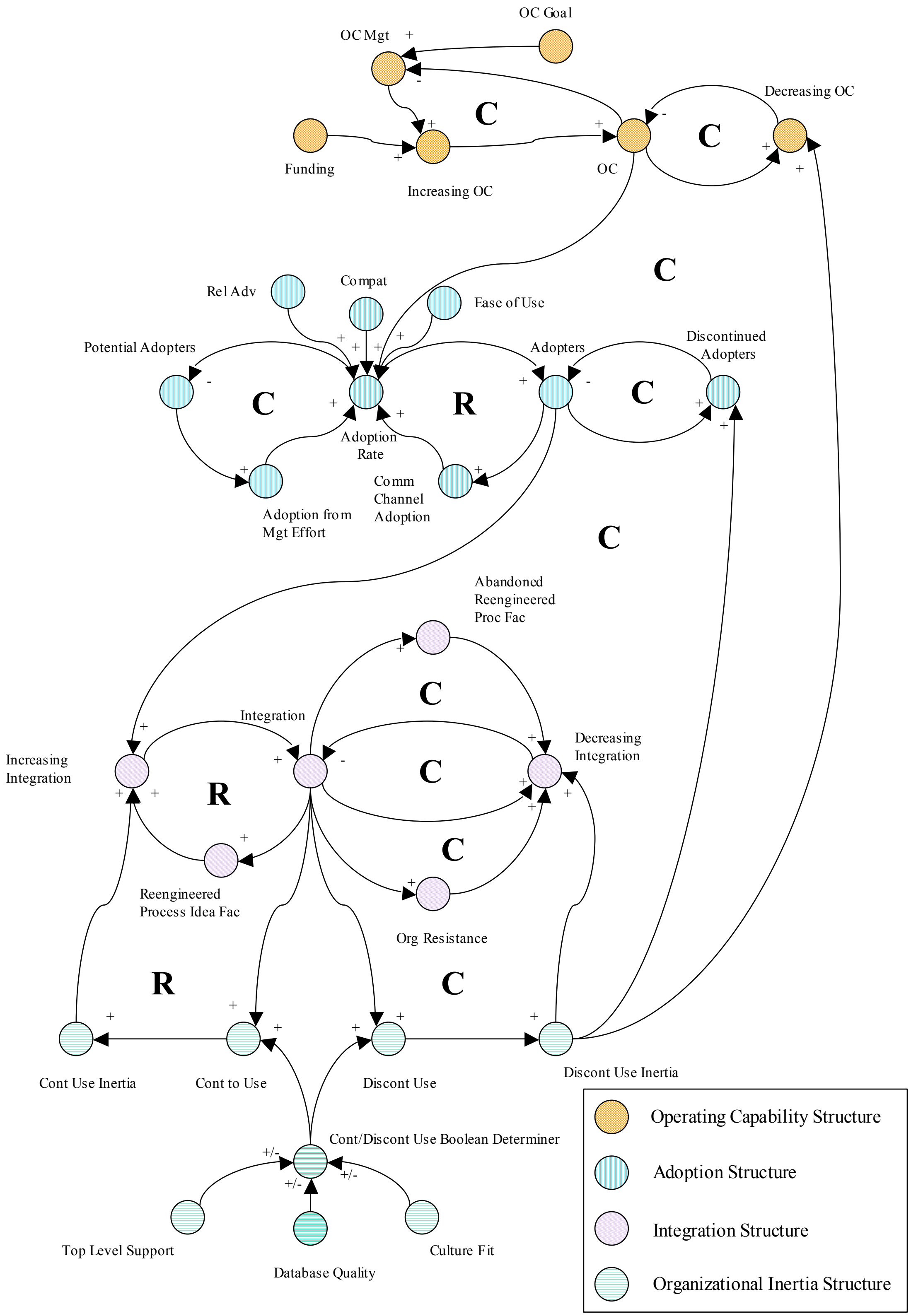


Figure 49: Combination of Model Structures for Main Chain Behavior Pattern

Figure 50 presents the complete causal diagram for the GeoBase integration model. Figure 50 differs from Figure 49 in that all of the management interventions are added to the complete main chain structure. It is interesting to note that each of the management interventions is endogenous to the system since each forms a compensating loop. However, these compensating loops are only activated in the presence of discontinued use inertia, meaning, in the presence of discontinued use inertia, the time the manager must focus on operating capability increases (since the level of operating capability is diminishing), thus reducing the amount of time he can focus on the adoption-integration management interventions. In the context of poor organizational inertia, database quality will suffer since personnel do not continually update their information in the database. This database issue will force the manager to focus more time and effort on operating capability (trying to get people to update their information) and take away time from the adoption-integration efforts. In the presence of no discontinued use inertia, the management interventions will tend to support furthered integration over time (as operating capability management diminishes and allows the manager to spend more time on the adoption-integration management interventions discussed earlier).

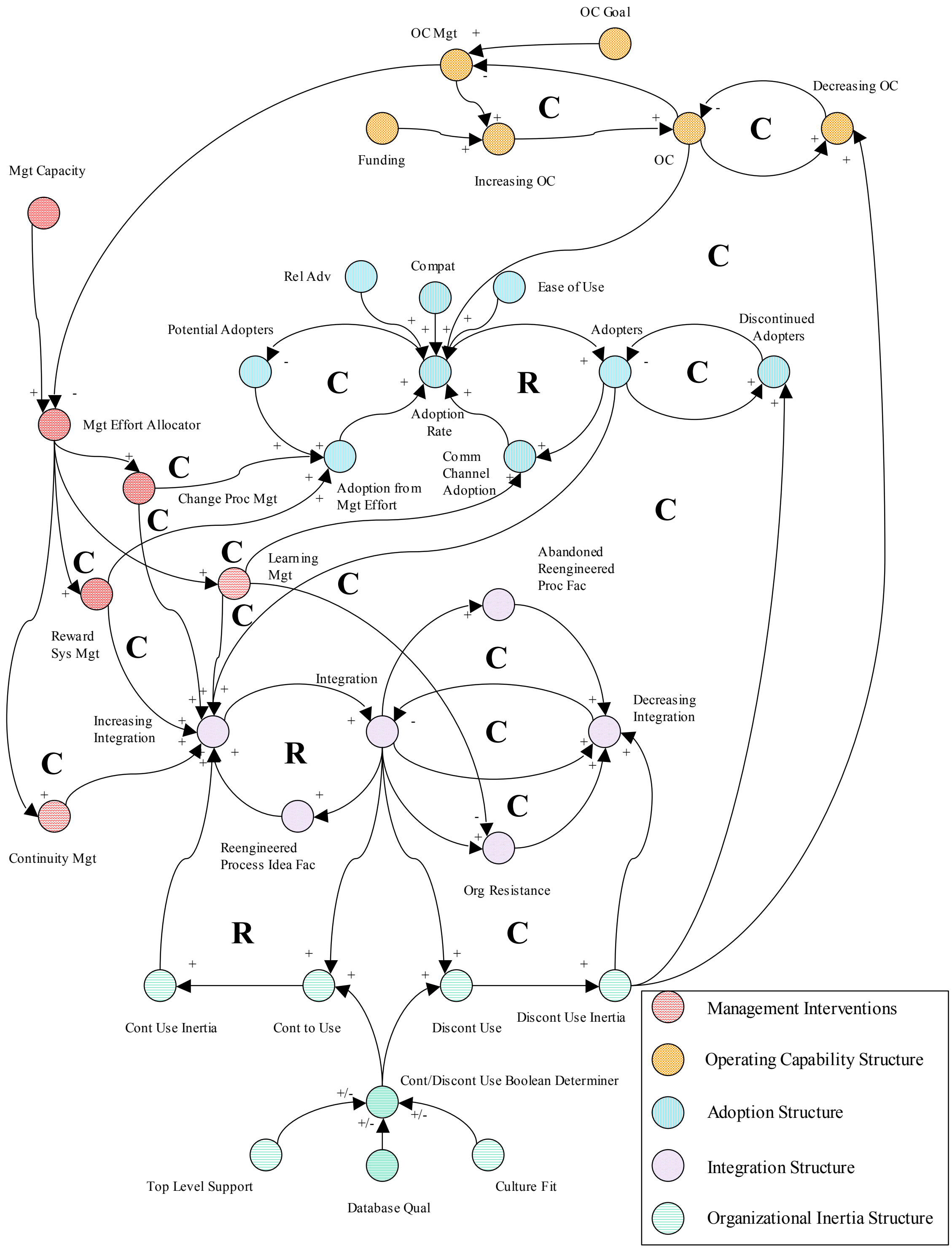


Figure 50: Complete Causal Diagram of GeoBase Implementation Model

Formulation of a Simulation Model

Since the dynamic hypothesis has been discussed in full to this point, a simulation model in the virtual world can be formulated where simulation, testing, and analysis can occur. In the formulation process, each model variable must be quantified (including equations) and only the structure derived from the dynamic hypothesis included in the formulated model. In a study where empirical data from the system exist, these data could be used to synchronize the model with real-world information. Unfortunately, in this system, there are no empirical data available, so other ways must be used to link variables together and define each variable range. These variable definitions should coincide with realistic assumptions from the real world, as to provide the model with reasonable performance parameters that the reader can identify with and understand.

Formulated Structure and Quantification of Aggregate Variables.

Operating Capability.

Figure 51 presents the formulation of the goal seeking structure in STELLA (system dynamics software package) as well as the undesired compensating influence from discontinued use inertia. For discussion on what each of the objects pictured in Figure 51 means, the reader should reference Chapter 3. There is one stock in this structure, Operating Capability (OC), which accumulates operating capability units over time based on its associated flows, Increasing OC and Decreasing OC. The units for OC are units of OC. It is important to assure that the model is mechanistically correct, meaning that each flow should increase or drain the OC stock with units of OC/unit of time.

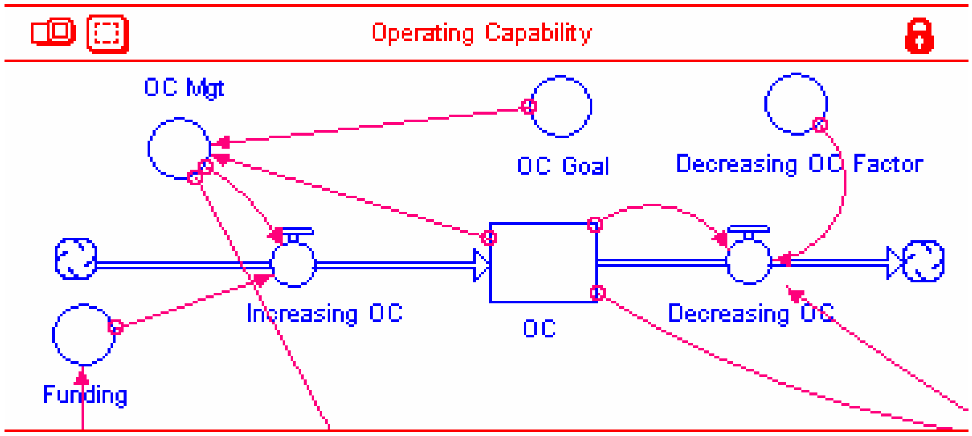


Figure 51: Operating Capability Formulated Structure in STELLA

OC is defined as a combination funding and OC management (OC Mgt), hence the Increasing OC flow equation is:

$$OC\ Mgt * Funding \qquad (1)$$

Equation 1 specifies that the increase in operating capability is a function of the level of funding for GeoBase and the amount of operating capability management intervention exerted. OC Mgt is defined as:

$$OC\ Goal - OC \qquad (2)$$

Equation 2 stipulates that OC Mgt is a function of both the goal for operating capability and what the current level of operating capability is.

Decreasing OC is a function of the level of operating capability and the level of discontinued use inertia (with a unit conversion factor – Decreasing OC Factor) that will drain OC when discontinued use inertia builds up in the system. In a context of continued use inertia (positive organizational inertia), the reference mode will follow the desired goal-seeking pattern that approaches steady state. In a context of discontinued use inertia (negative organizational inertia), the draining structure associated with decreasing OC will compensate for growth by depleting the OC stock and produce the undesired behavior pattern previously discussed. Without discontinued use inertia, there will be no structure to drain OC and deter it from its goal-seeking path. The reader will recall that the main chain structure introduces delays into the system, as multiple stocks in series will do, so the compensating effect from discontinued use inertia will not occur immediately. Drainage in this context takes a long-term view. Decreasing OC is defined as:

*Discontinued Use Inertia * OC * Decreasing OC Factor* (3)

These variables were quantified to synchronize simulation output with realistic behavior patterns and mechanistic soundness. For reasonable model simulation performance (reference Appendix B), the baseline values for each of the variables are as shown in Table 4. Table 4 shows the minimum, maximum, and baseline values that the statically quantified variables take in the operating capability structure. The testing section of the Appendix B contains more information on what these quantified values mean in the real world.

Table 4: Operating Capability (OC) Factor Values

Variable	MIN	MAX	BASELINE
OC	0	1	0.05
OC Goal	0	1	1
Funding	0	1	0.2
Decreasing OC Factor	NA	NA	0.2

Adoption.

Figure 52 presents the formulation of the s-shaped growth structure for adoption in STELLA as well as the undesired compensating influence from discontinued use inertia. There are two stocks in this structure – Potential Adopters and Adopters. These stocks are connected by a flow that transfers units of potential adopters (people) to adopters (also in units of people). Hence, the flow, Adoption Rate, has units of people/unit of time.

The Adoption Rate flow is governed by a number of influences. First, the technology adoption factors, relative advantage, ease of use, and compatibility, all play a role in how rapidly an innovation causes people to move from the potential adopter to the adopter pool. The level of operating capability also plays a role in the adoption rate (naturally, the higher, the better). Adoption Rate is also governed by two loops involving potential adopters and adopters. The first is called the adoption from management effort loop and is a function of the level of system manager intervention focused on this leadership action. The manager must spark initial interest and move personnel from the potential adopter to the adopter pool. This loop will diminish as the potential adopter pool decreases. As the adopter pool increases, the communication channel adoption loop will increase. The communication channel adoption loop is a function of the quality of interpersonal communication networks. The better the quality of the interpersonal communication networks, the faster the adopter pool will increase.

The compensating loop associated with discontinued use inertia includes a flow out of Adopters, called Discontinued Adopters, that flows units of people out of the system. This loop is activated when a level of discontinued use inertia builds up in the system. This model is formulated in such a way, based on the model's assumption, that once an individual discontinues use, he or she leaves the system permanently.

There are several other factors involved in this structure and arrows entering from other portions of the model. In this case, these other variables are for unit conversion and equation formulation purposes. The function of these variables in this portion of the model will be explained as the formulation discussion continues. The equation formulation was an iterative process as all associated variables were added in stepwise fashion.

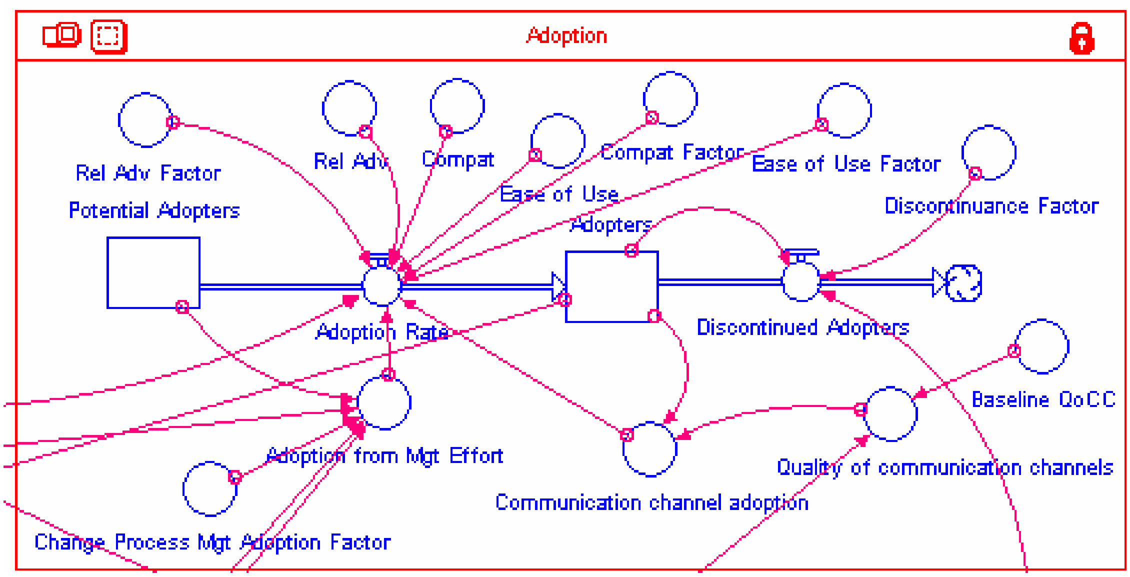


Figure 52: Adoption Formulated Structure in STELLA

Potential adopters are members of the organization (in ratio form, with 1 being the highest and 0 being the lowest) who are capable of using GIS applications in their work functions. The adopter stock is defined as earlier stated (reference Chapter 2 discussion of adoption). The adopter stock is also quantified in ratio form, with 1 being the highest and 0 the lowest.

The adoption rate is the most complicated equation in this structure because it involves quite a number of influences. Equation 4 is the product of four influences: adoption from management effort, communication channel adoption, operating capability, and the factored sum of the three innovation adoption factors (relative advantage, ease of use, and compatibility). The innovation adoption factors will be discussed in a later section. The adoption rate equation is:

*Adoption from Mgt Effort * Communication channel adoption *
(OC * ((Rel Adv Factor * Rel Adv) +
(Compat Factor * Compat) +
(Ease of Use Factor * Ease of Use)))* (4)

Adoption from management effort is a function of management effort and the level of the Potential Adopter stock. In this loop, the manager can focus on two of the four management interventions in the adoption-integration process: change process management and reward system management. The management intervention factors will be discussed in a later section. The equation for adoption from management effort is:

*(Change Process Mgt Adoption Factor*Change Process Mgt*Potential Adopters) +
(Reward Sys Mgt Factor*Reward System Mgt*Potential Adopters)* (5)

Communication channel adoption is a function of the number of adopters and the quality of the communication channels. The equation for communication channel adoption is:

*Adopters * Quality of communication channels* (6)

Quality of communication channels is a function of the baseline quality of communication inherent in the organization and how much effort the manager exerts on improving these channels. In this loop, the manager can have an impact on the quality of communication channels through learning management, specifically focusing on team learning where inter-organizational communication is stressed. The equation for quality of communication channels is:

Baseline QoCC + Learning Mgt (7)

Discontinued Adopters is a function of the level of Adopters and the level of Discontinued Use Inertia (with a unit conversion factor – Discontinuance Factor) that will drain the adopter stock when Discontinued Use Inertia builds up in the system. In a context of continued use inertia (positive organizational inertia), the reference mode will follow s-shaped growth for adopters and inverse s-shaped decline for potential adopters. In a context of discontinued use inertia, the draining structure associated with Discontinued Adopters will drain the adopter stock and cause the undesired behavior pattern shown in the adoption reference mode. The main chain structure will cause a delay in this compensating loop that will gain strength after some initial gains in adoption. The equation for discontinued adopters is:

*Adopters * Discontinued Use Inertia * Discontinuance Factor* (8)

These variables were quantified to synchronize simulation output with realistic behavior patterns and mechanistic soundness. For reasonable model simulation performance (reference Appendix B), the baseline values for each of the variables are as shown in Table 5. Table 5 shows the minimum, maximum, and baseline values that the statically quantified variables take in the adoption structure. Appendix B contains more information on what these quantified values mean in the real world.

Table 5: Adoption Factor Values

Variable	MIN	MAX	BASELINE
Potential Adopters	0	1	0.98
Adopters	0	1	0.02
Relative Advantage	0	10	9
Ease of Use	0	10	3
Compatibility	0	10	5
Baseline QoCC	0	1	0.5
Discontinuance Factor	NA	NA	0.2

Integration

Figure 53 presents the formulation of the s-shaped growth structure for integration in STELLA as well as the undesired compensating influence from discontinued use inertia. There is one stock in this structure -- Integration. The integration stock has two flows connected to it – an inflow (Increasing Integration) and an outflow (Decreasing Integration). The Integration stock accumulates units of integration and the two flows move units of integration/unit of time into and out of the stock. This formulation in the virtual world follows the s-shaped structure in the casual diagram for integration, which was derived from the reference mode behavior pattern for integration.

Increasing integration has many influences that must be accounted for, based on the model's definition of integration. Increasing integration is a function of the number of adopters in the organization, management interventions, organizational business process reengineering prowess, and, to a lesser degree, the organizational innovation continuity.

Decreasing integration also has multiple influences upon it. Decreasing integration is a function of organizational resistance, and, when there is discontinued use inertia built-up in the system, abandoned reengineered processes.

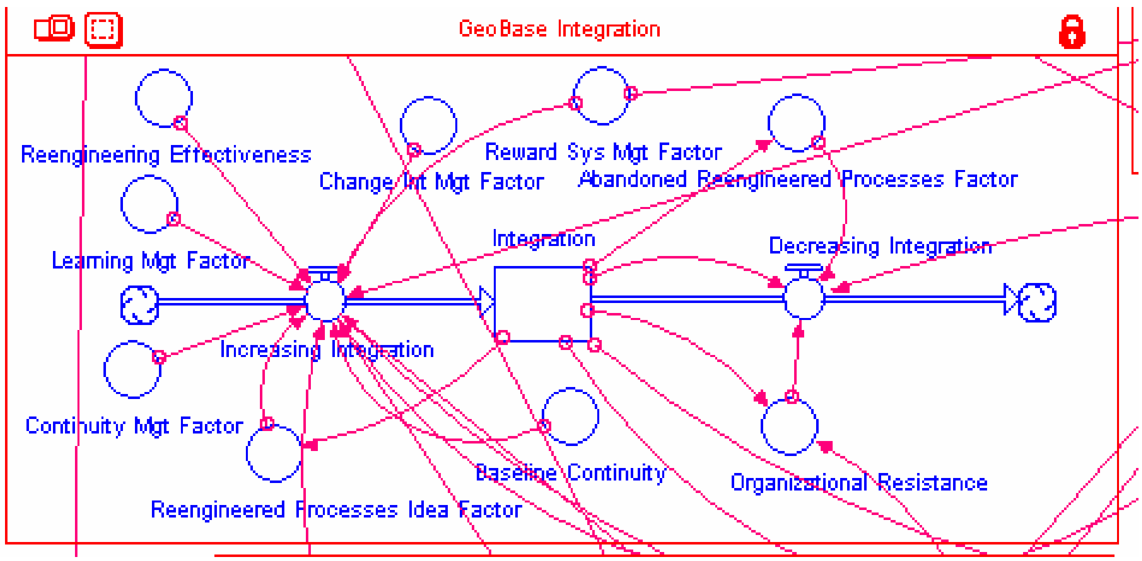


Figure 53: Integration Formulated Structure in STELLA

Increasing Integration has the most complicated equation in the integration structure (as well as the model as a whole) because it involves quite a number of influences. Equation 9 is the product of four influences: adopters, reengineered processes idea factor (which is a function of the level of integration), reengineering effectiveness, and continuity (which is a function of continued use inertia). Continuity is additive in this equation because it is relatively weak in comparison to the other factors under normal, baseline conditions. Baseline continuity refers to the natural level of continuity in the organization. The continuity management intervention will increase organizational continuity, which adds to Integration. Management interventions play a role in the reengineered processes idea factor and reengineering effectiveness portions of the equation. Reward system management plays a role in the reengineered processes idea factor portion of equation 9 because personnel will tend to pursue further reengineering initiatives if an idea program is in place that rewards that type of innovative thinking. Both learning and change process management are in the reengineering effectiveness portion of the equation because increased organizational learning will directly improve the effectiveness of business process reengineering and one of the main sections of change process management focuses directly on business process reengineering issues. The management intervention factors and how they interact will be discussed in a later section. The Increasing Integration equation is:

*(Adopters * (Reengineered Processes Idea Factor + (Reward Sys Mgt Factor * Reward System Mgt)) *(Reengineering Effectiveness +(Learning Mgt Factor * Learning Mgt) + (Change Int Mgt Factor * Change Process Mgt Factor * Change Process Mgt))) + ((Baseline Continuity + (Continuity Mgt Factor * Continuity Mgt)) * Continued Use Inertia)* (9)

Decreasing integration also has a few associated influences. Equation 10 is the product of four influences: integration, organizational resistance (which is a function of the level of integration), discontinued use inertia, and abandoned reengineered processes factor (which is a function of integration). The basic s-shape structure includes only the Integration * Organizational Resistance portion of equation 10. The Discontinued Use Inertia * Abandoned Reengineered Processes Factor portion of equation 10 gives life to the compensating loop that diminishes integration in a negative organizational inertia context, leading to undesired integration behavior. The decreasing integration equation is:

*(Integration * Organizational Resistance) + (Discontinued Use Inertia * Abandoned Reengineered Processes Factor)* (10)

There are two factors in the model that are direct functions of integration. These include reengineered processes idea factor and abandoned reengineered processes factor. They are formulated as:

Reengineered Processes Idea Factor = Integration (11)

Abandoned Reengineered Processes Factor = Integration (12)

Organizational Resistance is also a direct function of Integration, but managers can have a direct influence on this variable. Taking model functionality into account by adding logic that prevents simulation errors, the organizational resistance equation is:

IF((Integration-Learning_Mgt)>0)
THEN(Integration-Learning_Mgt)
ELSE(0) (13)

These variables were quantified to synchronize simulation output with realistic behavior patterns and mechanistic soundness. For reasonable model simulation performance (reference Appendix B), the baseline values for each of the variables are as shown in Table 6. Table 6 shows the minimum, maximum, and baseline values that the statically quantified variables take in the integration structure. Appendix B contains more information on what these quantified values mean in the real world.

Table 6: Integration Factor Values

Variable	MIN	MAX	BASELINE
Integration	0	NA	0.01
Continuity Mgt Factor	NA	NA	0.5
Baseline Continuity	0	1	0.25
Reengineering Effectiveness	0	10	3

Organizational Inertia.

Figure 54 presents the formulation of the accumulating structure for organizational inertia in STELLA. There are two stocks in this structure – one for positive organizational inertia above and beyond the desired behavioral assumption discussed previously (Continued Use Inertia) and one for negative organizational inertia (Discontinued Use Inertia). There are also two flows – Continuing to Use (for Continued Use Inertia) and Discontinuing Use (for Discontinued Use Inertia). The organizational inertia concept could have been presented as one stock, but the numerical calculations throughout the rest of the model would have been unduly complicated and inaccessible. The mix of the three organizational inertia variables in this structure (Top Level Support, Database Quality, and Culture Fit) determines whether the inertia built-up in the system is positive or negative. This aspect is formulated with a variable that uses Boolean logic to transfer flow to the positive or negative side. Hence, with one generalized exception, if there is flow to the positive (continued use inertia) side, there cannot be flow to the negative (discontinued use inertia) side and vice versa. The model makes the generalized assumption that in any organization, there is some level of positive continued use inertia that builds up -- simply by nature of the innovation existing within the organization and being used for something, as mundane as this something might be. This means, even in the presence of negative organizational inertia, that some small measure of positive organizational inertia will build-up over time that supports continued use. Each of the stocks has units in units of inertia. Each of the flows has units in units of inertia/unit of time. Each flow is a function of the level of integration and the level of organizational context (called the Organizational Fit Factor).

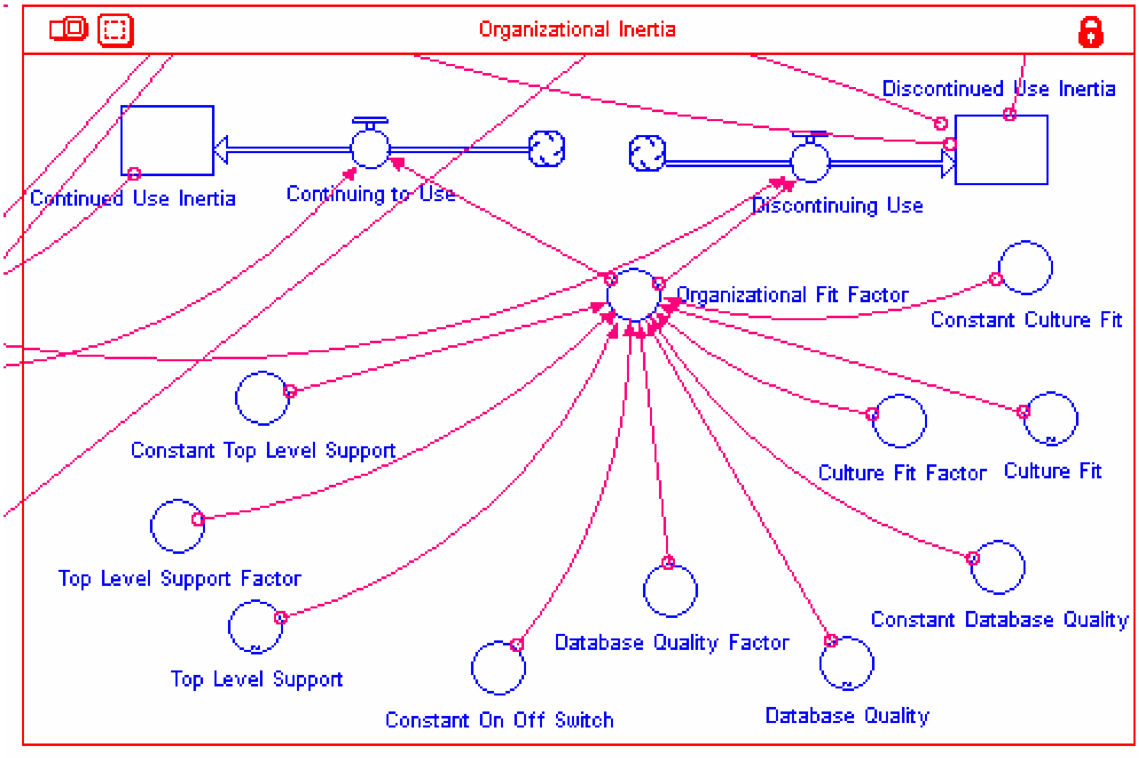


Figure 54: Organizational Inertia Formulated Structure in STELLA

Continuing to Use is the flow that feeds Continued Use Inertia. Continuing to Use is a function of the level of Integration and the Organizational Fit Factor (which is a function of the three organizational inertia factors). The discussion in the preceding paragraph explains why this flow is formulated as shown. Continuing to Use will always flow at least some small amount into Continued Use Inertia (the minimum 0.05*Integration portion is relatively small). The Continuing to Use equation is:

IF(Organizational Fit Factor > 0.05)
*THEN(Organizational Fit Factor * Integration)*
*ELSE(0.05 * Integration)* (14)

Discontinuing Use is the flow feeding Discontinued Use Inertia. It is primarily the same as the Continuing to Use flow, but will only flow to Discontinued Use Inertia if there is a negative number in organizational fit factor. The negative sign in the THEN statement of equation 15 acts as a switch to allow positive flow into discontinued use inertia (since only positive numbers can accumulate in a stock). The Discontinuing Use equation is:

IF(Organizational Fit Factor < 0)
*THEN(-Organizational Fit Factor * Integration)*
ELSE(0) (15)

Organizational Fit Factor consists of a simple calculation, but the equation (equation 16) appears unduly complicated because of the simulation controls that must be placed upon it for ease of modeler use. The Constant On Off Switch allows non-static variable definitions into these variables. If the switch is equal to zero, then the non-static variable definitions for the organizational inertia factors are used. If the switch is equal to 1, then the constant definitions are used. This switch allows the exploration of unique organizational situations without having to perform extensive model adjustments (just change one integer number). The organizational fit factor equation is the sum of the organizational inertia factors (with multiplied weighted factors that will be discussed in a later section). The organizational fit factor equation is:

*IF(Constant On Off Switch = 0) THEN((Culture Fit Factor * Culture Fit) + (Database Quality Factor * Database Quality) + (Top Level Support Factor * Top Level Support)) ELSE((Culture Fit Factor * Constant Culture Fit) + (Database Quality Factor * Constant Database Quality) + (Top Level Support Factor * Constant Top Level Support))* (16)

Each of the constant variables for organizational inertia (Top Level Support, Database Quality, and Culture Fit) can continuously vary over a range of two (from –1 to 1). Any positive number specifies a positive organizational context and any negative number specifies a negative organizational context. The summation of these numbers, with appropriate weighting, determines the overall organizational inertia context for the organization.

These variables were quantified to synchronize simulation output with realistic behavior patterns and mechanistic soundness. For reasonable model simulation performance (reference Appendix B), the baseline values for each of the variables are as shown in Table 7. Table 7 shows the minimum, maximum, and baseline values that the statically quantified variables take in the organizational inertia structure. Appendix B contains more information on what these quantified values mean in the real world.

Table 7: Organizational Inertia Factor Values

Variable	MIN	MAX	BASELINE
Continued Use Inertia	0	NA	0
Discontinued Use Inertia	0	NA	0
Constant Top Level Support	-1	1	0
Constant Database Quality	-1	1	0
Constant Culture Fit	-1	1	0
Constant On Off Switch	0	1	1

Management Interventions.

Figure 55 presents the formulation of the management interventions in STELLA. There are no stocks or flows, hence no structure, but these variables are endogenous to the model as discussed earlier. There are four management interventions in the adoption-integration portion of the model: learning management, change process management, reward system management, and continuity management. The operating capability portion is locked into the operating capability structure, so is not pictured here. It does have a strong influence on how the other management interventions are allocated though.

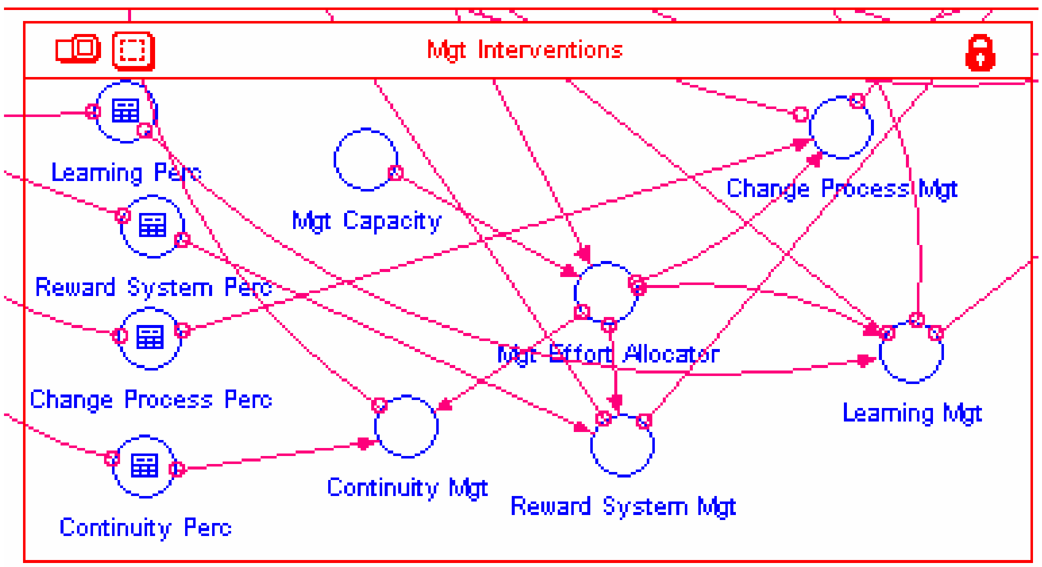


Figure 55: Management Interventions Formulation in STELLA

Mgt Effort Allocator is a variable that specifies the amount of time available to the manager for the four management interventions in the adoption-integration portion of the model. Some logic is included in this equation to avoid simulation errors and inconsistencies (reference Appendix B). OC Mgt is the management intervention variable in the operating capability structure that typically declines over time and frees up more time as operating capability increases. By subtracting OC Mgt from Mgt Capacity, the model will be able to specify a pool of time to split between the remaining four interventions based on the percentages specified. The mgt effort allocator equation is:

IF((Mgt Capacity – OC Mgt > 0) AND (OC Mgt > 0))
THEN(Mgt Capacity – OC Mgt)
ELSE(Mgt Capacity) (17)

For each of the four management interventions in the adoption-integration portion of the system, a percentage is specified: Learning Perc, Reward System Perc, Change Process Perc, and Continuity Perc. These four represent the pertinent percentages for each of the management interventions bearing the same root name (i.e., Reward System Perc is the percentage for Reward System Mgt). The relevant equations for Learning Mgt, Reward System Mgt, Change Process Mgt, and Continuity Mgt are:

*Learning Perc * Mgt Effort Allocator* (18)

*Reward System Perc * Mgt Effort Allocator* (19)

*Change Process Perc * Mgt Effort Allocator* (20)

*Continuity Perc * Mgt Effort Allocator* (21)

Based on the system constraints specified earlier, the sum of the percentages (each of which must fall between zero and one inclusively) must not be greater than one. Each of these percentages can vary continuously between zero and one, but the sum constraint limits the number of possible combinations. Each of the management interventions is included in various loops throughout the model – this portion of the model is where they are specified endogenously.

These variables were quantified to synchronize simulation output with realistic behavior patterns and mechanistic soundness. For reasonable model simulation performance (reference Appendix B), the baseline values for each of the variables are as shown in Table 8. Table 8 shows the minimum, maximum, and baseline values that the statically quantified variables take in the management intervention section. Appendix B contains more information on what these quantified values mean in the real world.

Table 8: Organizational Inertia Factor Values

Variable	MIN	MAX	BASELINE
Mgt Capacity	0	1	1
Learning Perc	0	1	0.25
Reward Perc	0	1	0.25
Change Process Perc	0	1	0.25
Continuity Perc	0	1	0.25

Overall Formulation.

Figure 56 presents the overall formulated structure in STELLA. Each of the aggregate variable structures were grouped within the title boxes to assist the reader decipher the figure. A few controls were added to the model to assist in avoiding mistakes during the simulation phase. A few of these include the table boxes in the center of the four management intervention percentage circles – these variables are defined in a table that provides easier access for number changes. The Mgt Checker variable simply sums the management intervention percentages to check if they sum to one. If not, the model purposefully does not run properly. Other than these modeler controls, the model is the complete picture of each of the individual pictures already discussed. This overall formulated structure is the same as the overall causal diagram – there is no structure in the overall formulated model that does not exist in the overall causal diagram. Since the overall causal diagram was derived from each of the individual reference mode behavior patterns, the model is consistent throughout.

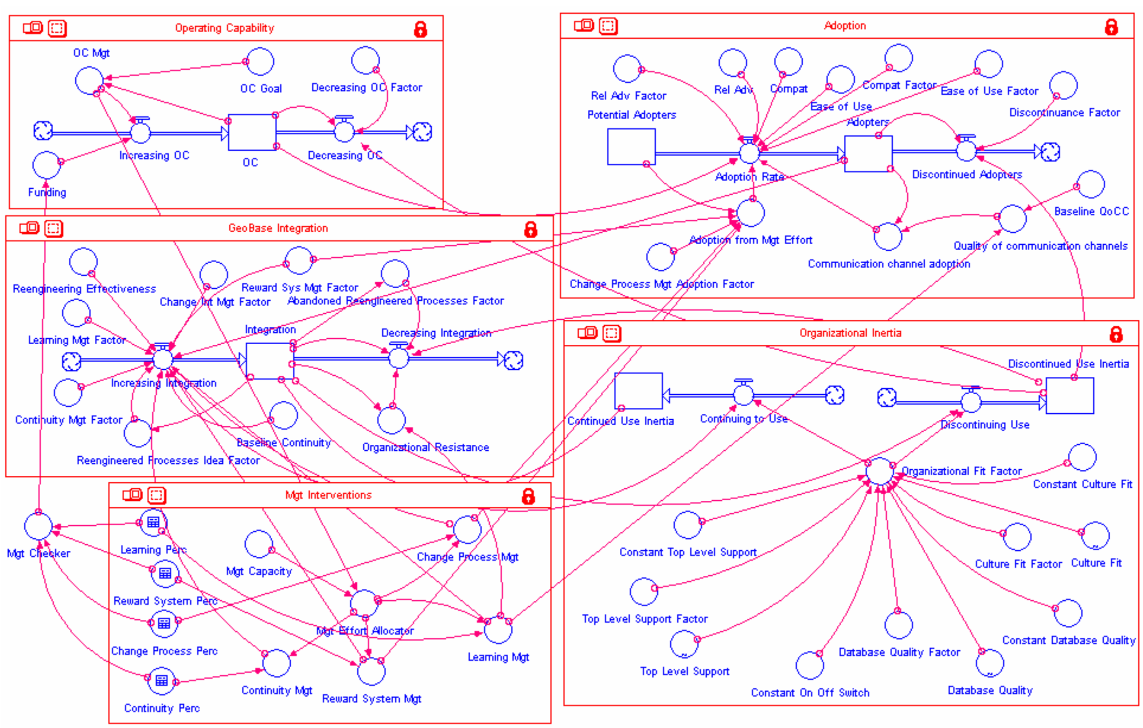


Figure 56: Overall Formulated Model in STELLA

<u>Model Factor Quantification.</u>

Use of the system dynamics approach allows the modeler and client to explore behavior patterns and behavior differences over time, even with a lack of empirical data from the system of study. This approach can yield significant benefits for system understanding and intervention, especially when expensive empirical information gathering is not feasible. However, a lack of empirical data can make quantifying the model difficult, specifically when variables interact with one another in the same equation. Hence, there must be a defensible method to relate variables that interact directly with one another. Grounding the model quantification of interrelated variables in the published scholarly literature is probably the most defensible method in this context.

The basic premise of this quantification procedure is to qualitatively explore the literature that has a broad view for major change initiatives and see how often certain elements of management interventions are discussed. Since aggregated factors are used in the model, there are many specific references from the literature that can be grouped under each of these headings. Based on the percentages of these aggregated discussions, one can get some idea of how important one factor is in relation to another. The literature review pool of literature was screened for selected articles and books that took a broad view of change or innovation diffusion initiatives and were respected in the field (oft quoted in other similar research). Tabulating specific discussions of elements present in this model allowed a qualitative analysis of each article for later quantification. Table 9 is a synopsis of this review.

Table 9 includes a qualitative analysis of three sections. Section 1, management interventions, includes the four adoption-integration management interventions (learning management, reward system management, change process management, and continuity management). Section 2, organizational inertia, includes the three organizational inertia factors (top level support, database quality, and culture fit). Section 3, technology adoption, includes the three technology adoption factors (relative advantage, ease of use, and compatibility). This qualitative assessment used eleven of the articles and books from the literature review, which qualified according to the specifications in the previous paragraph, and analyzed each for specific references that could be grouped under one of these aggregate headings. After gathering and sorting specific references from the literature, the total number of Xs from each section were counted and assigned a ratio percentage for each individual variable in each section. For example, in the management interventions section, there were 73 total Xs. The learning management variable received 16 of these Xs, so its ratio value was 0.21. Likewise, the reward system management variable had a ratio value of 0.19, the change process management variable had a ratio value of 0.5, and the continuity management variable had a ration value of 0.1. The change process management variable was split into four distinct stages, so each stage also received a ratio value where their sum would be 0.5. The management interventions section was split as follows:

Learning Management: 0.21

Reward System Management: 0.19

Change Process Management: 0.5

Analyzing and Planning Change: 0.17

Communicate the Change: 0.11

Changing from Status Quo to Desired State: 0.12

Institutionalizing New Approaches: 0.1

Continuity Management: 0.1

The same approach was followed for the organizational inertia section as was the management interventions section. The organizational inertia section was split as follows:

Top Level Support: 0.21

Database Quality: 0.25

Culture Fit: 0.54

A slightly different approach was followed for the technology adoption section, since there were more empirically quantifiable studies in the literature for this section. For example, some empirically quantified values were found in a study conducted by Agarwal and Prasad (2000) where they analyzed the same three factors used in this model (relative advantage, ease of use, and compatibility) in a technology adoption study. For each article with a focus on technology adoption analysis factors, the importance of each individual factor was quantified by allowing each writer three Xs for the technology adoption factor section and distributing them throughout it according to either quantified or inferred meaning from the article. For example, Davis et al. (1989) focus on two factors of the technology acceptance model: perceived usefulness and perceived ease of use. They also specify that users will tolerate a difficult interface in order to access functionality that is very important, while no amount of ease of use will compensate for a system that does not do a useful task. Hence, the it was determined that perceived ease of use was one quarter as important as perceived usefulness. As a result, the relative advantage section (closely associated with perceived usefulness) would receive 2.25 Xs and the ease of use section would receive 0.75 Xs for this article. Table 9 includes all of the article analysis for this section. After compiling the information for this section, the technology adoption section was split as follows:

Relative Advantage: 0.54

Ease of Use: 0.28

Compatibility: 0.18

With these weighting factors in place, a defensible equation quantification method (for equations with more than one factor included) could be performed to reflect these weightings. Table 10 provides a synopsis of the factors from the full model associated with these weightings, their values, and the numbered equations they appear in for reader reference. Weighting factors were not included in equations where there were not two or more factors together.

The management intervention factors are not the same as those summarized above, whereas the factors for technology adoption and organizational inertia are the same as above. For the management interventions, the baseline value for reward system management was set to 1 and the other factors arranged according to this specification. For example, the Learning Mgt Factor is 1.1. Comparing the values derived from Table 9 (Reward System Mgt = 0.19, Learning Mgt = .21) with the values from Table 10 (Reward System Mgt Factor = 1, Learning Mgt Factor = 1.1), the ratio value of the Table 9 comparison (0.19/0.21 = 0.90) is the same as Table 10 (1/1.1 = 0.90). The Change Process Mgt variable was also split into two parts when entered into the model. The first three portions of Change Process Mgt (Analyzing and Planning Change, Communicate the Change, and Changing from Status Quo to Desired State) fit best into the adoption portion of the management intervention (in the adoption from management effort loop), whereas the last portion (Institutionalizing New Approaches) seemed to fit best in the integration section of the model. Hence, these variables were split into two weighting factors: Change Process Mgt Adoption Factor and Change Int Mgt Factor. Change Process Mgt Adoption Factor took the weighting from the first three portions of Change Process Management (0.17 + 0.11 + 0.12 = 0.4) and Change Int Mgt Factor took the weighting from the last portion of Change Process Management (0.1). Hence, comparing Reward System Mgt Factor with Change Process Mgt Adoption Factor yields the ratio from Table 9 as 0.19/0.4 = 0.48 and the ratio from Table 10 as 1/2.1 = 0.48 (the same ratio). All factors in the management interventions portion were derived in this manner.

Since these weighted variables are included in the model, the model has a more defendable grounding in the literature. Each of the management interventions is included where they would naturally assist in the adoption-integration process. Inclusion of these management factors in the system structure allows the manager to investigate what type of context he or she is working in and better use his or her time doing the things that will bring the most impact on the GeoBase implementation system. With the dynamic hypothesis and formulation in place, a discussion of the testing phase can begin.

Table 9: Qualitative Analysis of Model Variable Weightings

Section 1: Management Interventions	Readines for Change Armenakis et al.	Diffusion of Innovations Rogers	Forced Adoption Ram & Jung	Effective Change Mgt Kotter	GIS in DoD Cullis	Change in 90s Armenakis & Bedeian
Learning Management						
Encourage Peer Interaction During Implementation			X			
Develop Employee Competence			X			
The more people involved, the better the outcome				X		
Lone individual development led to poor GIS performance organization-wide					X	
Require participation in team building and team participation						
Information acquisition programs (congenital,direct,experiences of others,strategic actions)						
Information distribution programs (company visits, personnel rotation, instruction and training)						
Team learning and role of dialouge						
Learning Contracts and Learning Sets						
Circular Structures (learning organizations transfer individual learning to organizational learning by making mental models explicit)						
Structured training experiences have value						
Participative decision making (participation in formalized strategic planning activities)						X
Vicarious learning programs (personnel observing others using tools)						X
Enactive mastery (small change step progression)						X
Mass media communication channels (company newsletters, advertising, training)		X				
Interpersonal communication channels (personnel, opinion leaders)		X				

Table 9 (cont): Qualitative Analysis of Model Variable Weightings

Section 1: Management Interventions	GIS Implementation Recommendations Geo InSight	Learning Organizations Romme & Dillen	Technology Adoption Agarwal & Prasad	TAM model Davis et al.	Adopting IT innovation Moore & Benbasat
Learning Management					
Encourage Peer Interaction During Implementation					
Develop Employee Competence					
The more people involved, the better the outcome					
Lone individual development led to poor GIS performance organization-wide					
Require participation in team building and team participation	X				
Information acquisition programs (congenital,direct,experiences of others,strategic actions)		X			
Information distribution programs (company visits, personnel rotation, instruction and training)		X			
Team learning and role of dialouge		X			
Learning Contracts and Learning Sets		X			
Circular Structures (learning organizations transfer individual learning to organizational learning by making mental models explicit)		X			
Structured training experiences have value			X		
Participative decision making (participation in formalized strategic planning activities)					
Vicarious learning programs (personnel observing others using tools)					
Enactive mastery (small change step progression)					
Mass media communication channels (company newsletters, advertising, training)					
Interpersonal communication channels (personnel, opinion leaders)					

Table 9 (cont): Qualitative Analysis of Model Variable Weightings

	Readines for Change	Diffusion of Innovations	Forced Adoption	Effective Change Mgt	GIS in DoD	Change in 90s
	Armenakis et al.	Rogers	Ram & Jung	Kotter	Cullis	Armenakis & Bedeian
Reward System Management						
Remove obstacles to the new vision				X		
Narrow job categories prevent productivity after change				X		
Personal outcomes of adoption determine long-term use					X	
Selection						X
Performance appraisal						X
Compensation						X
Individuals resist if self-interest is being threatened						X
Managers should focus attention on motivating personnel by highlighting the relative advantage and compatibility aspects of a new technology						
Perceived usefulness is based on forming intentions toward behaviors personnel believe will increase job performance which leads to pay increases and promotions						
Relative advantage -- innovation offers better way of doing same task, which will lead to better pay and promotion possibilities		X				
Observability -- the degree to which the results of an innovation are observable to others		X				

Table 9 (cont): Qualitative Analysis of Model Variable Weightings

	GIS Implementation Recommendations	Learning Organizations	Technology Adoption	TAM model	Adopting IT innovation
	Geo InSight	Romme & Dillen	Agarwal & Prasad	Davis et al.	Moore & Benbasat
Reward System Management					
Remove obstacles to the new vision					
Narrow job categories prevent productivity after change					
Personal outcomes of adoption determine long-term use					
Selection					
Performance appraisal					
Compensation					
Individuals resist if self-interest is being threatened					
Managers should focus attention on motivating personnel by highlighting the relative advantage and compatibility aspects of a new technology			X		
Perceived usefulness is based on forming intentions toward behaviors personnel believe will increase job performance which leads to pay increases and promotions				X	
Relative advantage -- innovation offers better way of doing same task, which will lead to better pay and promotion possibilities				X	X
Observability -- the degree to which the results of an innovation are observable to others					X

Table 9 (cont): Qualitative Analysis of Model Variable Weightings

	Readines for Change	Diffusion of Innovations	Forced Adoption	Effective Change Mgt	GIS in DoD	Change in 90s
	Armenakis et al.	Rogers	Ram & Jung	Kotter	Cullis	Armenakis & Bedeian
Change Process Management						
Incremental approach is important (don't skip steps)	X			X		X
Analyzing and planning change						X
Establishing a sense of urgency				X		
Form powerful guiding coalition				X		
Create a vision				X		
Develop strategic plan for achieving GIS success					X	
Require development team to set realistic expectations						
Encourage Peer Interaction During Implementation			X			
Readiness for change assessments are helpful	X					
TAM is relevant for managers wanting an "early warning technique" for system acceptability						
Communicate the Change						X
Change agent builds target's self efficacy	X			X		
Communicate the Vision				X		
Work through opinion leaders, interpersonal and mass media communication channels	X	X				
Focus on end user and not solely on technology					X	
Managers should focus attention on motivating personnel by highlighting the relative advantage and compatibility aspects of a new technology						
Changing from status quo to desired state						X
Gaining acceptance of new behaviors						X
Empower Others to Act on the Vision				X		
Ensure access for all users						
Facilitate Trial/triability		X	X			
Innovation adoption		X				
Institutionalizing New Approaches				X		
Planning for and creating short-term wins				X		
Consolidating Improvements and Producing Still More Change				X		
Consolidating and institutionalizing the new state						X
Highly visible pilot project that is successful						
For long-term routinization of technology, work process changes are necessary						
Innovation reinvention		X				

Table 9 (cont): Qualitative Analysis of Model Variable Weightings

	GIS Implementation Recommendations	Learning Organizations	Technology Adoption	TAM model	Adopting IT innovation
	Geo InSight	**Romme & Dillen**	**Agarwal & Prasad**	**Davis et al.**	**Moore & Benbasat**
Change Process Management					
Incremental approach is important (don't skip steps)					
Analyzing and planning change					
Establishing a sense of urgency					
Form powerful guiding coalition					
Create a vision					
Develop strategic plan for achieving GIS success					
Require development team to set realistic expectations	X				
Encourage Peer Interaction During Implementation					
Readiness for change assessments are helpful					
TAM is relevant for managers wanting an "early warning technique" for system acceptability				X	
Communicate the Change					
Change agent builds target's self efficacy					
Communicate the Vision					
Work through opinion leaders, interpersonal and mass media communication channels					
Focus on end user and not solely on technology					
Managers should focus attention on motivating personnel by highlighting the relative advantage and compatibility aspects of a new technology			X		
Changing from status quo to desired state					
Gaining acceptance of new behaviors					
Empower Others to Act on the Vision					
Ensure access for all users	X				
Facilitate Trial/triability					X
Innovation adoption					X
Institutionalizing New Approaches					
Planning for and creating short-term wins					
Consolidating Improvements and Producing Still More Change					
Consolidating and institutionalizing the new state					
Highly visible pilot project that is successful	X				
For long-term routinization of technology, work process changes are necessary			X		
Innovation reinvention					

Table 9 (cont): Qualitative Analysis of Model Variable Weightings

	Readines for Change	Diffusion of Innovations	Forced Adoption	Effective Change Mgt	GIS in DoD	Change in 90s
	Armenakis et al.	**Rogers**	**Ram & Jung**	**Kotter**	**Cullis**	**Armenakis & Bedeian**
Continuity Management						
Readiness for change assessments are helpful	X					
Not anchoring changes in the corportation's culture				X		
Many organizations had nothing written down -- leading to poor performance					X	
Personnel turnover causes much of the corporate knowledge to be lost					X	
Develop strategic plan for achieving GIS success					X	
Assemble a toolkit to show the way ahead					X	
Storage of Information (organizational memory)						

	GIS Implementation Recommendations	Learning Organizations	Technology Adoption	TAM model	Adopting IT innovation
	Geo InSight	**Romme & Dillen**	**Agarwal & Prasad**	**Davis et al.**	**Moore & Benbasat**
Continuity Management					
Readiness for change assessments are helpful					
Not anchoring changes in the corportation's culture					
Many organizations had nothing written down -- leading to poor performance					
Personnel turnover causes much of the corporate knowledge to be lost					
Develop strategic plan for achieving GIS success					
Assemble a toolkit to show the way ahead					
Storage of Information (organizational memory)		X			

Table 9 (cont): Qualitative Analysis of Model Variable Weightings

Section 2: Organizational Inertia	Readines for Change Armenakis et al.	Diffusion of Innovations Rogers	Forced Adoption Ram & Jung	Effective Change Mgt Kotter	GIS in DoD Cullis	Change in 90s Armenakis & Bedeian
Top Level Support						
Form powerful guiding coalition				X		
High Level of Management Commitment Required						
Top management support for GIS is crucial					X	
New organizational structures						X
Revised job descriptions						X
Innovation champion must have support of upper management		X				
Database Quality						
Ensure minimum data quality						
Confidence in the Quality of the Database					X	
Interpretation of information (database sharing/quality)						
Compatibility/usefulness		X				
Cultural Fit						
Forced adoption causes organizational resistance			X			X
Declaring victory too soon is poor management				X		
Poor fit of technology and organization hampers productivity					X	
70% of IT projects fail due to non-technical reasons					X	
Seek out resistance to GIS and treat as signal needing response					X	
Resistance resulting from difference between current identity and envisioned identity						X
Develop positive attitude toward change within organization						
Perceived job insecurity exhibits strong negative relationships with innovation						
Response to influence attempts will be determined by target's cultural membership	X					
Cynicism as a result of a history of failed change programs						X
Cynicism as a result of a history of poor management communication						X
Not anchoring changes in the corportation's culture				X		
Culture is explanation of why personnel did not perceive management pressure to adopt innovation						
Innovative vs. non-innovative organizations		X				

Table 9 (cont): Qualitative Analysis of Model Variable Weightings

Section 2: Organizational Inertia	GIS Implementation Recommendations Geo InSight	Learning Organizations Romme & Dillen	Technology Adoption Agarwal & Prasad	TAM model Davis et al.	Adopting IT innovation Moore & Benbasat
Top Level Support					
Form powerful guiding coalition					
High Level of Management Commitment Required	X				
Top management support for GIS is crucial					
New organizational structures					
Revised job descriptions					
Innovation champion must have support of upper management					
Database Quality					
Ensure minimum data quality	X				
Confidence in the Quality of the Database					
Interpretation of information (database sharing/quality)		X			
Compatibility/usefulness			X	X	X
Cultural Fit					
Forced adoption causes organizational resistance					
Declaring victory too soon is poor management					
Poor fit of technology and organization hampers productivity					
70% of IT projects fail due to non-technical reasons					
Seek out resistance to GIS and treat as signal needing response					
Resistance resulting from difference between current identity and envisioned identity					
Develop positive attitude toward change within organization	X				
Perceived job insecurity exhibits strong negative relationships with innovation			X		
Response to influence attempts will be determined by target's cultural membership					
Cynicism as a result of a history of failed change programs					
Cynicism as a result of a history of poor management communication					
Not anchoring changes in the corportation's culture					
Culture is explanation of why personnel did not perceive management pressure to adopt innovation			X		
Innovative vs. non-innovative organizations					

Table 9 (cont): Qualitative Analysis of Model Variable Weightings

Section 3: Technology Adoption	Readines for Change Armenakis et al.	Diffusion of Innovations Rogers	Forced Adoption Ram & Jung	Effective Change Mgt Kotter	GIS in DoD Cullis	Change in 90s Armenakis & Bedeian
Relative Advantage		(0.75*X)				
Perceived usefulness						
Observability		(0.75*X)				
Ease of Use						
Perceived ease of use						
Complexity		(0.75*X)				
Users will tolerate a difficult interface in order to access functionality that is very important, while no amount of ease of use will compensate for a system that does not do a useful task						
Compatibility		(0.75*X)				

Section 3: Technology Adoption	GIS Implementation Recommendations Geo InSight	Learning Organizations Romme & Dillen	Technology Adoption Agarwal & Prasad	TAM model Davis et al.	Adopting IT innovation Moore & Benbasat
Relative Advantage			R^2 = 0.41: (1.2*X)		(0.75*X)
Perceived usefulness				(2.25*X)	
Observability					(0.75*X)
Ease of Use			R^2 = 0.35: (1.05*x)		
Perceived ease of use				(0.75*X)	
Complexity					(0.75*X)
Users will tolerate a difficult interface in order to access functionality that is very important, while no amount of ease of use will compensate for a system that does not do a useful task					
Compatibility			R^2 = 0.19: (0.75*X)		(0.75*X)

Table 10: Weighted Factors in Formulated Model Summary Table

Variable	Value	Equation Number in which Factor Appears
Management Interventions		
Learning Mgt Factor	1.1	9
Reward System Mgt Factor	1	5, 9
Change Process Mgt Adoption Factor	2.1	5
Change Int Mgt Factor	0.5	9
Continuity Mgt Factor	0.5	9
Technology Adoption		
Rel Adv Factor	0.54	4
Ease of Use Factor	0.28	4
Compat factor	0.18	4
Organizational Inertia		
Top Level Support Factor	0.21	16
Database Quality Factor	0.25	16
Culture Fit Factor	0.54	16

Testing

Boundary Adequacy Test.

The purpose of the boundary adequacy test, as stated by Sterman (2000), is as follows:

> **Are the important concepts for addressing the problem endogenous to the model?**
>
> **Does the behavior of the model change significantly when boundary assumptions are relaxed?**
>
> **Do the policy recommendations change when the model boundary is extended?**

System dynamics models are the most useful when endogenous behavior is analyzed. Based on the analysis of the system structure, the GeoBase implementation model structure is endogenous. There are a few exogenous contextual variables, but they do not drive system behavior – there is an endogenous explanation for system behavior based on the system structure.

The system boundary is based on the research problem. Since the focus of this research is on a squadron-size organization, it would be difficult to extend the model boundary to include variables outside the control of the system manager. For example, funding is exogenous in this system since funding allocation decisions for GeoBase are not made at the squadron level. Extending the study boundary to include Air Staff would allow for the exploration of funding decisions more closely, but the added complexity would force the aggregation of many of the concepts inherent in this smaller system boundary. This level of aggregation would run counter to the research problem and questions.

It is concluded from the system structural assessment test that the important concepts in this model, primarily operating capability, adoption, integration, and organizational inertia, are endogenous. The management interventions are also endogenous. The system boundary is adequate to address the research problem and questions.

Structure Assessment Test.

The purpose of the structure assessment test, as stated by Sterman (2000), is as follows:

> **Is the model structure consistent with relevant descriptive knowledge of the system?**
>
> **Is the level of aggregation appropriate?**
>
> **Does the model conform to basic physical laws such as conservation laws?**
>
> **Do the decision rules capture the behavior of the actors in the system?**

Based on the literature review, client coordination, and other relevant system background, the model structure is consistent with relevant descriptive knowledge of the system. The key is to accurately capture the reference mode behavior patterns and base the model structure on these patterns. Great care was taken to accomplish this element of the modeling process.

The modeler must always struggle with what level of aggregation is appropriate for the model. One way to determine if the model is too disaggregated is through sensitivity testing (reference Appendix B). If a variable in the system does not affect the system in any appreciable way when altered, it can probably be aggregated into other variables. The modeler must take care not to overly aggregate the model as well. If the model is too aggregated, there are usually difficulties answering the questions associated with the research problem the model hopes to help address.

The model is based on assumptions that are generally true in the real world. The model realistically functions in accordance with organizational behavior findings presented in the literature. The model also assumes that managers will want to improve GeoBase system performance by using recommendations by experts in the field of organizational improvement. Many of the interventions discussed in this model may not be currently used in many of the squadron organizations attempting to implement GeoBase, but these management interventions represent the best methods managers can use to improve system performance. One of the goals for this research is to recommend a cocktail of management interventions that should most effectively improve system performance based on the context of the organization.

Parameter Assessment Test.

The purpose of the parameter assessment test, as stated by Sterman (2000), is as follows:

> **Are the parameter values consistent with relevant descriptive and numerical knowledge of the system?**

Do all parameters have real world counterparts?

The system parameters are as realistic as practicable based on the amount of data available in the literature and from the system itself. With the lack of empirical data from the real world and the uniqueness of this research effort, this model is linked as closely to the literature and system as possible. The model factors themselves are realistic in the system and are reflective of relevant factors from the literature. The factor weightings were derived from a qualitative assessment of the descriptive elements of the literature – which was the best method available for weighting analysis under the research conditions.

Behavior Reproduction Test.

The purpose of the behavior reproduction test, as stated by Sterman (2000), is as follows:

> **Does the model produce the behavior of interest in the system (qualitatively and quantitatively)?**
>
> **Does it endogenously generate the symptoms of difficulty motivating the study?**
>
> **Does the model generate the various modes of behavior observed in the real system?**

Figure 57 shows the baseline output from the system with all variables at their baseline levels. Since this research will contain a number of these figures, the forthcoming discussion will explain how they are organized. At the top of Figure 57 there are a number of variable names: 1: OC (operating capability), 2: Potential Adopters, 3: Adopters, and 4: Integration. Each of the traces on the graph, labeled 1 through 4, represents each of their respective displayed variables. The scale on the left side of the graph (Y-axis) shows the scales for each of the traces. These too are labeled 1 through 4 and represent the trace scales for each of their respective variables. The X-axis presents the time scale in years. The time scope for this research is ten years, so the X-axis ends at ten years. Each of the proceeding graphs will have differing variables at different scales.

In the baseline condition shown in Figure 57, the various curves present the desired performance of each variable, as specified in each of their reference mode behavior patterns, as well as the main chain behavior resulting in a lagged response for adopters and integration. The operating capability (OC) trace (Trace 1) displays a goal-seeking behavior pattern as it approaches its goal value of 1. It starts at 0.05 and progressively approaches 1. After ten years, its final value is 0.87. Had the simulation been allowed to run for a longer period of time, it would have eventually come to a static steady-state level of 1. The potential adopters trace (Trace 2) begins at its initial value of 0.98 and displays inverse s-shaped behavior, eventually coming to a low value of 0 after 8.1 years. The adopters trace (Trace 3) begins at its initial value of 0.02 and displays s-shaped behavior, eventually coming to a high value of 1 after 8.1 years. Remember that the stocks for potential adopters and adopters are linked, so when a unit of the potential adopters stocks flows out, it travels directly to the adopter stock (the reason for their inverse behavior patterns). The integration trace (Trace 4) begins at an initial value of 0.01 and also displays s-shaped behavior, eventually coming to a value of 3.81 after ten years. The main chain behavior pattern shows the time lags between operating capability, adopters, and integration.

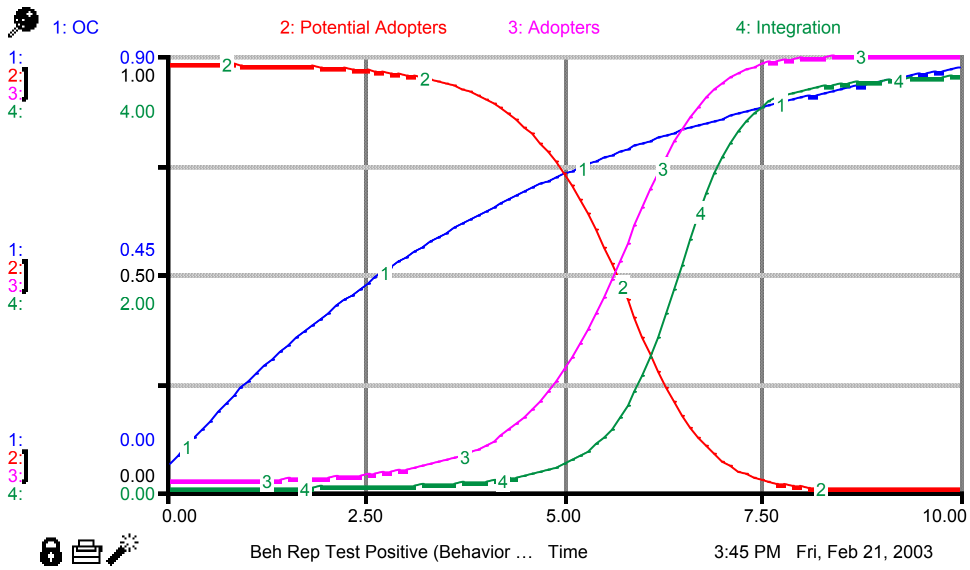


Figure 57: Behavior Reproduction Test for Desired System Performance (All Variables at Baseline Levels)

Each of the unique structures must be simulated to ensure that the structure is driving the behavior pattern of interest as opposed to an exogenous influence. Each individual model structure (operating capability, adoption, integration, and organizational inertia) was taken out of the holistic model and individually tested to assure the structure was driving the simulated behavior pattern. Since each of the individual structures have been taken out of the model, so there is no main chain behavior pattern – each of the simulations has no initial delays. Figure 58 shows the simulated behavior of the operating capability structure alone. As expected, it displayed goal-seeking behavior. Figure 59 shows the simulated behavior of the adoption structure alone. As expected, it displays static s-shape behavior (s-shaped goal-seeking behavior with the “the goal” of zero potential adopters). Figure 60 shows the simulated behavior of the integration structure alone. As expected, it displays s-shape behavior. Figure 61 shows the simulated behavior of the integration structure (with all of the input going to the continued use inertia stock) alone. As expected, it displays accumulating behavior. Based on these results, each of the model structures drives the reference mode behavior pattern.

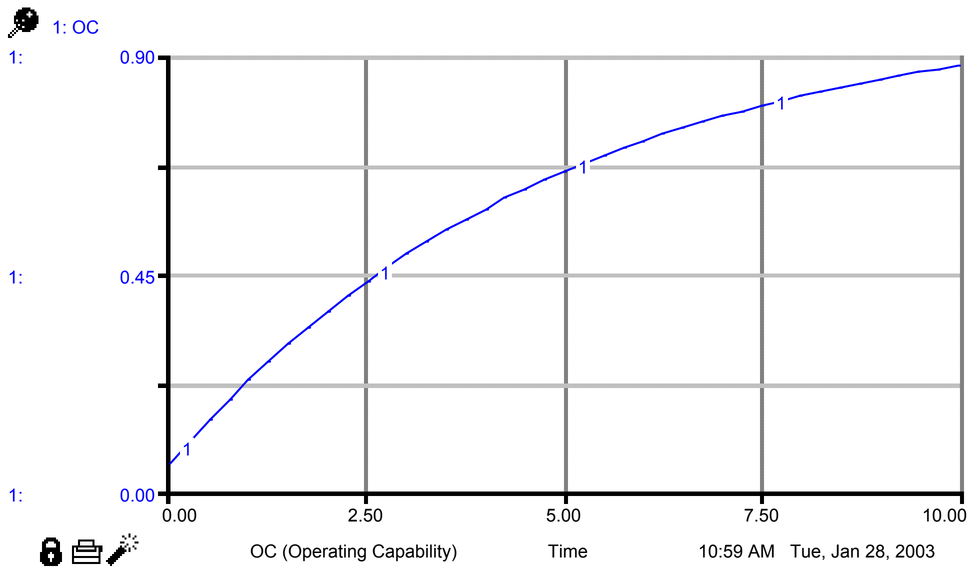


Figure 58: Operating Capability Behavior Reproduction Test for Operating Capability Structure Alone

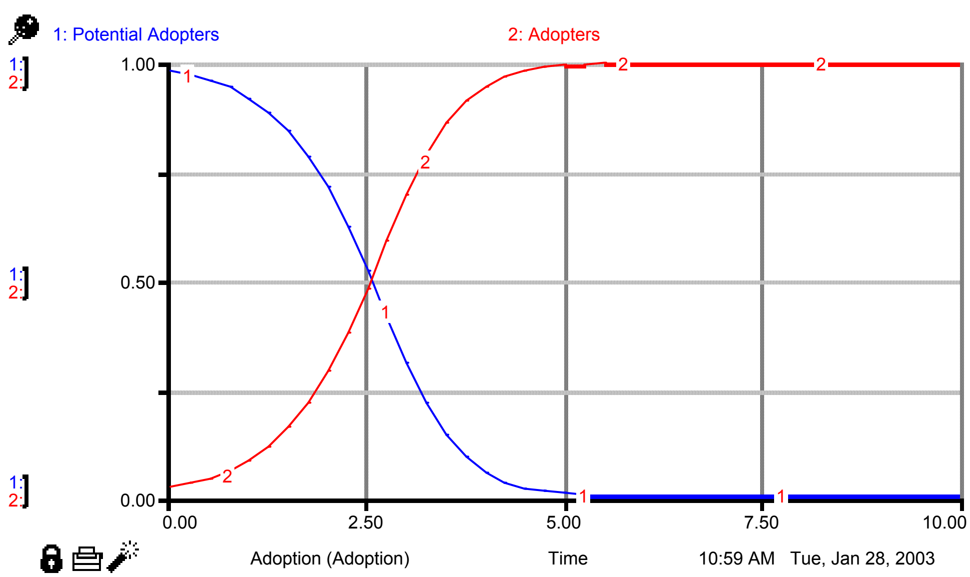


Figure 59: Adoption Behavior Reproduction Test for Adoption Structure Alone

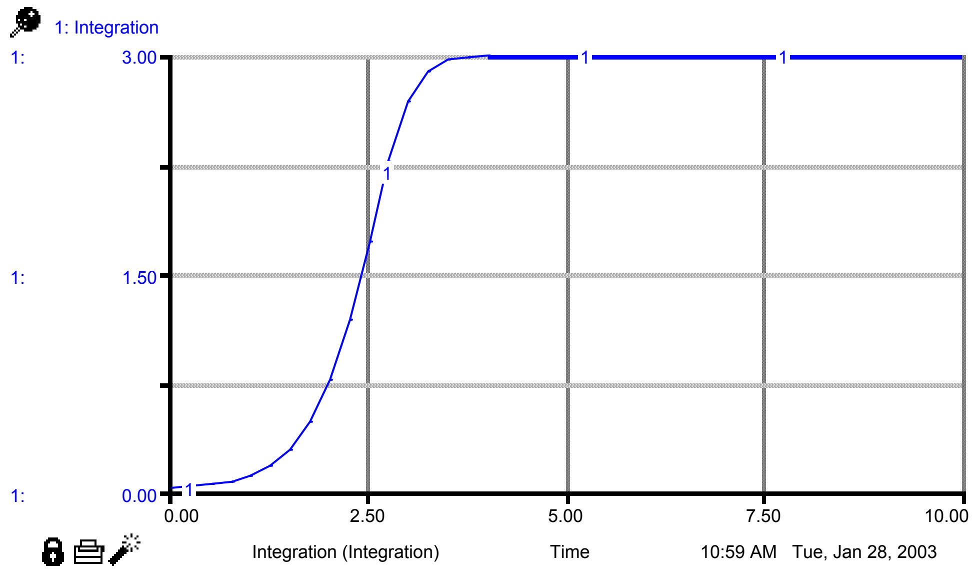


Figure 60: Integration Behavior Reproduction Test for Integration Structure Alone

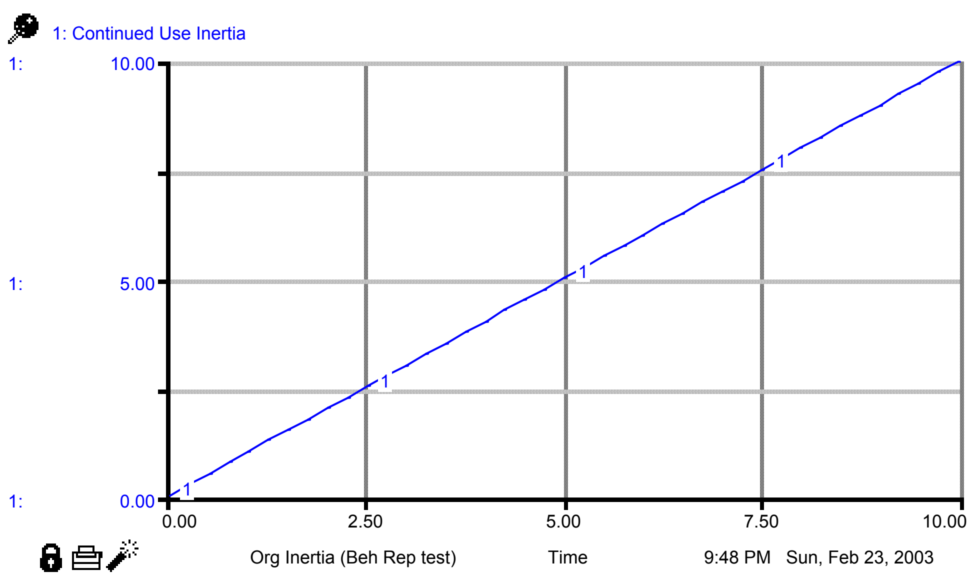


Figure 61: Organizational Inertia Structure for Organizational Inertia Structure Alone

Figure 62 presents the behavior reproduction test for the undesired condition for each of these variables (with discontinued use inertia built up in the system). This undesired behavior pattern represents the innovation not meeting organizational needs in the long-term. Each of the variables shown in Figure 62 have short-term acceptable performance, but when discontinued use inertia begins building up in the system, the compensating loops in the system overcome the reinforcing loops and the system declines as expected. The delayed compensating behavior is expected due to the main chain structure with multiple stocks.

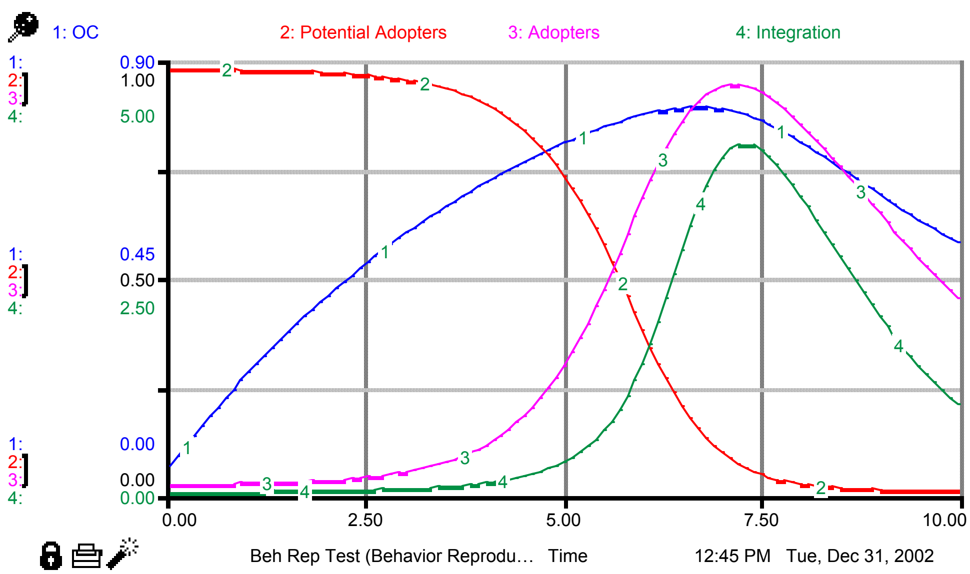


Figure 62: Behavior Reproduction Test for Undesired System Performance (Discontinued Use Inertia Built Up)

There is an historical problem associated with GIS-related IT investments in the Air Force. As Lieutenant General Zettler, AF/IL, succinctly stated, “when it comes to management/fielding of new IT capabilities, ‘we do extremely poorly’” (Department of the Air Force, 2002a). The model has been formulated with this important historical facet in mind. Without proper management of the organizational elements of the system, it is doomed to failure. Managers typically focus only on the technical aspects at the expense of the organizational aspects and the IT projects dwindle and die as a result.

Simulating this concept in the model can be done by setting all of the adoption-integration management percentages to zero and keeping everything else at its baseline conditions. Figure 63 presents this behavioral pattern. OC functions normally over time in accordance with the reference mode for OC, but potential adopters and adopters remain flat and integration only rises slightly (notice the scale for the integration variable). The performance of the variables in Figure 63 is indicative of historical behavior.

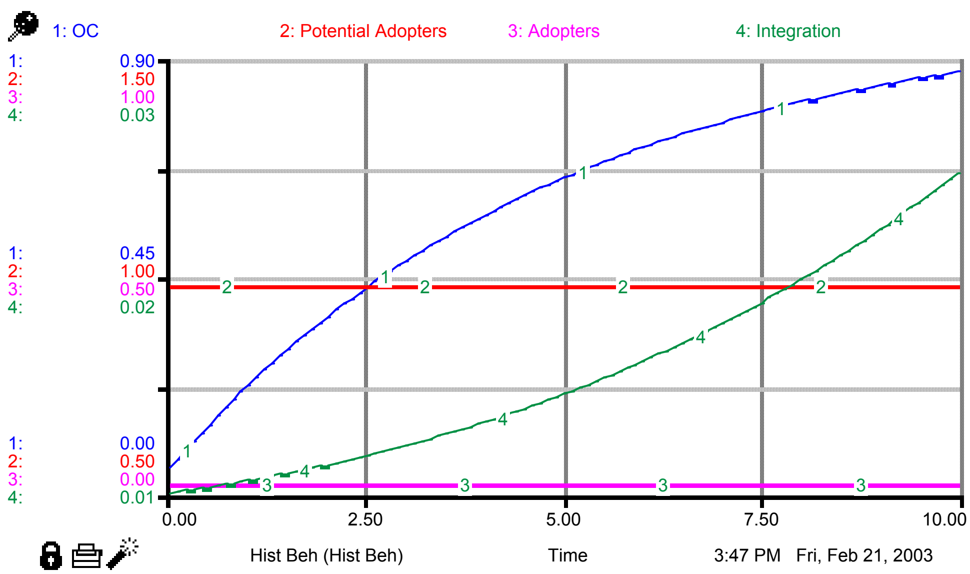


Figure 63: Behavior Reproduction Test for Historical Behavior (All Variables at Baseline Levels with No Adoption-Integration Management Intervention)

It is important to note that the scaled numbers associated with each of these variables are only used for comparative purposes within individual variables, hence a value of 1 for adopters is not comparable to a value of 1 for integration. The purpose for quantifying each of these system metrics is to enable the performance of comparative analysis, not to attempt to tie numbers from this model to actual empirical data from the real system. It is also important to note that magnitudes of difference between model outputs do not mean that metrics from the real system would compare in the same way. For example, if one simulation output for integration is 4 after ten years and another integration simulation output is 2 after ten years, this does not mean that the combination of variables in simulation 1 will provide twice-as-good integration performance as the combination of variables from simulation 2 in the real world. A more realistic assessment would be that the combination of variables in simulation 1 would tend to produce significantly better integration performance, all else being equal, than the set of variables from simulation 2.

The model simulation outputs shown in Figures 4-29 and 4-30 achieve the reference mode behavior patterns discussed earlier, so the model passes the behavior reproduction test.

Other Tests.

The remainder of the testing section is located in Appendix B. Remaining tests include: extreme conditions, sensitivity analysis, and behavior anomaly tests. There was nothing found during the course of model testing that precluded the model from going on into the policy design and evaluation phase. Appendix B also contains information about how the model parameters correspond to real-world parameters, based on a high-low scale. The reader is invited to peruse Appendix B to get a feel for the remaining types of tests that were completed on the model, to get a feel for what each of the model variables represents in the real world, and get a better feel for the model and its level of robustness.

Policy Design and Evaluation

To this point, a dynamic hypothesis has been created, a model, derived from the dynamic hypothesis, has been formulated in the virtual world, and this formulated model tested. Now that all of these requirements are in place, the discussion of the policy design and evaluation phase can begin. At this point, the process of analyzing the model, running simulations, and making recommendations can be a bit creative.

Model analysis will take place under a static context, meaning the system manager cannot have any effect on the exogenous contextual variables in the system (such as the level of funding, whether or not the IT innovation is meeting organizational needs, and organizational culture). This type of analysis is consistent with the way the model was created. To break with this assumption would force an unrealistic expansion of the system boundary so that the system manager would have some control over the context he would be working in. In this model, if the system is bound to build-up negative organizational inertia (meaning the IT innovation is not meeting organizational needs), the system manager can do nothing to prevent eventual collapse.

For static context analysis, a matrix of organizational contexts was created and a method devised to sample the management intervention space in order to make recommendations on what combinations of management interventions would be most effective under short-term and long-term scenarios. One of the assumptions associated with all of the adoption-integration management interventions is that the manager must exert the same level of effort throughout the sampling period. For example, if the manager exerts 50% of his excess effort (remember the manager must focus on operating capability first and spread the remainder of his effort to the adoption-integration interventions) on change process management at the beginning of the simulation period, he cannot change this percentage. This assumption is unrealistic in the real world, but provides a method to compare the strength of different combinations of management interventions on equal footing.

Table 11 presents the matrix of organizational context scenarios. There are specific contextual variables in the system that can be adjusted to reflect various organizational contexts. The initial conditions portion of Table 11 contains two components: operating capability and adopters. Two scenarios will be simulated for each of these: high and low. In the high operating capability scenario, the organization has a relatively large initial operating capability as a result of previous investments in technology and GIS equipment, as well as management teams for the GIS and its database. There would still be a lot to do to increase operating capability to the goal value, but this organization would be well ahead of its organizational peers. The low value for operating capability would match the baseline assumption in the model – that there is some level of operating capability (probably in the form of computer equipment and some computer support specialists), but not much. The high value for adopters would be comparable to a high number of individuals in the organization that have initially accepted GeoBase and have agreed to the requirements for adoption. Conversely, the low value would match the baseline assumptions that only two percent of the potential adopters have already adopted. The organizational context variables that define the static context the manager must work in are adjusted based on the organizational context specification.

In the poor organizational context scenario, a number of variables in the model are set at low values, allowing discontinued use inertia to build up fairly rapidly. Under the poor organizational context scenario, the system is assured to have an initial rise and then a rapid decline as discontinued use inertia builds up. The poor organizational context also reflects a rigid organization that is more resistant to change than the others.

The baseline organizational context setting is the same as the model baseline. There will not be any negative organizational inertia that builds up, but there isn't much positive organizational inertia that builds up either. This context will allow the model to generate the desired state reference mode. The manager can affect change in the system by increasing the level of integration and shortening the time for integration to increase.

In the positive organizational context setting, positive inertia will build up more rapidly and potential adopters will have better perceptions of the innovation, reflecting an innovative organization, less resistant to change than the others. This will inherently increase system performance, but the manager will still be in a position to improve performance based on a mix of management interventions. The 3X4 matrix has twelve contexts for study under the static assumption. Each context is labeled 1 through 12 on the table to enable easier discussion for each context more easily throughout this document.

Table 11: Organizational Context Matrix

Initial Conditions		Organizational Context		
Operating Capability	**Adopters**	**Poor Organizational Context**	**Baseline Organizational Context**	**Positive Organizational Context**
High	High	**1**	**5**	**9**
High	Low	**2**	**6**	**10**
Low	High	**3**	**7**	**11**
Low	Low	**4**	**8**	**12**

Table 12 includes the values assigned to specific variables under each of the various contexts. The values are lower for the poor context and higher for the positive context. There was some liberty taken in assigning variable values for each of these contexts, but the general conclusions should be the same regardless of the number assignment. Even in the poor organizational context, top-level support should never fall below zero (this would mean top level leaders would be openly hostile towards the innovation, so it would never grow). Top-level support with a value of zero means top-level leaders are neither in favor of nor openly against the innovation – they leave it to the innovation manager to deal with and provide the necessary funding to keep the program functioning. The other factors are derived by modeler determination, based on the context.

Table 12: Variable Value Assignment Under Various Conditions

Operating Capability & Adopters		**Poor Organizational Context**		**Baseline Organizational Context**		**Positive Organizational Context**	
High		Top Level Support	0	Top Level Support	0	Top Level Support	0.4
OC	0.5	Database Quality	-0.4	Database Quality	0	Database Quality	0.4
Pot Adop	0.5	Culture Fit	-0.4	Culture Fit	0	Culture Fit	0.4
Adop	0.5	Rel Adv	5	Rel Adv	9	Rel Adv	9
Low		Ease of Use	2	Ease of Use	3	Ease of Use	3
OC	0.05	Compatibility	3	Compatibility	5	Compatibility	7
Pot Adop	0.98	Baseline QoCC	0.3	Baseline QoCC	0.5	Baseline QoCC	0.7
Adop	0.02	Baseline Continuity	0.1	Baseline Continuity	0.25	Baseline Continuity	0.5

For the twelve contexts of study, a uniform method was devised to sample the management intervention sampling space. Each of the four adoption-integration management interventions can vary continuously between zero and one, with the constraint that all must sum to one. The reader probably recognizes that there are an infinite number of combinations between these variables, so the variable percentages had to be discretized to find a reasonable number of combinations to analyze. The following five discrete percentages were specified for each of the variables: 0, 0.25, 0.5, 0.75, and 1. Since there are four variables with five discrete numbers, there are 625 possible combinations. With the additional constraint that all must sum to one, the sampling space has 35 unique combinations.

Table 13 presents each of the combinations that will be used for each of the twelve context simulation packages. Since integration is the focus of this research, the analysis will focus solely on how integration behaves over time. The model will be adjusted according to the context under study and the various simulations runs will result in 35 traces on the same graph (using a comparative graph). The purpose for the simulation comparative graph is to look for behavioral pattern differences, as well as magnitudes of difference. Since 35 traces are too numerous to label on one graph, a table will be created that will track behavior at various discrete points throughout the simulation period (making it easier to analyze integration level at each time interval). After completing the simulation runs, the data will be tabulated, pattern development will be observed, the best performing combination of management interventions for short-term, long-term, and overall performance will be specified, and the findings discussed.

Table 13: Sampling Combinations for Each Organizational Context

Simulation Trace	Change Process Management	Continuity Management	Learning Management	Reward System Management
1	0	0	0	1
2	0	0	0.25	0.75
3	0	0	0.5	0.5
4	0	0	0.75	0.25
5	0	0	1	0
6	0	0.25	0	0.75
7	0	0.25	0.25	0.5
8	0	0.25	0.5	0.25
9	0	0.25	0.75	0
10	0	0.5	0	0.5
11	0	0.5	0.25	0.25
12	0	0.5	0.5	0
13	0	0.75	0	0.25
14	0	0.75	0.25	0
15	0	1	0	0
16	0.25	0	0	0.75
17	0.25	0	0.25	0.5
18	0.25	0	0.5	0.25
19	0.25	0	0.75	0
20	0.25	0.25	0	0.5
21	0.25	0.25	0.25	0.25
22	0.25	0.25	0.5	0
23	0.25	0.5	0	0.25
24	0.25	0.5	0.25	0
25	0.25	0.75	0	0
26	0.5	0	0	0.5
27	0.5	0	0.25	0.25
28	0.5	0	0.5	0
29	0.5	0.25	0	0.25
30	0.5	0.25	0.25	0
31	0.5	0.5	0	0
32	0.75	0	0	0.25
33	0.75	0	0.25	0
34	0.75	0.25	0	0
35	1	0	0	0

Context 1 Analysis.

Figure 64 presents the comparative graph for the set of simulation runs under context 1 (the high operating capability, high adopter, and poor organizational context scenario). Based on the poor organizational context, Integration behaves as expected. Integration rises relatively early since there are high initial values for operating capability and adopters, but Integration eventually peaks and rapidly declines after the discontinued use inertia compensating loops begin to dominate. It is interesting to note that there seem to be two sets of behavioral patterns, with each set's peak separated by approximately one year. The first set peaks at about the 1.8 to 2.6 year point and the second set peaks at the 3.2 to 4.5 year point. The first set has better performance in the short term, but falls off before the second set. The second set has a more gradual build toward its peak, but rises higher and has better performance in the long-term. Each simulation run has approximately the same level of performance after ten years. The values for the peak value and the time each simulation reaches its peak value (information gleaned from the comparative simulation table) were tabulated and trends in this data were observed that would help decipher system performance under these difficult conditions.

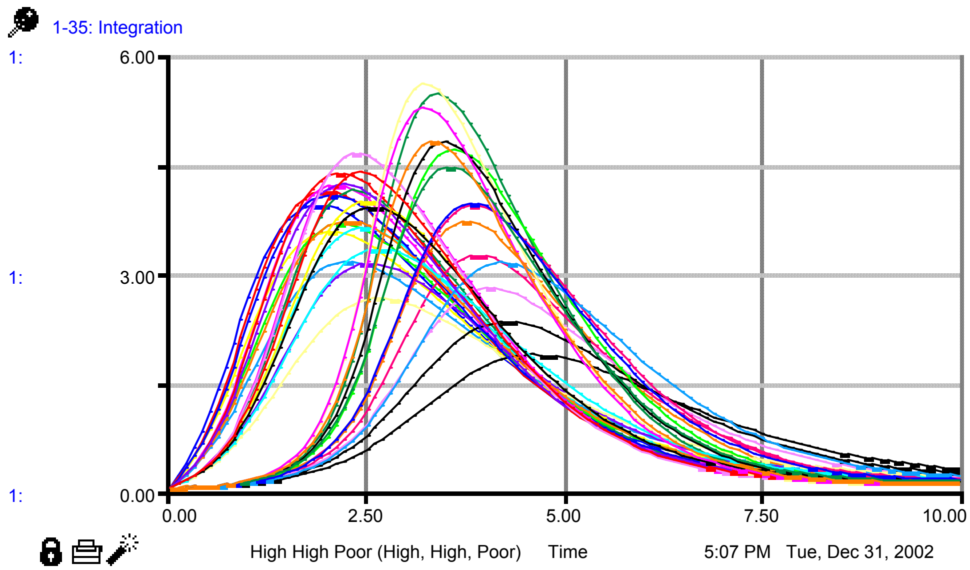


Figure 64: Context 1 (High Operating Capability, High Adopters, and Poor Organizational Context) Comparative Graph

Table 14 presents the results of the simulation runs for context 1, with simulations sorted by time to peak in ascending order (sorted by last column in the table). The data sets previously mentioned (separation by time to peak) were highlighted with two different shades. The first set ends at the time to peak point of 2.6 years and the second set begins at the time to peak point of 3.2 years.

The trend in the Table 14 data involves reward system management. The time to peak gets longer as the percentage of available time the manager invests in reward system management decreases. In terms of time to peak, there does not seem to be any other pattern in the data for the other three management interventions.

Table 15 presents the results of the simulation runs for context 1, with simulations sorted by peak in ascending order (second to last column). The main noticeable trend involves continuity management. For the most part, the peak level for Integration increases as the percentage of available time the manager invests in continuity management decreases.

Table 14: Context 1 Tabulated Information (Sorted by Time at Peak in Ascending Order)

Simulation Trace	Change Process Management	Continuity Management	Learning Management	Reward System Management	Peak	Time at Peak
1	0	0	0	1	1.96	1.8
2	0	0	0.25	0.75	2.06	1.9
3	0	0	0.5	0.5	2.1	2
6	0	0.25	0	0.75	1.78	2
16	0.25	0	0	0.75	2.03	2
7	0	0.25	0.25	0.5	1.83	2.1
17	0.25	0	0.25	0.5	2.18	2.1
10	0	0.5	0	0.5	1.57	2.2
20	0.25	0.25	0	0.5	1.85	2.2
26	0.5	0	0	0.5	2.11	2.2
4	0	0	0.75	0.25	2.7	2.3
18	0.25	0	0.5	0.25	2.32	2.3
8	0	0.25	0.5	0.25	1.81	2.4
27	0.5	0	0.25	0.25	2.33	2.4
11	0	0.5	0.25	0.25	1.56	2.5
21	0.25	0.25	0.25	0.25	1.99	2.5
29	0.5	0.25	0	0.25	1.95	2.5
32	0.75	0	0	0.25	2.19	2.5
13	0	0.75	0	0.25	1.32	2.6
23	0.25	0.5	0	0.25	1.66	2.6
28	0.5	0	0.5	0	2.8	3.2
33	0.75	0	0.25	0	2.63	3.3
35	1	0	0	0	2.4	3.3
19	0.25	0	0.75	0	2.73	3.4
30	0.5	0.25	0.25	0	2.4	3.5
34	0.75	0.25	0	0	2.23	3.5
22	0.25	0.25	0.5	0	2.35	3.6
5	0	0	1	0	1.85	3.8
24	0.25	0.5	0.25	0	1.96	3.8
31	0.5	0.5	0	0	1.98	3.8
9	0	0.25	0.75	0	1.62	3.9
12	0	0.5	0.5	0	1.39	4
14	0	0.75	0.25	0	1.16	4.2
25	0.25	0.75	0	0	1.57	4.2
15	0	1	0	0	0.93	4.5

Table 15: Context 1 Tabulated Information (Sorted by Peak in Ascending Order)

Simulation Trace	Change Process Management	Continuity Management	Learning Management	Reward System Management	Peak	Time at Peak
15	0	1	0	0	0.93	4.5
14	0	0.75	0.25	0	1.16	4.2
13	0	0.75	0	0.25	1.32	2.6
12	0	0.5	0.5	0	1.39	4
11	0	0.5	0.25	0.25	1.56	2.5
10	0	0.5	0	0.5	1.57	2.2
25	0.25	0.75	0	0	1.57	4.2
9	0	0.25	0.75	0	1.62	3.9
23	0.25	0.5	0	0.25	1.66	2.6
6	0	0.25	0	0.75	1.78	2
8	0	0.25	0.5	0.25	1.81	2.4
7	0	0.25	0.25	0.5	1.83	2.1
20	0.25	0.25	0	0.5	1.85	2.2
5	0	0	1	0	1.85	3.8
29	0.5	0.25	0	0.25	1.95	2.5
1	0	0	0	1	1.96	1.8
24	0.25	0.5	0.25	0	1.96	3.8
31	0.5	0.5	0	0	1.98	3.8
21	0.25	0.25	0.25	0.25	1.99	2.5
16	0.25	0	0	0.75	2.03	2
2	0	0	0.25	0.75	2.06	1.9
3	0	0	0.5	0.5	2.1	2
26	0.5	0	0	0.5	2.11	2.2
17	0.25	0	0.25	0.5	2.18	2.1
32	0.75	0	0	0.25	2.19	2.5
34	0.75	0.25	0	0	2.23	3.5
18	0.25	0	0.5	0.25	2.32	2.3
27	0.5	0	0.25	0.25	2.33	2.4
22	0.25	0.25	0.5	0	2.35	3.6
35	1	0	0	0	2.4	3.3
30	0.5	0.25	0.25	0	2.4	3.5
33	0.75	0	0.25	0	2.63	3.3
4	0	0	0.75	0.25	2.7	2.3
19	0.25	0	0.75	0	2.73	3.4
28	0.5	0	0.5	0	2.8	3.2

Two of the simulation runs were chosen that represent the best short-term or long-term performance (highlighted in Table 15). Simulation 4 has the best short-term results (based on peak value and its place in the lower time to peak set) and simulation 28 has the best long-term results (based on the highest peak overall and its place in the longer to peak set). The premier management interventions do not include any focus on continuity management and both are focused on only two factors each. For positive short-term results (at the expense of higher peak performance later) the system manager should focus on learning management and reward system management (with three quarters of the emphasis on learning management and the other quarter on reward system management). For better long-term performance (at the expense of earlier peak gains) the system manager should focus half of his effort on change process management and the other half on learning management.

Organizational context 1 is fairly unrealistic in the real world, in the sense that there would be high adopters and high operating capability initially, but a poor organizational context. However, it does illustrate some interesting findings. Focusing a large portion of time on learning management under these conditions will produce better performance. For better long-term performance, the manager should also focus effort on change process management. For better short-term performance, the manager should also focus on reward system management.

Context 2 Analysis.

Figure 65 presents the comparative graph for the simulation runs under context 2 (the high operating capability, low adopter, and poor organizational context scenario). Based on the poor organizational context, Integration behaves as expected. Integration generally does not rise as early as in context 1 (shown in Figure 64), but does peak at higher values for a few of the simulations. Since Integration takes longer to build up, the decline is not as dramatic and some of the traces do not show a decline at all. The context 2 simulations in Figure 65 do not have any groupings as in context 1 (shown in Figure 64). The traces are fairly well dispersed throughout the simulation area. A few rise above the others, but then drop off more precipitously. For analysis under this context, data was gathered for each simulation at the 5, 7.5, and 10-year points. Information was included on the peak and time at peak for the three simulations that peaked at the highest level at various points in time. From this data, the best short-term, mid-term, and long-term implications for management interventions will be studied under these conditions.

Table 16 presents the information for the context 2 simulations sorted in ascending order based on the level at year 5. The simulations that had an Integration level above 1.00 at the 5-year point were highlighted, which shall be called the good short-term performers. The only pattern that can be identified in this sorted data is the fact that none of the good short-term performers has any continuity management focus. Only one of the peak performers, simulation 33 (peak performers are those with any numbers in the peak and time to peak columns), could be considered to have good short-term performance.

Table 17 presents the information for the context 2 simulations sorted in ascending order based on the level at year 7.5. The simulations that had an Integration level above 1.00 at the 7.5-year point were highlighted, which shall be called the good mid-term performers. There are more simulations with good mid-term performance than short-term performance and all of the peak performers, simulations 19, 28, and 33, are included in this group. Again, in each of the good mid-term performers, there are low values for continuity, but they are not devoid of a focus on continuity as a whole.

Table 18 presents the information for the context 2 simulations sorted in ascending order based on the level at year 10. The simulations that had an Integration level above 1.00 at the 10-year point were highlighted, which shall be called the good long-term performers. There are only two simulations with good long-term performance, simulations 22 and 24, and none of the peak performers are in this group. There is no focus on reward system management in the good long-term performers. The focus is fairly evenly distributed to the other interventions. It is interesting to note the high level of continuity management focus associated with the best long-term performance simulation, simulation 24.

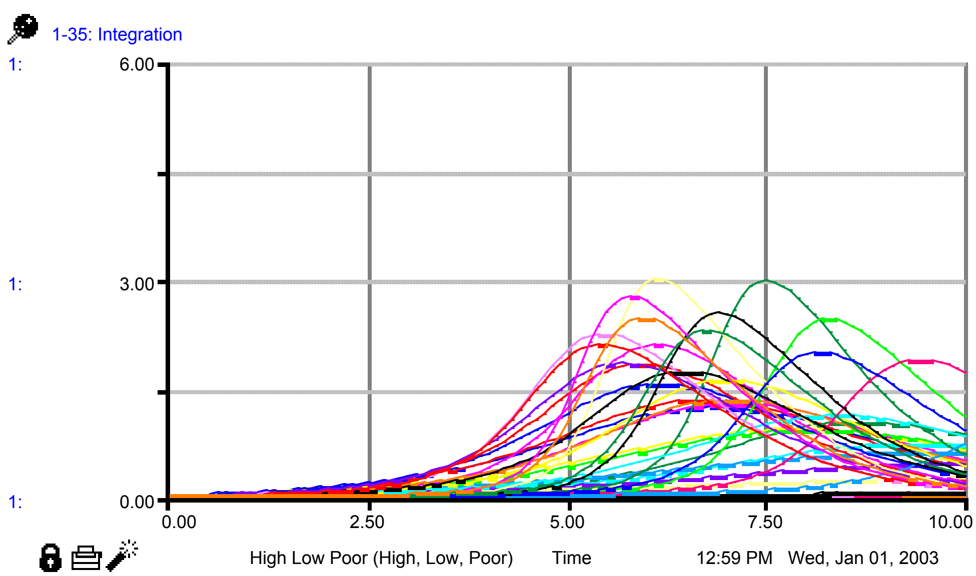


Figure 65: Context 2 (High Operating Capability, Low Adopters, and Poor Organizational Context) Comparative Graph

Table 16: Context 2 Tabulated Information (Sorted by Level at 5 Years)

Simulation Trace	Change Process Management	Continuity Management	Learning Management	Reward System Management	Peak	Time at Peak	Level at 5 years	Level at 7.5 years	Level at 10 years
5	0	0	1	0			0.02	0.02	0.03
9	0	0.25	0.75	0			0.02	0.02	0.03
12	0	0.5	0.5	0			0.02	0.02	0.03
14	0	0.75	0.25	0			0.02	0.03	0.04
15	0	1	0	0			0.02	0.02	0.04
25	0.25	0.75	0	0			0.02	0.08	0.71
24	0.25	0.5	0.25	0			0.03	0.33	1.72
22	0.25	0.25	0.5	0			0.04	1.53	1.11
31	0.5	0.5	0	0			0.05	1.53	0.91
19	0.25	0	0.75	0	2.98	7.5	0.07	2.98	0.56
13	0	0.75	0	0.25			0.09	0.17	0.25
11	0	0.5	0.25	0.25			0.13	0.32	0.46
8	0	0.25	0.5	0.25			0.16	0.51	0.7
30	0.5	0.25	0.25	0			0.16	2.17	0.32
4	0	0	0.75	0.25			0.2	0.82	0.84
10	0	0.5	0	0.5			0.23	0.48	0.6
34	0.75	0.25	0	0			0.23	1.87	0.29
23	0.25	0.5	0	0.25			0.25	0.98	0.81
7	0	0.25	0.25	0.5			0.39	0.88	0.66
6	0	0.25	0	0.75			0.45	0.91	0.64
21	0.25	0.25	0.25	0.25			0.57	1.51	0.41
28	0.5	0	0.5	0	3	6.1	0.61	1.55	0.14
20	0.25	0.25	0	0.5			0.63	1.29	0.46
3	0	0	0.5	0.5			0.64	1.25	0.49
1	0	0	0	1			0.78	1.15	0.44
29	0.5	0.25	0	0.25			0.82	1.35	0.28
2	0	0	0.25	0.75			0.84	1.21	0.4
35	1	0	0	0			1.01	1.2	0.13
16	0.25	0	0	0.75			1.13	1.15	0.28
18	0.25	0	0.5	0.25			1.21	1.32	0.19
33	0.75	0	0.25	0	2.76	5.8	1.31	1.14	0.11
17	0.25	0	0.25	0.5			1.39	1.1	0.2
26	0.5	0	0	0.5			1.54	0.97	0.18
32	0.75	0	0	0.25			1.91	0.81	0.12
27	0.5	0	0.25	0.25			2.01	0.84	0.12

Table 17: Context 2 Tabulated Information (Sorted by Level at 7.5 Years)

Simulation Trace	Change Process Management	Continuity Management	Learning Management	Reward System Management	Peak	Time at Peak	Level at 5 years	Level at 7.5 years	Level at 10 years
5	0	0	1	0			0.02	0.02	0.03
9	0	0.25	0.75	0			0.02	0.02	0.03
12	0	0.5	0.5	0			0.02	0.02	0.03
15	0	1	0	0			0.02	0.02	0.04
14	0	0.75	0.25	0			0.02	0.03	0.04
25	0.25	0.75	0	0			0.02	0.08	0.71
13	0	0.75	0	0.25			0.09	0.17	0.25
11	0	0.5	0.25	0.25			0.13	0.32	0.46
24	0.25	0.5	0.25	0			0.03	0.33	1.72
10	0	0.5	0	0.5			0.23	0.48	0.6
8	0	0.25	0.5	0.25			0.16	0.51	0.7
32	0.75	0	0	0.25			1.91	0.81	0.12
4	0	0	0.75	0.25			0.2	0.82	0.84
27	0.5	0	0.25	0.25			2.01	0.84	0.12
7	0	0.25	0.25	0.5			0.39	0.88	0.66
6	0	0.25	0	0.75			0.45	0.91	0.64
26	0.5	0	0	0.5			1.54	0.97	0.18
23	0.25	0.5	0	0.25			0.25	0.98	0.81
17	0.25	0	0.25	0.5			1.39	1.1	0.2
33	0.75	0	0.25	0	2.76	5.8	1.31	1.14	0.11
1	0	0	0	1			0.78	1.15	0.44
16	0.25	0	0	0.75			1.13	1.15	0.28
35	1	0	0	0			1.01	1.2	0.13
2	0	0	0.25	0.75			0.84	1.21	0.4
3	0	0	0.5	0.5			0.64	1.25	0.49
20	0.25	0.25	0	0.5			0.63	1.29	0.46
18	0.25	0	0.5	0.25			1.21	1.32	0.19
29	0.5	0.25	0	0.25			0.82	1.35	0.28
21	0.25	0.25	0.25	0.25			0.57	1.51	0.41
22	0.25	0.25	0.5	0			0.04	1.53	1.11
31	0.5	0.5	0	0			0.05	1.53	0.91
28	0.5	0	0.5	0	3	6.1	0.61	1.55	0.14
34	0.75	0.25	0	0			0.23	1.87	0.29
30	0.5	0.25	0.25	0			0.16	2.17	0.32
19	0.25	0	0.75	0	2.98	7.5	0.07	2.98	0.56

Table 18: Context 2 Tabulated Information (Sorted by Level at 10 Years)

Simulation Trace	Change Process Management	Continuity Management	Learning Management	Reward System Management	Peak	Time at Peak	Level at 5 years	Level at 7.5 years	Level at 10 years
5	0	0	1	0			0.02	0.02	0.03
9	0	0.25	0.75	0			0.02	0.02	0.03
12	0	0.5	0.5	0			0.02	0.02	0.03
15	0	1	0	0			0.02	0.02	0.04
14	0	0.75	0.25	0			0.02	0.03	0.04
33	0.75	0	0.25	0	2.76	5.8	1.31	1.14	0.11
32	0.75	0	0	0.25			1.91	0.81	0.12
27	0.5	0	0.25	0.25			2.01	0.84	0.12
35	1	0	0	0			1.01	1.2	0.13
28	0.5	0	0.5	0	3	6.1	0.61	1.55	0.14
26	0.5	0	0	0.5			1.54	0.97	0.18
18	0.25	0	0.5	0.25			1.21	1.32	0.19
17	0.25	0	0.25	0.5			1.39	1.1	0.2
13	0	0.75	0	0.25			0.09	0.17	0.25
16	0.25	0	0	0.75			1.13	1.15	0.28
29	0.5	0.25	0	0.25			0.82	1.35	0.28
34	0.75	0.25	0	0			0.23	1.87	0.29
30	0.5	0.25	0.25	0			0.16	2.17	0.32
2	0	0	0.25	0.75			0.84	1.21	0.4
21	0.25	0.25	0.25	0.25			0.57	1.51	0.41
1	0	0	0	1			0.78	1.15	0.44
11	0	0.5	0.25	0.25			0.13	0.32	0.46
20	0.25	0.25	0	0.5			0.63	1.29	0.46
3	0	0	0.5	0.5			0.64	1.25	0.49
19	0.25	0	0.75	0	2.98	7.5	0.07	2.98	0.56
10	0	0.5	0	0.5			0.23	0.48	0.6
6	0	0.25	0	0.75			0.45	0.91	0.64
7	0	0.25	0.25	0.5			0.39	0.88	0.66
8	0	0.25	0.5	0.25			0.16	0.51	0.7
25	0.25	0.75	0	0			0.02	0.08	0.71
23	0.25	0.5	0	0.25			0.25	0.98	0.81
4	0	0	0.75	0.25			0.2	0.82	0.84
31	0.5	0.5	0	0			0.05	1.53	0.91
22	0.25	0.25	0.5	0			0.04	1.53	1.11
24	0.25	0.5	0.25	0			0.03	0.33	1.72

The main management intervention generalization that can be made from the simulations under context 2 is that continuity management is useful for a long-term focus, but not at all if a short-term focus reigns. For the best short-term performance, the system manager should focus on change process management half of the available time and split his focus between learning management and reward system management the other half of the available time. For the best mid-term performance, the manager should focus a quarter of his available time on change process management and the other three quarters on learning management. This mix represents one of the peak performers as well. For the best long-term performance, the manager should focus half of his available time on continuity management and the other half split between change process management and learning management.

Context 3 Analysis.

Figure 66 presents the comparative graph for the set of simulation runs under context 3 (the low operating capability, high adopter, and poor organizational context scenario). Based on the poor organizational context, Integration behaves as expected. Integration rises relatively early since there is a high initial value for adopters, but Integration eventually peaks and rapidly declines after the discontinued use inertia compensating loops begin to dominate. In this context, the model behaves very similarly with the simulations for context 1 (in terms of two sets of time to peak data). However, in Figure 3, the first set peaks at about the 2.6 to 3.5 year point and the second set peaks at the 4.1 to 4.6 year point. The peaks are also appreciably smaller than those for context 1 (Figure 64), since there is a low value for operating capability initially. The first set has better performance in the short term, but falls off before the second set. The second set has a more gradual build toward its peak, but rises higher and has better performance in the long term. Each simulation run has approximately the same level of performance after ten years. The values for the peak and the time each simulation reaches its peak value (information gleaned from the comparative simulation table) were tabulated and trends in this data observed that would help decipher system performance under these difficult conditions.

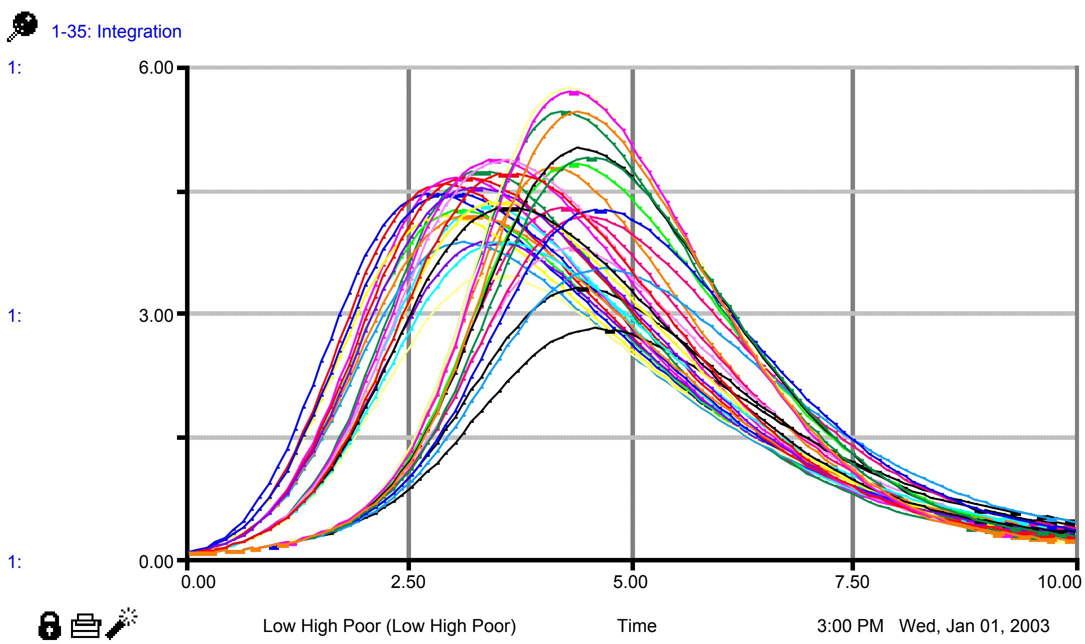


Figure 66: Context 3 (Low Operating Capability, High Adopters, and Poor Organizational Context) Comparative Graph

Table 19 presents the results of the simulation runs for context 3, with simulations sorted by time to peak in ascending order (sorted by last column in the table). The data sets previously mentioned (separation by time to peak) were highlighted with two different shades. The first set ends at the time to peak point of 3.5 years and the second set begins at the time to peak point of 4.1 years.

The main noticeable trend in the data involves reward system management, just as context 1. The time to peak gets longer as the percentage of available time the manager invests in reward system management decreases. For time to peak sorting, there does not seem to be any other pattern in the data for the other three management interventions.

Table 20 presents the results of the simulation runs for context 3, with simulations sorted by peak in ascending order (second to last column). Again, the main noticeable trend involves continuity management. For the most part, the peak level for Integration increases as the percentage of available time the manager invests in continuity management decreases.

Table 19: Context 3 Tabulated Information (Sorted by Time to Peak)

Simulation Trace	Change Process Management	Continuity Management	Learning Management	Reward System Management	Peak	Time at Peak
1	0	0	0	1	1.47	2.6
6	0	0.25	0	0.75	1.38	2.8
2	0	0	0.25	0.75	1.51	2.8
16	0.25	0	0	0.75	1.48	2.9
20	0.25	0.25	0	0.5	1.38	3
7	0	0.25	0.25	0.5	1.41	3
3	0	0	0.5	0.5	1.55	3
10	0	0.5	0	0.5	1.28	3.1
17	0.25	0	0.25	0.5	1.54	3.1
26	0.5	0	0	0.5	1.5	3.2
13	0	0.75	0	0.25	1.14	3.3
11	0	0.5	0.25	0.25	1.28	3.3
4	0	0	0.75	0.25	1.57	3.3
8	0	0.25	0.5	0.25	1.43	3.4
21	0.25	0.25	0.25	0.25	1.44	3.4
18	0.25	0	0.5	0.25	1.61	3.4
23	0.25	0.5	0	0.25	1.28	3.5
29	0.5	0.25	0	0.25	1.42	3.5
32	0.75	0	0	0.25	1.56	3.5
27	0.5	0	0.25	0.25	1.61	3.5
5	0	0	1	0	1.58	4.1
12	0	0.5	0.5	0	1.25	4.2
9	0	0.25	0.75	0	1.42	4.2
19	0.25	0	0.75	0	1.81	4.2
28	0.5	0	0.5	0	1.91	4.2
22	0.25	0.25	0.5	0	1.6	4.3
33	0.75	0	0.25	0	1.9	4.3
15	0	1	0	0	0.92	4.4
14	0	0.75	0.25	0	1.09	4.4
24	0.25	0.5	0.25	0	1.38	4.4
30	0.5	0.25	0.25	0	1.66	4.4
35	1	0	0	0	1.81	4.4
31	0.5	0.5	0	0	1.41	4.5
34	0.75	0.25	0	0	1.63	4.5
25	0.25	0.75	0	0	1.17	4.6

Table 20: Context 3 Tabulated Information (Sorted by Peak)

Simulation Trace	Change Process Management	Continuity Management	Learning Management	Reward System Management	Peak	Time at Peak
15	0	1	0	0	0.92	4.4
14	0	0.75	0.25	0	1.09	4.4
13	0	0.75	0	0.25	1.14	3.3
25	0.25	0.75	0	0	1.17	4.6
12	0	0.5	0.5	0	1.25	4.2
10	0	0.5	0	0.5	1.28	3.1
11	0	0.5	0.25	0.25	1.28	3.3
23	0.25	0.5	0	0.25	1.28	3.5
6	0	0.25	0	0.75	1.38	2.8
20	0.25	0.25	0	0.5	1.38	3
24	0.25	0.5	0.25	0	1.38	4.4
7	0	0.25	0.25	0.5	1.41	3
31	0.5	0.5	0	0	1.41	4.5
9	0	0.25	0.75	0	1.42	4.2
29	0.5	0.25	0	0.25	1.42	3.5
8	0	0.25	0.5	0.25	1.43	3.4
21	0.25	0.25	0.25	0.25	1.44	3.4
1	0	0	0	1	1.47	2.6
16	0.25	0	0	0.75	1.48	2.9
26	0.5	0	0	0.5	1.5	3.2
2	0	0	0.25	0.75	1.51	2.8
17	0.25	0	0.25	0.5	1.54	3.1
3	0	0	0.5	0.5	1.55	3
32	0.75	0	0	0.25	1.56	3.5
4	0	0	0.75	0.25	1.57	3.3
5	0	0	1	0	1.58	4.1
22	0.25	0.25	0.5	0	1.6	4.3
18	0.25	0	0.5	0.25	1.61	3.4
27	0.5	0	0.25	0.25	1.61	3.5
34	0.75	0.25	0	0	1.63	4.5
30	0.5	0.25	0.25	0	1.66	4.4
19	0.25	0	0.75	0	1.81	4.2
35	1	0	0	0	1.81	4.4
33	0.75	0	0.25	0	1.9	4.3
28	0.5	0	0.5	0	1.91	4.2

Two of the simulation runs were chosen that represent the best short-term or long-term performance (highlighted in Table 20). Simulation 18 has the best short-term results (based on peak value and its position in the lower time to peak set) and simulation 28 has the best long-term results (based on the highest peak overall and its position in the longer to peak set). The premier management interventions do not include any focus on continuity management. For the best short-term results (at the expense of higher peak performance later) the system manager should focus on learning management, change process management, and reward system management. The manager should focus half of his available time on learning management and split the other half between change process management and reward system management. For better long-term performance (at the expense of earlier peak gains) the system manager should focus half of his effort on change process management and the other half on learning management (the same best long-term mix as for context 1).

Context 4 Analysis.

Figure 67 presents the comparative graph for the set of simulation runs under context 4 (the low operating capability, low adopter, and poor organizational context scenario). Based on the poor organizational context, Integration behaves as expected. Based on the low initial values for operating capability and adopters, Integration takes quite awhile to accumulate. Integration is depressed in the system until approximately year six, where some of the traces begin growing. Most of the peaks are in the eight to ten-year timeframe, so there is not much time between the short and long time horizons. Since Integration takes longer to build up, the decline is not as dramatic and some of the traces do not show a decline at all. Like the simulations for context 2, the traces are fairly well dispersed throughout the simulation area, with a few rising above the others, but then dropping off more precipitously. For analysis under this context, data was gathered for each simulation at the 7 and 10-year points. Information on the peak and time at peak was included for the three simulations that peaked at the highest level at various points in time. From this data, the best short-term and long-term implications for management interventions will be specified under these conditions.

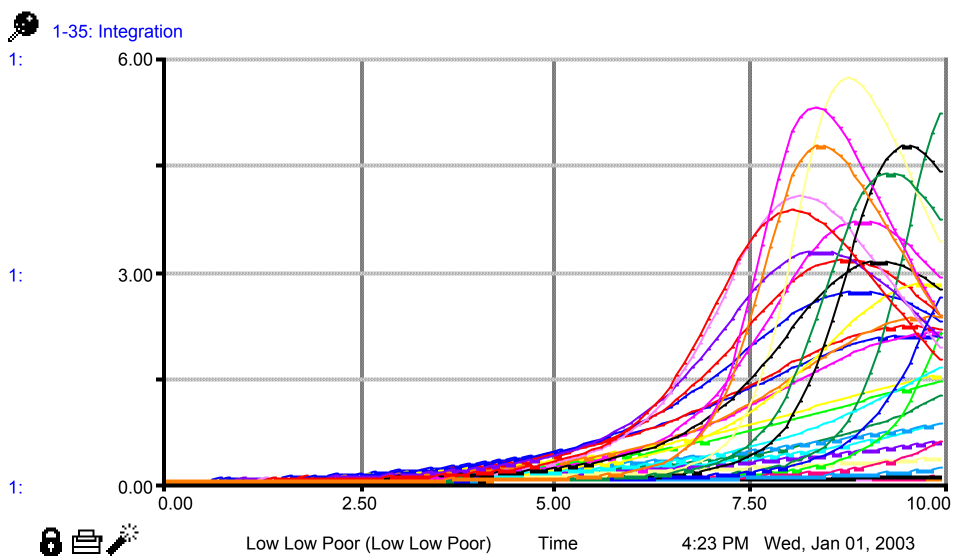


Figure 67: Context 4 (Low Operating Capability, Low Adopters, and Poor Organizational Context) Comparative Graph

Table 21 presents the information for the context 4 simulations sorted in ascending order based on the level at year 7. The simulations that had an Integration level above 1.00 at the 5-year point were highlighted, which shall be called the good short-term performers. There are only two simulations with good short-term performance, simulations 27 and 32. The only pattern that can be identified in this sorted data is the fact that none of the good short-term performers has any management focus on continuity management. Only one of the peak performers, simulation 27, could be considered to have good short-term performance.

Table 22 presents the information for the context 4 simulations sorted in ascending order based on the level at year 10. The simulations that had an Integration level above 1.00 at the 10-year point were highlighted, which shall be called the good long-term performers. There are quite a few good long-term performers and two of the three peak performers are good long-term performers. The manager's focus is fairly evenly distributed for all of the management interventions in the good long-term performer simulations. The manager only focuses on learning management and change process management in the best long-term simulation, simulation 19.

For the best short-term performance, the system manager should focus on change process management three quarters of his available time and focus one quarter of his time on reward system management. For the best long-term performance, the system manager should focus on learning management three quarters of his available time and focus one quarter of his time on change process management. For the best mix of short and long-term performance, the manager should focus half of his available time on change process management and split his or her remaining time between learning management and reward system management (this is reflective of peak performer simulation 27).

Table 21: Context 4 Tabulated Information (Sorted by Level at Year 7)

Simulation Trace	Change Process Management	Continuity Management	Learning Management	Reward System Management	Peak	Time at Peak	Level at 7 years	Level at 10 years
5	0	0	1	0			0.02	0.03
9	0	0.25	0.75	0			0.02	0.03
12	0	0.5	0.5	0			0.02	0.03
14	0	0.75	0.25	0			0.02	0.03
15	0	1	0	0			0.02	0.03
25	0.25	0.75	0	0			0.03	0.09
24	0.25	0.5	0.25	0			0.03	0.28
22	0.25	0.25	0.5	0			0.03	1.04
31	0.5	0.5	0	0			0.04	1.3
19	0.25	0	0.75	0			0.04	2.61
16	0.25	0	0	0.75			0.07	1.13
30	0.5	0.25	0.25	0			0.08	2.2
13	0	0.75	0	0.25			0.09	0.16
11	0	0.5	0.25	0.25			0.11	0.28
34	0.75	0.25	0	0			0.11	1.85
8	0	0.25	0.5	0.25			0.13	0.4
4	0	0	0.75	0.25			0.14	0.6
28	0.5	0	0.5	0	2.86	8.8	0.16	1.69
10	0	0.5	0	0.5			0.18	0.4
23	0.25	0.5	0	0.25			0.18	0.8
7	0	0.25	0.25	0.5			0.28	0.7
6	0	0.25	0	0.75			0.32	0.75
21	0.25	0.25	0.25	0.25			0.32	1.4
3	0	0	0.5	0.5			0.39	1.05
35	1	0	0	0			0.39	1.17
20	0.25	0.25	0	0.5			0.4	1.16
33	0.75	0	0.25	0	2.65	8.4	0.41	1.18
29	0.5	0.25	0	0.25			0.44	1.36
1	0	0	0	1			0.52	1.02
2	0	0	0.25	0.75			0.53	1.07
18	0.25	0	0.5	0.25			0.55	1.44
17	0.25	0	0.25	0.5			0.77	1.17
26	0.5	0	0	0.5			0.93	1.02
27	0.5	0	0.25	0.25	2.02	8.2	1.08	0.95
32	0.75	0	0	0.25			1.14	0.86

Table 22: Context 4 Tabulated Information (Sorted by Level at Year 10)

Simulation Trace	Change Process Management	Continuity Management	Learning Management	Reward System Management	Peak	Time at Peak	Level at 7 years	Level at 10 years
5	0	0	1	0			0.02	0.03
9	0	0.25	0.75	0			0.02	0.03
12	0	0.5	0.5	0			0.02	0.03
14	0	0.75	0.25	0			0.02	0.03
15	0	1	0	0			0.02	0.03
25	0.25	0.75	0	0			0.03	0.09
13	0	0.75	0	0.25			0.09	0.16
11	0	0.5	0.25	0.25			0.11	0.28
24	0.25	0.5	0.25	0			0.03	0.28
8	0	0.25	0.5	0.25			0.13	0.4
10	0	0.5	0	0.5			0.18	0.4
4	0	0	0.75	0.25			0.14	0.6
7	0	0.25	0.25	0.5			0.28	0.7
6	0	0.25	0	0.75			0.32	0.75
23	0.25	0.5	0	0.25			0.18	0.8
32	0.75	0	0	0.25			1.14	0.86
27	0.5	0	0.25	0.25	2.02	8.2	1.08	0.95
1	0	0	0	1			0.52	1.02
26	0.5	0	0	0.5			0.93	1.02
22	0.25	0.25	0.5	0			0.03	1.04
3	0	0	0.5	0.5			0.39	1.05
2	0	0	0.25	0.75			0.53	1.07
16	0.25	0	0	0.75			0.07	1.13
20	0.25	0.25	0	0.5			0.4	1.16
17	0.25	0	0.25	0.5			0.77	1.17
35	1	0	0	0			0.39	1.17
33	0.75	0	0.25	0	2.65	8.4	0.41	1.18
31	0.5	0.5	0	0			0.04	1.3
29	0.5	0.25	0	0.25			0.44	1.36
21	0.25	0.25	0.25	0.25			0.32	1.4
18	0.25	0	0.5	0.25			0.55	1.44
28	0.5	0	0.5	0	2.86	8.8	0.16	1.69
34	0.75	0.25	0	0			0.11	1.85
30	0.5	0.25	0.25	0			0.08	2.2
19	0.25	0	0.75	0			0.04	2.61

Context 5 Analysis.

The focus is now turned from the poor organizational context scenarios to the baseline scenarios. The baseline scenarios provide the system with the context to behave according to the desired behavior pattern in the reference modes diagrams. Discontinued use inertia does not build up in the system, so none of the discontinued use inertia compensating loops will dominate and force integration to decline after some initial gains. The focus for the manager now is going to be how to intervene in the system to maximize performance. The system context will allow positive performance behavior, but the system manager can have a large impact on the magnitude of that positive performance and how quickly it occurs. These scenarios are more realistic in the real world and should provide some useful insights into how best to manage a typical squadron system.

Figure 68 presents the comparative graph for the set of simulation runs under context 5 (the high operating capability, high adopter, and baseline organizational context scenario). Based on the baseline organizational context, Integration behaves in line with the desired system behavior. Based on the high initial values for operating capability and adopters, Integration increases rapidly and eventually levels-off. In this type of context, the system will tend to shepherd itself, but the manager can still have a significant impact on performance. From immediate inspection of Figure 68, there appears to be two sets of traces; one set increases and levels-off earlier and a second set increases at a later time. For comparative purposes, each simulation trace will be compared at the 1.5, 5, and 10-year points and any patterns and conclusions that result will be discussed.

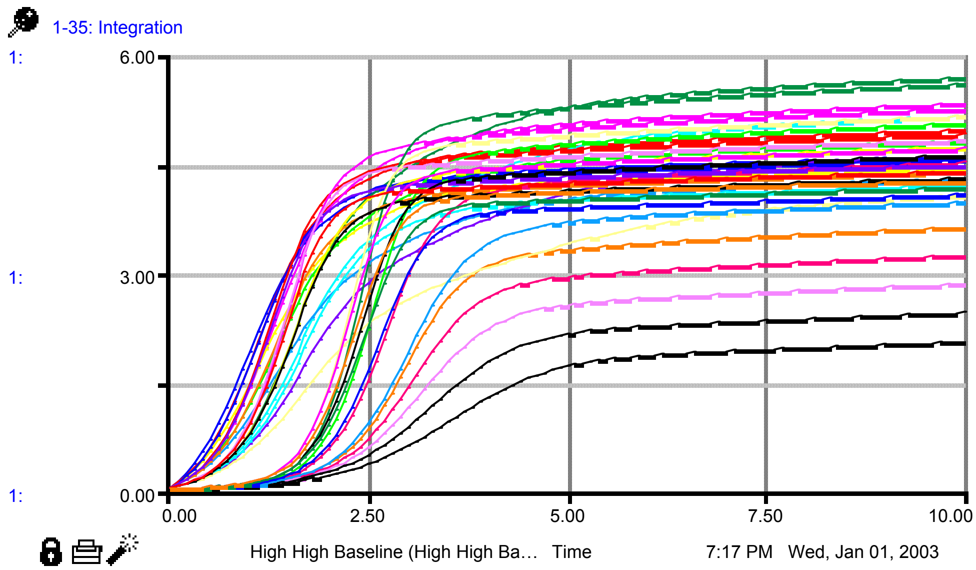


Figure 68: Context 5 (High Operating Capability, High Adopters, and Baseline Organizational Context) Comparative Graph

Table 23 presents the information for the context 5 simulations sorted in ascending order based on the level at year 1.5. From this sorted information, one can discern between the better short-term performers and the not as effective short-term performers. The not as effective short-term performers are highlighted in Table 23 in the lighter shade and the better short-term performers are highlighted in Table 23 with the darker shade (at the bottom). Reward system management was a required element for the simulation to fall into the better short-term performers set. If the manager did not focus on reward system management, the associated simulation would take longer to develop a high level of Integration. There are a number of intersections in Figure 68 where simulations may be poor short-term performers, but much better long-term performers.

Since there are a number of these intersections in the data throughout the simulation period, making it difficult to ascertain which management intervention cocktail is the most effective overall, a method was devised to find a composite score for each simulation based on ranked performance at the 1.5, 5, and 10 year points (which would respectively represent short, mid, and long-term performance). This ranking method was accomplished by first gathering all of the data shown in Table 23. Each simulation (1 – 35) was then ranked based on its position in the sorted tables for each point in time. In each case, the simulation with the highest Integration level at that point in time would receive a ranking of 1. Likewise, the simulation with the lowest Integration level at that point in time would receive a ranking of 35. Each simulation was ranked at each of the year points previously mentioned and the compiled the information was compiled into a table. The composite score is the sum of the rankings, so a lower score would represent better overall performance.

Table 24 presents the composite score table sorted by composite score throughout simulation period in ascending order for context 5. The simulations with a composite score of 30 or lower (meaning, as a whole, these simulations ranked in the top 10 for each point in time) were highlighted. Based on the goals of the organization or manager being good overall performance in all of the periods of time, simulation 3 is recommended as the best overall performer. In this case, the manager should focus half of his or her available time on learning management and the other half on reward system management. For mediocre short-term performance, but very good mid-term and long-term performance, the simulation 4 is recommended. In this case, the manager would devote three-quarters of his or her available time to learning management and the other quarter to reward system management. For excellent short-term performance and fairly good mid and long-term performance, simulation 2 is recommended. In this case, the manager would devote a quarter of his or her available time to learning management and three-quarters to reward system management. In any case, the goals of the organization and manager would dictate which of the simulations would offer the best management intervention cocktail to achieve those goals. In common with the three best management cocktails is the lack of focus on change process management or continuity management in this positive context with high initial values for operating capability and adopters.

Table 23: Context 5 Tabulated Information (Sorted by Level at Year 1.5)

Simulation Trace	Change Process Management	Continuity Management	Learning Management	Reward System Management	Level at 1.5 years	Level at 5 years	Level at 10 years
15	0	1	0	0	0.08	1.41	1.7
14	0	0.75	0.25	0	0.09	1.79	2.03
12	0	0.5	0.5	0	0.1	2.12	2.37
9	0	0.25	0.75	0	0.11	2.45	2.69
5	0	0	1	0	0.12	2.76	3.02
25	0.25	0.75	0	0	0.12	3.08	3.31
24	0.25	0.5	0.25	0	0.15	3.55	3.77
31	0.5	0.5	0	0	0.16	3.25	3.4
22	0.25	0.25	0.5	0	0.18	3.98	4.22
19	0.25	0	0.75	0	0.22	4.4	4.67
30	0.5	0.25	0.25	0	0.22	3.67	3.85
34	0.75	0.25	0	0	0.22	3.34	3.48
35	1	0	0	0	0.28	3.43	3.56
28	0.5	0	0.5	0	0.29	4.08	4.3
33	0.75	0	0.25	0	0.31	3.76	3.93
13	0	0.75	0	0.25	0.91	2.82	3.39
11	0	0.5	0.25	0.25	1.13	3.4	3.85
23	0.25	0.5	0	0.25	1.26	3.34	3.51
8	0	0.25	0.5	0.25	1.38	3.92	4.3
10	0	0.5	0	0.5	1.58	3.35	3.57
29	0.5	0.25	0	0.25	1.63	3.44	3.59
21	0.25	0.25	0.25	0.25	1.65	3.76	3.95
4	0	0	0.75	0.25	1.66	4.4	4.74
7	0	0.25	0.25	0.5	1.95	3.8	4.01
32	0.75	0	0	0.25	1.98	3.53	3.66
20	0.25	0.25	0	0.5	2.03	3.51	3.66
18	0.25	0	0.5	0.25	2.09	4.16	4.38
6	0	0.25	0	0.75	2.12	3.56	3.71
27	0.5	0	0.25	0.25	2.15	3.85	4.02
3	0	0	0.5	0.5	2.36	4.22	4.44
26	0.5	0	0	0.5	2.45	3.6	3.74
17	0.25	0	0.25	0.5	2.55	3.91	4.09
1	0	0	0	1	2.58	3.7	3.83
16	0.25	0	0	0.75	2.58	3.66	3.79
2	0	0	0.25	0.75	2.59	3.96	4.14

Table 24: Context 5 Composite Score Table (Sorted by Composite Score Throughout Simulation Period)

Simulation Trace	Change Process Management	Continuity Management	Learning Management	Reward System Management	Rank at 1.5 Years	Rank at 5 Years	Rank at 10 Years	Composite Score Throughout Simulation Period
3	0	0	0.5	0.5	6	3	3	12
4	0	0	0.75	0.25	13	1	1	15
2	0	0	0.25	0.75	1	7	8	16
18	0.25	0	0.5	0.25	9	4	4	17
17	0.25	0	0.25	0.5	4	9	9	22
27	0.5	0	0.25	0.25	7	10	10	27
19	0.25	0	0.75	0	26	2	2	30
8	0	0.25	0.5	0.25	17	8	6	31
28	0.5	0	0.5	0	22	5	5	32
1	0	0	0	1	3	14	16	33
7	0	0.25	0.25	0.5	12	11	11	34
16	0.25	0	0	0.75	2	16	17	35
21	0.25	0.25	0.25	0.25	14	12	12	38
22	0.25	0.25	0.5	0	27	6	7	40
26	0.5	0	0	0.5	5	17	19	41
6	0	0.25	0	0.75	8	18	20	46
33	0.75	0	0.25	0	21	13	13	47
32	0.75	0	0	0.25	11	20	21	52
20	0.25	0.25	0	0.5	10	21	22	53
30	0.5	0.25	0.25	0	25	15	14	54
11	0	0.5	0.25	0.25	19	24	15	58
29	0.5	0.25	0	0.25	15	22	23	60
10	0	0.5	0	0.5	16	25	24	65
24	0.25	0.5	0.25	0	29	19	18	66
23	0.25	0.5	0	0.25	18	26	26	70
35	1	0	0	0	23	23	25	71
34	0.75	0.25	0	0	24	27	27	78
13	0	0.75	0	0.25	20	30	29	79
31	0.5	0.5	0	0	28	28	28	84
25	0.25	0.75	0	0	30	29	30	89
5	0	0	1	0	31	31	31	93
9	0	0.25	0.75	0	32	32	32	96
12	0	0.5	0.5	0	33	33	33	99
14	0	0.75	0.25	0	34	34	34	102
15	0	1	0	0	35	35	35	105

Context 6 Analysis.

Figure 69 presents the comparative graph for the set of simulation runs under context 6 (the high operating capability, low adopter, and baseline organizational context scenario). Based on the baseline organizational context, Integration behaves in line with the desired system behavior. Based on the high initial values for operating capability, Integration increases fairly rapidly and eventually levels-off. Figure 69 does not appear to have any kind of groupings and the simulations are spread fairly uniformly through the middle portion of the graph. There are a number of intersections of simulation data, so similar analysis will be performed for context 6 as for context 5. For comparative purposes, each simulation trace will be compared at the 3.7, 6.2, and 10-year points and any patterns and conclusions that result will be discussed.

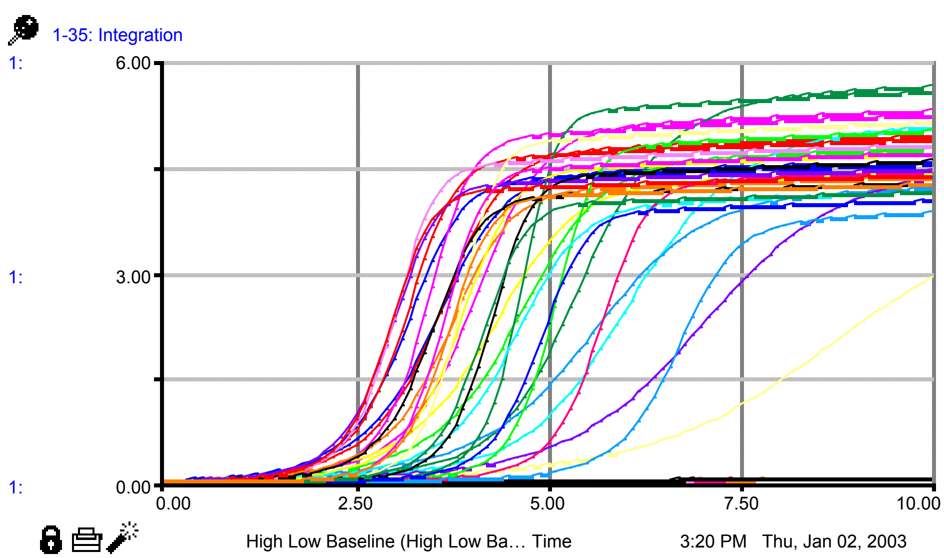


Figure 69: Context 6 (High Operating Capability, Low Adopters, and Baseline Organizational Context) Comparative Graph

Table 25 presents the composite score table sorted by composite score throughout simulation period in ascending order for context 6. The simulations with a composite score of 30 or lower (meaning, as a whole, these simulations ranked in the top 10 for each point in time) were highlighted. Based on the goals of the organization or manager being good overall performance in all of the periods of time, simulation 18 is recommended as the best overall performer. In this case, the manager should focus a quarter of his available time on change process management, a half on learning management, and a quarter on reward system management. Simulations 17 and 27 also have balanced performance and these also focus on the same three management interventions to varying degrees. For very mediocre short-term performance, but very good mid-term and long-term performance, simulation 19 is recommended. In this case, the manager would devote a quarter of his available time to change process management and three-quarters to learning management. In any case, the goals of the organization and manager would dictate which of the simulations would offer the best management intervention cocktail to achieve those goals. In common with all of the better management cocktails is the lack of focus on continuity management in this positive context with a high initial value for operating capability and a low initial level of adopters.

Table 25: Context 6 Composite Score Table (Sorted by Composite Score Throughout Simulation Period)

Simulation Trace	Change Process Management	Continuity Management	Learning Management	Reward System Management	Rank at 3.7 Years	Rank at 6.2 Years	Rank at 10 Years	Composite Score Throughout Simulation Period
18	0.25	0	0.5	0.25	5	3	4	12
17	0.25	0	0.25	0.5	3	7	9	19
27	0.5	0	0.25	0.25	1	8	10	19
3	0	0	0.5	0.5	15	2	3	20
2	0	0	0.25	0.75	8	5	8	21
28	0.5	0	0.5	0	14	4	5	23
19	0.25	0	0.75	0	24	1	2	27
33	0.75	0	0.25	0	10	9	12	31
1	0	0	0	1	9	11	15	35
16	0.25	0	0	0.75	6	13	16	35
21	0.25	0.25	0.25	0.25	13	10	13	36
26	0.5	0	0	0.5	4	15	17	36
4	0	0	0.75	0.25	22	16	1	39
32	0.75	0	0	0.25	2	17	20	39
22	0.25	0.25	0.5	0	28	6	7	41
7	0	0.25	0.25	0.5	18	14	11	43
30	0.5	0.25	0.25	0	20	12	14	46
20	0.25	0.25	0	0.5	11	18	21	50
29	0.5	0.25	0	0.25	7	20	23	50
6	0	0.25	0	0.75	16	19	19	54
8	0	0.25	0.5	0.25	23	27	6	56
35	1	0	0	0	12	21	24	57
34	0.75	0.25	0	0	17	22	26	65
23	0.25	0.5	0	0.25	19	23	27	69
10	0	0.5	0	0.5	21	26	25	72
24	0.25	0.5	0.25	0	29	25	18	72
11	0	0.5	0.25	0.25	26	28	22	76
31	0.5	0.5	0	0	25	24	28	77
13	0	0.75	0	0.25	27	30	30	87
25	0.25	0.75	0	0	30	29	29	88
15	0	1	0	0	31	31	32	94
14	0	0.75	0.25	0	32	32	31	95
12	0	0.5	0.5	0	33	33	33	99
9	0	0.25	0.75	0	34	34	34	102
5	0	0	1	0	35	35	35	105

Context 7 Analysis.

Figure 70 presents the comparative graph for the set of simulation runs under context 7 (the low operating capability, high adopter, and baseline organizational context scenario). Based on the baseline organizational context, Integration behaves in line with the desired system behavior. Based on the high initial values for operating capability, Integration increases fairly rapidly and eventually levels-off. The context 7 simulations are similar to the context 5 simulations in that there appear to be short-term groupings. There are a number of intersections of simulation data, so a similar analysis for context 7, as for contexts 5 and 6, will be performed. For comparative purposes, each simulation trace will be compared at the 3, 6, and 10-year points and any patterns and conclusions that result will be discussed.

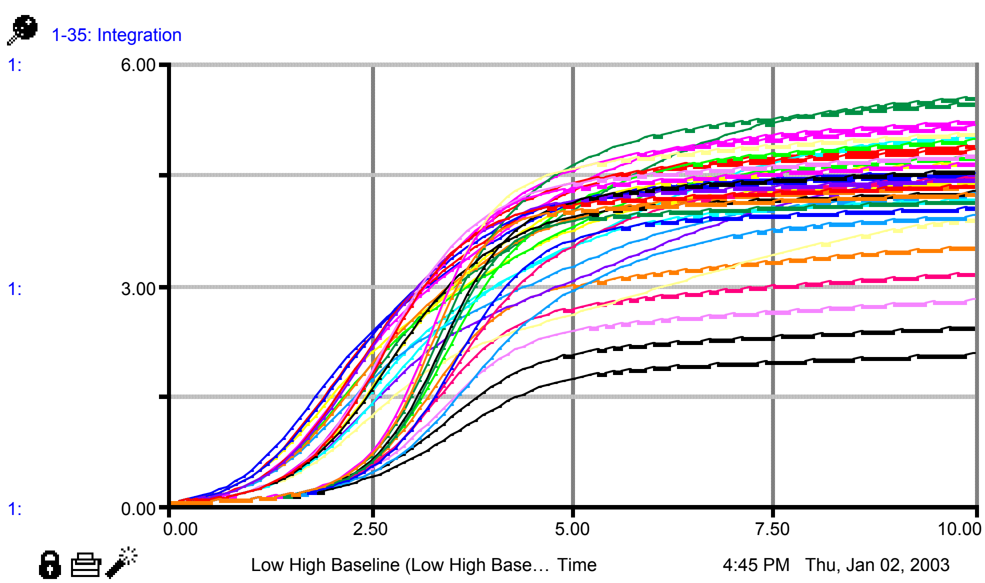


Figure 70: Context 7 (Low Operating Capability, High Adopters, and Baseline Organizational Context) Comparative Graph

Table 26 presents the information for the context 7 simulations sorted in ascending order based on the level at year 3. From this sorted information, one is able to discern between the better short-term performers and the not as effective short-term performers. The not as effective short-term performers are highlighted in Table 26 in the lighter shade and the better short-term performers are highlighted in Table 26 with the darker shade (at the bottom). Reward system management was a required element for all of the simulations falling into the better short-term performers set. For the most part, if the manager did not focus on reward system management, the associated simulation would take longer to develop a high level of Integration. There are a number of intersections in Figure 70 where simulations may be poor short-term performers, but much better long-term performers.

Table 27 presents the composite score table sorted by composite score throughout simulation period in ascending order for context 7. The simulations with a composite score of 30 or lower (meaning, as a whole, these simulations ranked in the top 10 for each point in time) were highlighted. Based on the goals of the organization or manager being good overall performance in all of the periods of time, simulation 3 is recommended as the best overall performer. In this case, the manager should focus a half of his available time on learning management and the other half on reward system management. Simulations 18, 2, and 17 also have balanced performance and these also focus on learning and reward system management, but simulation 18 also focuses on change process management. For mediocre short-term performance, but very good long-term performance, simulation 4 is recommended. In this case, the manager would devote three-quarters of his available time to learning and a quarter to reward system management. In any case, the goals of the organization and manager would dictate which of the simulations would offer the best management intervention cocktail to achieve those goals. In common with all of the better management cocktails is the lack of focus on continuity management in this positive context with a low initial value for operating capability and a high initial level of adopters.

Table 26: Context 7 Tabulated Information (Sorted by Level at Year 3)

Simulation Trace	Change Process Management	Continuity Management	Learning Management	Reward System Management	Level at 3 years	Level at 6 years	Level at 10 years
15	0	1	0	0	0.49	1.53	1.69
14	0	0.75	0.25	0	0.61	1.8	2
25	0.25	0.75	0	0	0.64	2.8	3.26
12	0	0.5	0.5	0	0.71	2.07	2.3
24	0.25	0.5	0.25	0	0.81	3.31	3.69
31	0.5	0.5	0	0	0.81	3.18	3.35
9	0	0.25	0.75	0	0.82	2.34	2.61
5	0	0	1	0	0.93	2.6	2.91
22	0.25	0.25	0.5	0	0.99	3.76	4.12
34	0.75	0.25	0	0	1.02	3.3	3.44
30	0.5	0.25	0.25	0	1.07	3.57	3.78
19	0.25	0	0.75	0	1.19	4.17	4.55
35	1	0	0	0	1.25	3.38	3.51
28	0.5	0	0.5	0	1.33	3.94	4.2
13	0	0.75	0	0.25	1.35	2.42	3.23
33	0.75	0	0.25	0	1.35	3.66	3.86
11	0	0.5	0.25	0.25	1.56	2.89	3.73
23	0.25	0.5	0	0.25	1.64	3.19	3.45
10	0	0.5	0	0.5	1.77	3.03	3.51
8	0	0.25	0.5	0.25	1.78	3.37	4.18
21	0.25	0.25	0.25	0.25	1.92	3.61	3.87
29	0.5	0.25	0	0.25	1.93	3.37	3.53
4	0	0	0.75	0.25	2	3.84	4.61
7	0	0.25	0.25	0.5	2	3.52	3.93
6	0	0.25	0	0.75	2.07	3.38	3.65
20	0.25	0.25	0	0.5	2.07	3.41	3.6
18	0.25	0	0.5	0.25	2.21	4	4.28
32	0.75	0	0	0.25	2.23	3.46	3.61
3	0	0	0.5	0.5	2.25	3.95	4.34
27	0.5	0	0.25	0.25	2.28	3.74	3.95
1	0	0	0	1	2.32	3.58	3.78
2	0	0	0.25	0.75	2.33	3.8	4.06
16	0.25	0	0	0.75	2.37	3.57	3.74
17	0.25	0	0.25	0.5	2.37	3.79	4.01
26	0.5	0	0	0.5	2.37	3.53	3.68

Table 27: Context 7 Composite Score Table (Sorted by Composite Score Throughout Simulation Period)

Simulation Trace	Change Process Management	Continuity Management	Learning Management	Reward System Management	Rank at 3 Years	Rank at 6 Years	Rank at 10 Years	Composite Score Throughout Simulation Period
3	0	0	0.5	0.5	7	3	3	13
18	0.25	0	0.5	0.25	9	2	4	15
2	0	0	0.25	0.75	4	6	8	18
17	0.25	0	0.25	0.5	2	7	9	18
4	0	0	0.75	0.25	13	5	1	19
27	0.5	0	0.25	0.25	6	9	10	25
19	0.25	0	0.75	0	24	1	2	27
1	0	0	0	1	5	12	14	31
28	0.5	0	0.5	0	22	4	5	31
16	0.25	0	0	0.75	3	13	16	32
26	0.5	0	0	0.5	1	15	19	35
21	0.25	0.25	0.25	0.25	15	11	12	38
7	0	0.25	0.25	0.5	12	16	11	39
22	0.25	0.25	0.5	0	27	8	7	42
33	0.75	0	0.25	0	20	10	13	43
8	0	0.25	0.5	0.25	16	22	6	44
32	0.75	0	0	0.25	8	17	21	46
6	0	0.25	0	0.75	11	19	20	50
20	0.25	0.25	0	0.5	10	18	22	50
30	0.5	0.25	0.25	0	25	14	15	54
29	0.5	0.25	0	0.25	14	21	23	58
11	0	0.5	0.25	0.25	19	28	17	64
35	1	0	0	0	23	20	24	67
10	0	0.5	0	0.5	17	27	25	69
23	0.25	0.5	0	0.25	18	25	26	69
24	0.25	0.5	0.25	0	31	23	18	72
34	0.75	0.25	0	0	26	24	27	77
13	0	0.75	0	0.25	21	31	30	82
31	0.5	0.5	0	0	30	26	28	84
5	0	0	1	0	28	30	31	89
25	0.25	0.75	0	0	33	29	29	91
9	0	0.25	0.75	0	29	32	32	93
12	0	0.5	0.5	0	32	33	33	98
14	0	0.75	0.25	0	34	34	34	102
15	0	1	0	0	35	35	35	105

Context 8 Analysis.

Context 8 is the baseline context for the model overall. In most squadron settings, this would represent the general context that a manager would probably be working in, so analysis in this context is probably the most common and realistic of the twelve static scenarios.

Figure 71 presents the comparative graph for the set of simulation runs under context 8 (the low operating capability, low adopter, and baseline organizational context scenario). Based on the baseline organizational context, Integration behaves in line with the desired system behavior. Based on the low initial values for operating capability and adopters, Integration increases slower in comparison to other contexts under the baseline conditions, but it still eventually increases and levels-off. There are a number of intersections of simulation data, so similar analysis will be performed for context 8 as for the others under the baseline conditions. For comparative purposes, each simulation trace will be compared at the 5.5, 8, and 10-year points and any patterns and conclusions that result will be discussed.

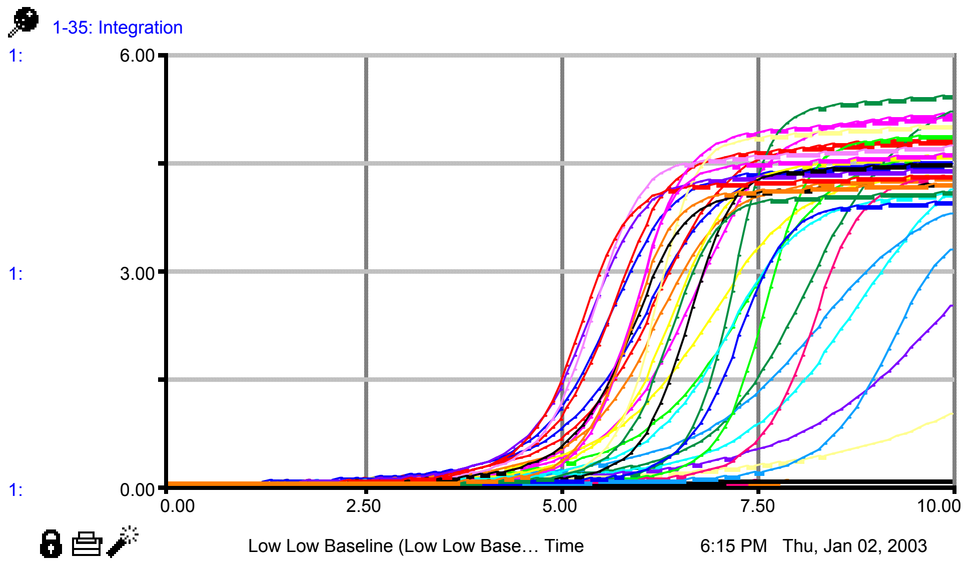


Figure 71: Context 8 (Low Operating Capability, Low Adopters, and Baseline Organizational Context) Comparative Graph

Table 28 presents the composite score table sorted by composite score throughout simulation period in ascending order for context 8. The simulations with a composite score of 30 or lower (meaning, as a whole, these simulations ranked in the top 10 for each point in time) were highlighted. Based on the goals of the organization or manager being good overall performance in all of the periods of time, simulation 18 is recommended as the best overall performer. In this case, the manager should focus a quarter of his available time on change process management, a half on learning management, and a quarter on reward system management. Simulations 17 and 27 also have balanced performance and these also focus on the same three management interventions to varying degrees. For very mediocre short-term performance, but very good mid-term and long-term performance, simulation 19 is recommended. In this case, the manager would devote a quarter of his available time to change process management and three-quarters to learning management. In any case, the goals of the organization and manager would dictate which of the simulations would offer the best management intervention cocktail to achieve those goals. In common with all of the better management cocktails is the lack of focus on continuity management in this positive context with low initial values for operating capability and adopters.

Table 28: Context 8 Composite Score Table (Sorted by Composite Score Throughout Simulation Period)

Simulation Trace	Change Process Management	Continuity Management	Learning Management	Reward System Management	Rank at 5.5 Years	Rank at 8 Years	Rank at 10 Years	Composite Score Throughout Simulation Period
18	0.25	0	0.5	0.25	9	2	4	15
17	0.25	0	0.25	0.5	5	5	8	18
27	0.5	0	0.25	0.25	3	7	9	19
3	0	0	0.5	0.5	13	4	3	20
2	0	0	0.25	0.75	8	6	7	21
28	0.5	0	0.5	0	17	3	5	25
16	0.25	0	0	0.75	4	10	15	29
19	0.25	0	0.75	0	27	1	1	29
1	0	0	0	1	6	11	13	30
33	0.75	0	0.25	0	11	8	11	30
26	0.5	0	0	0.5	2	13	16	31
32	0.75	0	0	0.25	1	14	18	33
21	0.25	0.25	0.25	0.25	15	9	12	36
29	0.5	0.25	0	0.25	7	16	21	44
4	0	0	0.75	0.25	21	24	2	47
7	0	0.25	0.25	0.5	16	21	10	47
20	0.25	0.25	0	0.5	12	15	20	47
30	0.5	0.25	0.25	0	22	12	14	48
35	1	0	0	0	10	17	22	49
6	0	0.25	0	0.75	14	20	17	51
22	0.25	0.25	0.5	0	28	19	6	53
34	0.75	0.25	0	0	18	18	24	60
23	0.25	0.5	0	0.25	19	23	25	67
10	0	0.5	0	0.5	20	25	27	72
8	0	0.25	0.5	0.25	23	27	23	73
24	0.25	0.5	0.25	0	29	26	19	74
31	0.5	0.5	0	0	26	22	26	74
11	0	0.5	0.25	0.25	24	28	29	81
13	0	0.75	0	0.25	25	29	30	84
25	0.25	0.75	0	0	30	30	28	88
15	0	1	0	0	31	31	31	93
14	0	0.75	0.25	0	32	32	32	96
12	0	0.5	0.5	0	33	33	33	99
9	0	0.25	0.75	0	34	34	34	102
5	0	0	1	0	35	35	35	105

Context 9 Analysis.

The focus now shifts from the baseline organizational context scenarios to the positive scenarios. The positive scenarios provide the system with the context to behave according to the desired behavior pattern in the reference mode diagrams, but also allow the system to steadily increase performance after the s-shaped leveling-off has occurred. Again, discontinued use inertia does not build up in the system, so none of the discontinued use inertia compensating loops will dominate and force integration to decline after some initial gains. Just like under the baseline conditions, the focus for the manager is going to be how to intervene in the system to maximize performance. The system context will allow positive performance behavior, but the system manager can still have a large impact on the magnitude of that positive performance and how quickly it occurs. These scenarios are fairly realistic in the real world and would coincide with an innovative organization. The simulations in this scenario should provide some useful insights into how best to manage an innovative squadron system.

Figure 72 presents the comparative graph for the set of simulation runs under context 9 (the high operating capability, high adopter, and positive organizational context scenario). Of the positive organizational context scenarios, this is one of the more realistic under these conditions. Based on the positive organizational context, Integration behaves in line with the desired system behavior. Based on the high initial values for operating capability and adopters, Integration increases rapidly and keeps steadily rising based on the continued use inertia–integration reinforcing loop additions. In this type of context, the system will tend to shepherd itself, but the manager can still have a significant impact on performance. From immediate inspection of Figure 72, there appear to be two sets of traces; one set increases earlier than a second set, which increases at a later time. For comparative purposes, each simulation trace will be compared at the 2, 5, and 10-year points and any patterns and conclusions that result will be discussed.

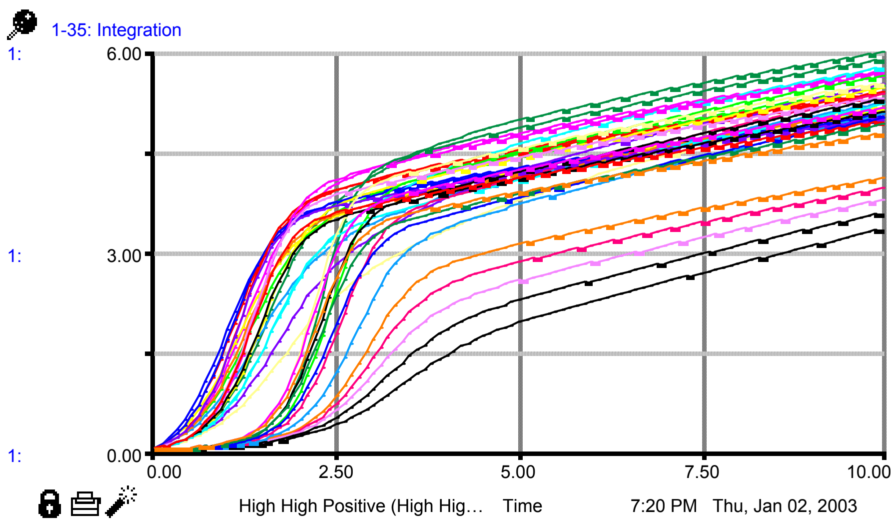


Figure 72: Context 9 (High Operating Capability, High Adopters, and Positive Organizational Context) Comparative Graph

Table 29 presents the information for the context 9 simulations sorted in ascending order based on the level at year 2. From this sorted information, one can discern between the better short-term performers and the not as effective short-term performers. The not as effective short-term performers are highlighted in Table 29 in the lighter shade and the better short-term performers are highlighted in Table 29 with the darker shade (at the bottom). Reward system management was a required element for the simulation to fall into the better short-term performers set. If the manager did not focus on reward system management, the associated simulation would take longer to develop a high level of Integration. There are a number of intersections in Figure 72 where simulations may be poor short-term performers, but much better long-term performers.

Table 29: Context 9 Tabulated Information (Sorted by Level at Year 2)

Simulation Trace	Change Process Management	Continuity Management	Learning Management	Reward System Management	Level at 2 years	Level at 5 years	Level at 10 years
15	0	1	0	0	0.19	1.91	3.32
14	0	0.75	0.25	0	0.23	2.24	3.56
12	0	0.5	0.5	0	0.26	2.54	3.76
9	0	0.25	0.75	0	0.29	2.82	3.94
5	0	0	1	0	0.32	3.09	4.09
25	0.25	0.75	0	0	0.43	3.69	5.06
24	0.25	0.5	0.25	0	0.63	4.1	5.37
31	0.5	0.5	0	0	0.73	3.8	5.01
22	0.25	0.25	0.5	0	0.85	4.48	5.64
34	0.75	0.25	0	0	1	3.85	4.9
30	0.5	0.25	0.25	0	1.08	4.18	5.28
19	0.25	0	0.75	0	1.14	4.85	5.89
35	1	0	0	0	1.21	3.88	4.76
33	0.75	0	0.25	0	1.41	4.21	5.15
28	0.5	0	0.5	0	1.46	4.54	5.53
13	0	0.75	0	0.25	1.73	3.75	5.21
11	0	0.5	0.25	0.25	2.15	4.2	5.5
8	0	0.25	0.5	0.25	2.59	4.6	5.76
10	0	0.5	0	0.5	2.62	4.1	5.24
23	0.25	0.5	0	0.25	2.62	4.05	5.21
4	0	0	0.75	0.25	3.05	4.96	6
29	0.5	0.25	0	0.25	3.08	4.09	5.09
7	0	0.25	0.25	0.5	3.1	4.44	5.49
6	0	0.25	0	0.75	3.16	4.2	5.17
21	0.25	0.25	0.25	0.25	3.17	4.4	5.46
20	0.25	0.25	0	0.5	3.23	4.16	5.15
32	0.75	0	0	0.25	3.3	4.09	4.94
26	0.5	0	0	0.5	3.48	4.17	5
1	0	0	0	1	3.49	4.25	5.05
16	0.25	0	0	0.75	3.53	4.22	5.04
27	0.5	0	0.25	0.25	3.55	4.41	5.32
3	0	0	0.5	0.5	3.58	4.77	5.71
2	0	0	0.25	0.75	3.62	4.52	5.39
17	0.25	0	0.25	0.5	3.67	4.48	5.37
18	0.25	0	0.5	0.25	3.68	4.72	5.68

Table 30 presents the composite score table sorted by composite score throughout the simulation period in ascending order for context 9. The simulations with a composite score of 30 or lower (meaning, as a whole, these simulations ranked in the top 10 for each point in time) were highlighted. Based on the goals of the organization or manager being good overall performance in all of the periods of time, simulation 18 is recommended as the best overall performer. In this case, the manager should focus a quarter of his or her available time on change process management, half his or her time on learning management, and the last quarter on reward system management. For mediocre short-term performance, but very good mid-term and long-term performance, simulation 4 is recommended. In this case, the manager would devote three-quarters of his available time to learning management and the other quarter to reward system management. It is interesting to note that a focus on continuity management ranks in the group of better management intervention cocktails (simulation 8). In this case, the short-term performance is mediocre, but the long-term performance is very good. In any case, the goals of the organization and manager would dictate which of the simulations would offer the best management intervention cocktail to achieve those goals. In this context, the manager has more flexibility in what he focuses on to get better system performance – there is a place for all of the management interventions if so desired.

Table 30: Context 9 Composite Score Table (Sorted by Composite Score Throughout Simulation Period)

Simulation Trace	Change Process Management	Continuity Management	Learning Management	Reward System Management	Rank at 2 Years	Rank at 5 Years	Rank at 10 Years	Composite Score Throughout Simulation Period
18	0.25	0	0.5	0.25	1	4	5	10
3	0	0	0.5	0.5	4	3	4	11
4	0	0	0.75	0.25	15	1	1	17
2	0	0	0.25	0.75	3	7	11	21
17	0.25	0	0.25	0.5	2	8	12	22
8	0	0.25	0.5	0.25	18	5	3	26
19	0.25	0	0.75	0	24	2	2	28
27	0.5	0	0.25	0.25	5	11	14	30
7	0	0.25	0.25	0.5	13	10	9	32
21	0.25	0.25	0.25	0.25	11	12	10	33
28	0.5	0	0.5	0	21	6	7	34
22	0.25	0.25	0.5	0	27	9	6	42
1	0	0	0	1	7	13	24	44
11	0	0.5	0.25	0.25	19	17	8	44
16	0.25	0	0	0.75	6	14	25	45
6	0	0.25	0	0.75	12	16	19	47
20	0.25	0.25	0	0.5	10	20	21	51
10	0	0.5	0	0.5	17	21	16	54
26	0.5	0	0	0.5	8	19	27	54
33	0.75	0	0.25	0	22	15	20	57
23	0.25	0.5	0	0.25	16	25	17	58
30	0.5	0.25	0.25	0	25	18	15	58
29	0.5	0.25	0	0.25	14	24	22	60
32	0.75	0	0	0.25	9	23	28	60
24	0.25	0.5	0.25	0	29	22	13	64
13	0	0.75	0	0.25	20	29	18	67
35	1	0	0	0	23	26	30	79
31	0.5	0.5	0	0	28	28	26	82
34	0.75	0.25	0	0	26	27	29	82
25	0.25	0.75	0	0	30	30	23	83
5	0	0	1	0	31	31	31	93
9	0	0.25	0.75	0	32	32	32	96
12	0	0.5	0.5	0	33	33	33	99
14	0	0.75	0.25	0	34	34	34	102
15	0	1	0	0	35	35	35	105

Context 10 Analysis.

Figure 73 presents the comparative graph for the set of simulation runs under context 10 (the high operating capability, low adopter, and positive organizational context scenario). Based on the positive organizational context, Integration behaves in line with the desired system behavior. Based on the high initial values for operating capability and adopters, Integration increases rapidly and keeps steadily rising based on the continued use inertia–integration reinforcing loop additions. Figure 10 does not appear to have any kind of groupings and the simulations are spread fairly uniformly through the middle portion of the graph. There are a number of intersections of simulation data, so similar analysis will be performed for context 10 as for the others in the baseline and positive contexts. For comparative purposes, each simulation will be compared at the 3.5, 5.5, and 10-year points and any patterns and conclusions that result will be discussed.

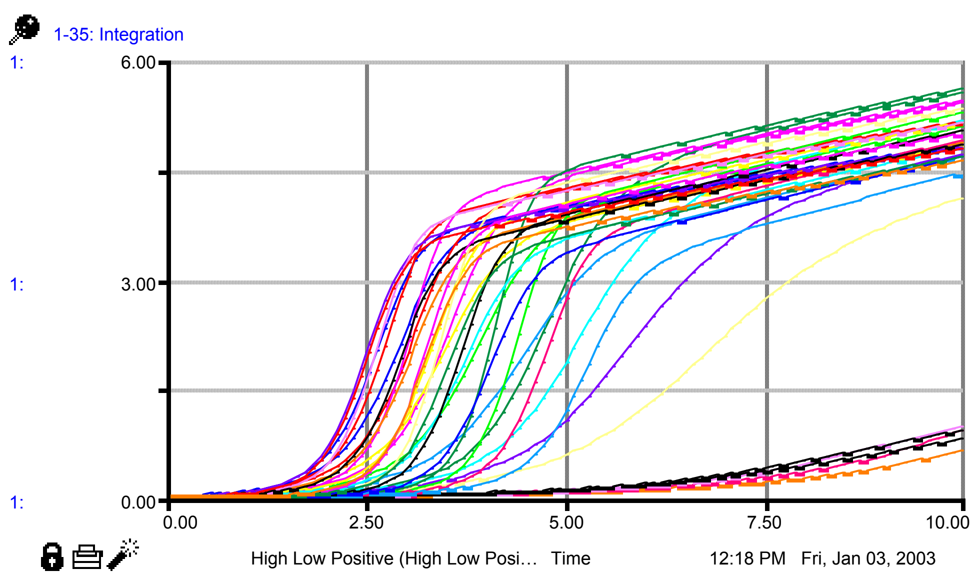


Figure 73: Context 10 (High Operating Capability, Low Adopters, and Positive Organizational Context) Comparative Graph

Table 31 presents the composite score table sorted by composite score throughout simulation period in ascending order for context 10. The simulations with a composite score of 30 or lower (meaning, as a whole, these simulations ranked in the top 10 for each point in time) were highlighted. Based on the goals of the organization or manager being good overall performance in all of the periods of time, simulation 18 is recommended as the best overall performer. In this case, the manager should focus a quarter of his available time on change process management, half his time on learning management, and the last quarter on reward system management. For very mediocre short-term performance, but the best mid-term and long-term performance, simulation 19 is recommended. In this case, the manager would devote three-quarters of his available time to learning management and the other quarter to change process management. Continuity dropped out of the group of better management intervention cocktails under this context, but was close to being included (simulation 21 missed the top group by one composite score point). In any case, the goals of the organization and manager would dictate which of the simulations would offer the best management intervention cocktail to achieve those goals. In this context, it would be more fruitful for the manager to focus on change process management, learning management, and reward system management -- a combination of these, which does not include continuity management.

Table 31: Context 10 Composite Score Table (Sorted by Composite Score Throughout Simulation Period)

Simulation Trace	Change Process Management	Continuity Management	Learning Management	Reward System Management	Rank at 3.5 Years	Rank at 5.5 Years	Rank at 10 Years	Composite Score Throughout Simulation Period
18	0.25	0	0.5	0.25	3	2	3	8
17	0.25	0	0.25	0.5	2	5	8	15
27	0.5	0	0.25	0.25	1	7	11	19
3	0	0	0.5	0.5	15	3	4	22
28	0.5	0	0.5	0	14	4	5	23
2	0	0	0.25	0.75	8	6	10	24
19	0.25	0	0.75	0	23	1	1	25
21	0.25	0.25	0.25	0.25	13	9	9	31
16	0.25	0	0	0.75	5	11	17	33
33	0.75	0	0.25	0	11	10	14	35
26	0.5	0	0	0.5	4	13	19	36
1	0	0	0	1	7	12	20	39
22	0.25	0.25	0.5	0	26	8	6	40
20	0.25	0.25	0	0.5	10	17	16	43
29	0.5	0.25	0	0.25	9	18	18	45
32	0.75	0	0	0.25	6	16	23	45
4	0	0	0.75	0.25	24	20	2	46
7	0	0.25	0.25	0.5	20	14	12	46
30	0.5	0.25	0.25	0	18	15	13	46
6	0	0.25	0	0.75	16	19	21	56
8	0	0.25	0.5	0.25	25	27	7	59
35	1	0	0	0	12	21	28	61
23	0.25	0.5	0	0.25	19	23	22	64
34	0.75	0.25	0	0	17	22	26	65
24	0.25	0.5	0.25	0	29	24	15	68
10	0	0.5	0	0.5	21	26	25	72
31	0.5	0.5	0	0	22	25	27	74
11	0	0.5	0.25	0.25	27	29	24	80
25	0.25	0.75	0	0	30	28	29	87
13	0	0.75	0	0.25	28	30	30	88
14	0	0.75	0.25	0	32	32	32	96
15	0	1	0	0	31	31	34	96
12	0	0.5	0.5	0	33	33	31	97
9	0	0.25	0.75	0	34	34	33	101
5	0	0	1	0	35	35	35	105

Context 11 Analysis.

Figure 74 presents the comparative graph for the set of simulation runs under context 11 (the low operating capability, high adopter, and positive organizational context scenario). Based on the positive organizational context, Integration behaves in line with the desired system behavior. Based on the high initial values for adopters, Integration increases rapidly and keeps steadily rising based on the continued use inertia–integration reinforcing loop additions. The context 11 simulations are similar to the context 9 simulations in that there appear to be short-term groupings. There are a number of intersections of simulation data, so similar analysis will be performed for context 11 as for the other contexts under the baseline and positive conditions. For comparative purposes, each simulation will be compared at the 2.5, 5, and 10-year points and any patterns and conclusions that result will be discussed.

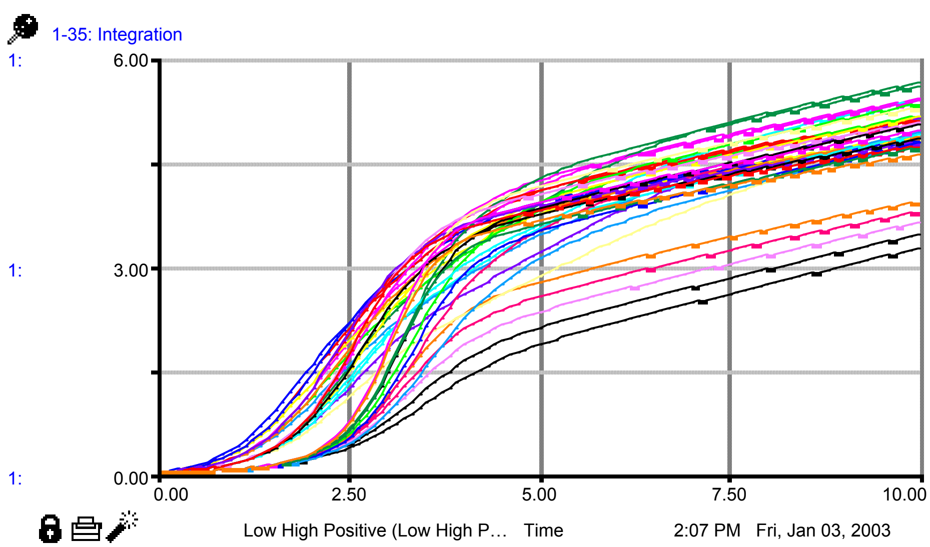


Figure 74: Context 11 (Low Operating Capability, High Adopters, and Positive Organizational Context) Comparative Graph

Table 32 presents the information for the context 11 simulations sorted in ascending order based on the level at year 2.5. From this sorted information, one can discern between the better short-term performers and the not as effective short-term performers. The not as effective short-term performers are highlighted in Table 32 in the lighter shade and the better short-term performers are highlighted in Table 32 with the darker shade (at the bottom). Reward system management was a required element for the simulation to fall into the better short-term performers set. If the manager did not focus on reward system management, the associated simulation would take longer to develop a high level of Integration. There are a number of intersections in Figure 11 where simulations may be poor short-term performers, but much better long-term performers.

Table 32: Context 11 Tabulated Information (Sorted by Level at Year 2.5)

Simulation Trace	Change Process Management	Continuity Management	Learning Management	Reward System Management	Level at 2.5 years	Level at 5 years	Level at 10 years
15	0	1	0	0	0.35	1.85	3.24
14	0	0.75	0.25	0	0.41	2.09	3.44
25	0.25	0.75	0	0	0.43	3.09	4.78
12	0	0.5	0.5	0	0.45	2.32	3.62
9	0	0.25	0.75	0	0.49	2.54	3.77
24	0.25	0.5	0.25	0	0.51	3.51	5.07
31	0.5	0.5	0	0	0.52	3.49	4.77
5	0	0	1	0	0.53	2.76	3.92
22	0.25	0.25	0.5	0	0.58	3.9	5.35
30	0.5	0.25	0.25	0	0.62	3.83	5.04
34	0.75	0.25	0	0	0.62	3.6	4.7
19	0.25	0	0.75	0	0.65	4.26	5.6
28	0.5	0	0.5	0	0.73	4.14	5.29
35	1	0	0	0	0.73	3.65	4.61
33	0.75	0	0.25	0	0.76	3.91	4.95
13	0	0.75	0	0.25	1.11	2.84	4.81
11	0	0.5	0.25	0.25	1.24	3.19	5.12
23	0.25	0.5	0	0.25	1.31	3.58	4.89
8	0	0.25	0.5	0.25	1.39	3.54	5.39
21	0.25	0.25	0.25	0.25	1.49	3.92	5.14
29	0.5	0.25	0	0.25	1.53	3.74	4.83
4	0	0	0.75	0.25	1.55	3.89	5.65
10	0	0.5	0	0.5	1.58	3.43	4.91
18	0.25	0	0.5	0.25	1.69	4.23	5.38
7	0	0.25	0.25	0.5	1.75	3.79	5.17
27	0.5	0	0.25	0.25	1.76	4.04	5.06
32	0.75	0	0	0.25	1.76	3.8	4.73
20	0.25	0.25	0	0.5	1.82	3.79	4.88
6	0	0.25	0	0.75	1.92	3.75	4.89
3	0	0	0.5	0.5	1.93	4.14	5.41
17	0.25	0	0.25	0.5	2.04	4.08	5.11
26	0.5	0	0	0.5	2.07	3.87	4.78
2	0	0	0.25	0.75	2.12	4.07	5.13
16	0.25	0	0	0.75	2.18	3.91	4.82
1	0	0	0	1	2.2	3.91	4.83

Table 33 presents the composite score table sorted by composite score throughout simulation period in ascending order for context 11. The simulations with a composite score of 30 or lower (meaning, as a whole, these simulations ranked in the top 10 for each point in time) were highlighted. Based on the goals of the organization or manager being good overall performance in all of the periods of time, simulation 3 is recommended as the best overall performer. In this case, the manager should focus half of his available time on learning management and the other half on reward system management. For very mediocre short-term performance, but very good mid-term and long-term performance, simulation 19 is recommended. In this case, the manager would devote three-quarters of his available time to learning management and the other quarter to change process management. Continuity management is the only management intervention not in the mix for this context. In any case, the goals of the organization and manager would dictate which of the simulations would offer the best management intervention cocktail to achieve those goals. By focusing on learning management and reward system management alone, in this context, the manager has the best opportunity to maximize system performance.

Table 33: Context 11 Composite Score Table (Sorted by Composite Score Throughout Simulation Period)

Simulation Trace	Change Process Management	Continuity Management	Learning Management	Reward System Management	Rank at 2.5 Years	Rank at 5 Years	Rank at 10 Years	Composite Score Throughout Simulation Period
3	0	0	0.5	0.5	6	3	3	12
2	0	0	0.25	0.75	3	6	10	19
18	0.25	0	0.5	0.25	12	2	5	19
17	0.25	0	0.25	0.5	5	5	12	22
19	0.25	0	0.75	0	24	1	2	27
4	0	0	0.75	0.25	14	13	1	28
27	0.5	0	0.25	0.25	10	7	14	31
1	0	0	0	1	1	10	21	32
21	0.25	0.25	0.25	0.25	16	8	9	33
28	0.5	0	0.5	0	23	4	7	34
7	0	0.25	0.25	0.5	11	17	8	36
16	0.25	0	0	0.75	2	11	23	36
26	0.5	0	0	0.5	4	14	25	43
6	0	0.25	0	0.75	7	19	18	44
8	0	0.25	0.5	0.25	17	24	4	45
22	0.25	0.25	0.5	0	27	12	6	45
20	0.25	0.25	0	0.5	8	18	20	46
33	0.75	0	0.25	0	21	9	16	46
32	0.75	0	0	0.25	9	16	28	53
30	0.5	0.25	0.25	0	26	15	15	56
10	0	0.5	0	0.5	13	27	17	57
29	0.5	0.25	0	0.25	15	20	22	57
11	0	0.5	0.25	0.25	19	28	11	58
23	0.25	0.5	0	0.25	18	23	19	60
24	0.25	0.5	0.25	0	30	25	13	68
35	1	0	0	0	22	21	30	73
13	0	0.75	0	0.25	20	30	24	74
34	0.75	0.25	0	0	25	22	29	76
31	0.5	0.5	0	0	29	26	27	82
25	0.25	0.75	0	0	33	29	26	88
5	0	0	1	0	28	31	31	90
9	0	0.25	0.75	0	31	32	32	95
12	0	0.5	0.5	0	32	33	33	98
14	0	0.75	0.25	0	34	34	34	102
15	0	1	0	0	35	35	35	105

Context 12 Analysis.

Figure 75 presents the comparative graph for the set of simulation runs under context 12 (the low operating capability, low adopter, and positive organizational context scenario). This contextual study is realistic in the sense that an organization may have a history of innovativeness, hence a positive context, but GeoBase is so new that the organization must go through the growth process in operating capability and adoption. Based on the positive organizational context, Integration behaves in line with the desired system behavior. Based on the low initial values for operating capability and adopters, Integration begins to rise later than Integration for the other positive contexts. After leveling-off, Integration keeps steadily rising due to the continued use inertia–integration reinforcing loop additions. For comparative purposes, each simulation will be compared at the 5, 7.5, and 10-year points and any patterns and conclusions that result will be discussed.

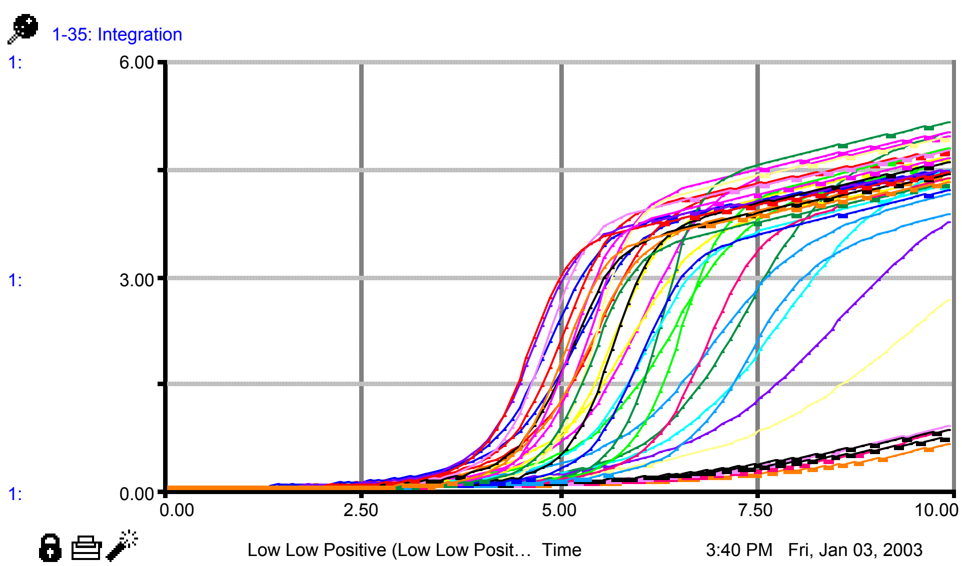


Figure 75: Context 12 (Low Operating Capability, Low Adopters, and Positive Organizational Context) Comparative Graph

Table 34 presents the composite score table sorted by composite score throughout the simulation period in ascending order for context 12. The simulations with a composite score of 30 or lower (meaning, as a whole, these simulations ranked in the top 10 for each point in time) were highlighted. Based on the goals of the organization or manager being good overall performance in all of the periods of time, simulation 18 is recommended as the best overall performer. In this case, the manager should focus a quarter of his available time on change process management, half his time on learning management, and the last quarter on reward system management. For very mediocre short-term performance, but the best mid-term and long-term performance, simulation 19 is recommended. In this case, the manager would devote three-quarters of his available time to learning management and the other quarter to change process management. In any case, the goals of the organization and manager would dictate which of the simulations would offer the best management intervention cocktail to achieve those goals. In this context, it would be more fruitful for the manager to focus on a combination of the three management interventions represented in the better overall performer group, which does not include continuity management.

Table 34: Context 12 Composite Score Table (Sorted by Composite Score Throughout Simulation Period)

Simulation Trace	Change Process Management	Continuity Management	Learning Management	Reward System Management	Rank at 5 Years	Rank at 7.5 Years	Rank at 10 Years	Composite Score Throughout Simulation Period
18	0.25	0	0.5	0.25	12	2	2	16
17	0.25	0	0.25	0.5	5	5	7	17
27	0.5	0	0.25	0.25	3	6	8	17
28	0.5	0	0.5	0	15	3	5	23
3	0	0	0.5	0.5	17	4	4	25
2	0	0	0.25	0.75	10	7	9	26
16	0.25	0	0	0.75	4	10	14	28
33	0.75	0	0.25	0	9	8	11	28
19	0.25	0	0.75	0	27	1	1	29
26	0.5	0	0	0.5	2	12	15	29
32	0.75	0	0	0.25	1	15	18	34
21	0.25	0.25	0.25	0.25	16	9	10	35
1	0	0	0	1	7	13	17	37
22	0.25	0.25	0.5	0	28	11	6	45
29	0.5	0.25	0	0.25	8	17	20	45
30	0.5	0.25	0.25	0	19	14	12	45
20	0.25	0.25	0	0.5	11	16	19	46
35	1	0	0	0	6	18	23	47
4	0	0	0.75	0.25	23	26	3	52
7	0	0.25	0.25	0.5	18	21	13	52
6	0	0.25	0	0.75	14	19	21	54
34	0.75	0.25	0	0	13	20	24	57
23	0.25	0.5	0	0.25	20	22	25	67
8	0	0.25	0.5	0.25	24	28	16	68
31	0.5	0.5	0	0	22	23	26	71
10	0	0.5	0	0.5	21	25	27	73
24	0.25	0.5	0.25	0	29	24	22	75
11	0	0.5	0.25	0.25	25	29	29	83
25	0.25	0.75	0	0	30	27	28	85
13	0	0.75	0	0.25	26	30	30	86
14	0	0.75	0.25	0	31	31	32	94
12	0	0.5	0.5	0	33	32	31	96
15	0	1	0	0	32	33	34	99
9	0	0.25	0.75	0	34	34	33	101
5	0	0	1	0	35	35	35	105

Summary of Contextual Analysis.

Table 35 presents the best management intervention packages, based on a short-term, long-term, and overall performance, for each of the twelve contexts discussed to this point. For contexts 1 through 4 under the poor organizational context simulations, there is not an entry included for the best long-term performance based on the fact that all simulations end at approximately the same low point after ten years (due to the innovation not meeting organizational needs in the long-term). In each case under the poor organizational context, the best overall performer was based on the simulation with the highest peak value. The best short-term performer was selected from the simulations falling in the early peak set (if there was set separation as discussed in each applicable section) and having the highest peak. For the simulations under the baseline and positive organizational contexts, the best short-term performer was selected based on the best performance measured at the short-term point. The best long-term performer in these contexts was selected based on the best performance in the mid and long-term points. The best overall performer was selected from the simulations having the lowest composite score (explained in each applicable section).

Table 35: Best Management Intervention Packages for Each Context Based on Short-Term, Long-Term, and Overall Performance

	** Context Parameters	Change Process Management	Continuity Management	Learning Management	Reward System Management
Context 1	H,H,Poor	--	--	--	--
Short-term	H,H,Poor	0	0	0.75	0.25
Long-term	H,H,Poor	--	--	--	--
Overall	H,H,Poor	0.5	0	0.5	0
Context 2	H,L,Poor	--	--	--	--
Short-term	H,L,Poor	0.75	0	0.25	0
Long-term	H,L,Poor	--	--	--	--
Overall	H,L,Poor	0.25	0	0.75	0
Context 3	L,H,Poor	--	--	--	--
Short-term	L,H,Poor	0.25	0	0.5	0.25
Long-term	L,H,Poor	--	--	--	--
Overall	L,H,Poor	0.5	0	0.5	0
Context 4	L,L,Poor	--	--	--	--
Short-term	L,L,Poor	0.5	0	0.25	0.25
Long-term	L,L,Poor	--	--	--	--
Overall	L,L,Poor	0.5	0	0.5	0
Context 5	H,H,Baseline	--	--	--	--
Short-term	H,H,Baseline	0	0	0.25	0.75
Long-term	H,H,Baseline	0	0	0.75	0.25
Overall	H,H,Baseline	0	0	0.5	0.5
Context 6	H,L,Baseline	--	--	--	--
Short-term	H,L,Baseline	0.5	0	0.25	0.25
Long-term	H,L,Baseline	0.25	0	0.75	0
Overall	H,L,Baseline	0.25	0	0.5	0.25
Context 7	L,H,Baseline	--	--	--	--
Short-term	L,H,Baseline	0.5	0	0	0.5
Long-term	L,H,Baseline	0.25	0	0.75	0
Overall	L,H,Baseline	0	0	0.5	0.5
*** Context 8**	L,L,Baseline	--	--	--	--
Short-term	L,L,Baseline	0.75	0	0	0.25
Long-term	L,L,Baseline	0.25	0	0.75	0
Overall	L,L,Baseline	0.25	0	0.5	0.25
*** Context 9**	H,H,Positive	--	--	--	--
Short-term	H,H,Positive	0.25	0	0.5	0.25
Long-term	H,H,Positive	0	0	0.75	0.25
Overall	H,H,Positive	0.25	0	0.5	0.25
Context 10	H,L,Positive	--	--	--	--
Short-term	H,L,Positive	0.5	0	0.25	0.25
Long-term	H,L,Positive	0.25	0	0.75	0
Overall	H,L,Positive	0.25	0	0.5	0.25
Context 11	L,H,Positive	--	--	--	--
Short-term	L,H,Positive	0	0	0	1
Long-term	L,H,Positive	0.25	0	0.75	0
Overall	L,H,Positive	0	0	0.5	0.5
*** Context 12**	L,L,Positive	--	--	--	--
Short-term	L,L,Positive	0.75	0	0	0.25
Long-term	L,L,Positive	0.25	0	0.75	0
Overall	L,L,Positive	0.25	0	0.5	0.25

* Most realistic contexts that may be encountered in real world organizations
** Initial operating capability (high or low), initial adopters (high or low), organizational context

Comparison of Top Performers within Contexts.

Table 35 contains information for each of the top performers for each of the contexts, but the most realistic contexts (for long-term sustainment) include: context 8 (low initial operating capability, low initial adoption, baseline organizational context), context 9 (high initial operating capability, high initial adoption, positive organizational context), and context 12 (low initial operating capability, low initial adoption, positive organizational context). Within these more realistic contexts, the top short-term performer, top long-term performer, and top overall performer will be compared on the same graphs.

Figure 76 compares the top short-term performer (Trace 1), top long-term performer (Trace 2), and top overall performer (Trace 3) for context 8. There are tradeoffs for each of these. The top short-term performer rises more quickly, but does not have the same long-term impact as the others. The top overall performer seems to have the best combination of short-term and long-term performance of the group.

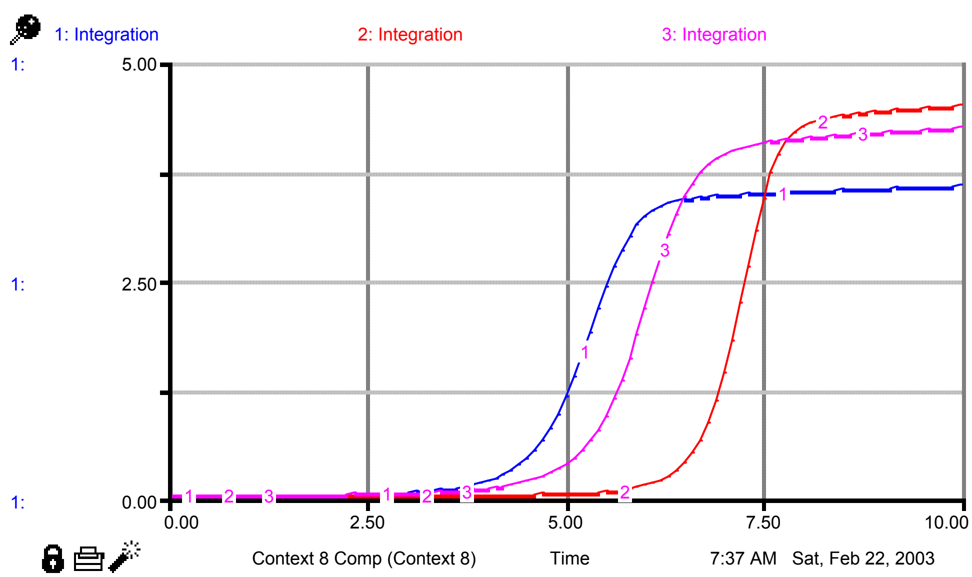


Figure 76: Context 8 Top-Performer Comparison

Figure 77 compares the top short-term performer (which also happens to be the top over all performer) (Trace 1) and top long-term performer (Trace 2) for context 9. These traces do not vary significantly from one another – the manager is bound to be successful since the high initial values for operating capability and adoption drive the system for good early performance, regardless of the better short-term or long-term performance management cocktail combinations. This is a highly desirable context to work in and may be present in a highly innovative organization with a good GIS history.

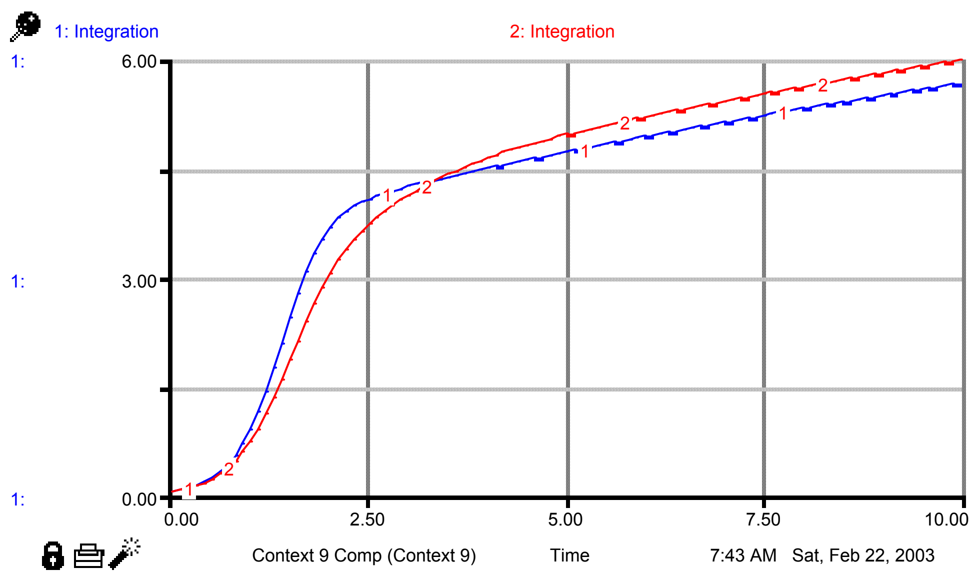


Figure 77: Context 9 Top-Performer Comparison

Figure 78 compares the top short-term performer (Trace 1), top long-term performer (Trace 2), and top overall performer (Trace 3) for context 12. There are tradeoffs for each of these. The top short-term performer rises more quickly, but does not have the same long-term impact as the others. The top overall performer seems to have the best combination of short-term and long-term performance of the group, especially since there is an appreciable difference in short-term performance when compared to the top long-term performer, but no major long-term difference between the two.

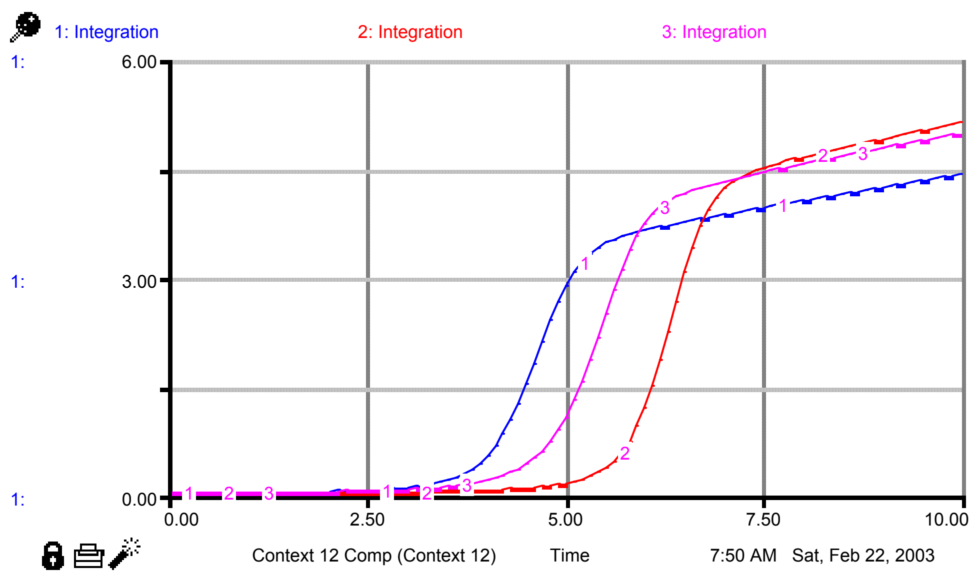


Figure 78: Context 12 Top-Performer Comparison

Comparison of Top Performers Across Contexts.

To this point, only comparisons between top performers have been completed within each discrete context. In this section, the top performers (short-term, long-term, and overall) will be compared across the three organizational contexts (poor, baseline, and positive) for 1) low initial operating capability and low initial adoption (low/low) and 2) high initial operating capability and high initial adoption (high/high). All of the top short-term performers will be compared across the three organizational contexts (poor, baseline, and positive) under low/low initial conditions and high/high initial conditions. The same will hold for the top long-term performers and top overall performers for the low/low and high/high initial conditions. The low/low and high/high initial conditions are the most realistic, so comparisons under low/high and high/low will not be included here. Hence, there will be six comparative graphs in this section.

Figure 79 compares all of the top short-term performers under low/low initial conditions for each of the organizational contexts. Trace 1 shows the top short-term performer under the poor organizational context (context 4 top short-term performer). Trace 2 shows the top short-term performer under the baseline organizational context (context 8 top short-term performer). Trace 3 shows the top short-term performer under the positive organizational context (context 12 top short-term performer). As expected, the timelines for integration decrease and the long-term integration levels increase as the organizational context improves. Trace 1 (poor organizational context) has the expected rise and fall behavior pattern since the IT innovation is not meeting the needs of the organization.

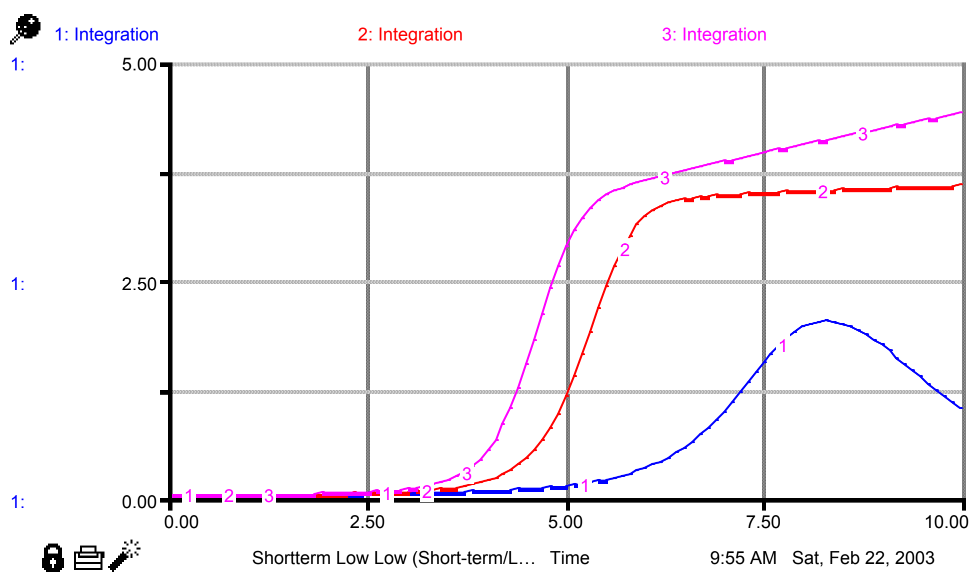


Figure 79: Top Short-Term Performer Comparison Across Contexts Under Low/Low Initial Conditions

Figure 80 compares all of the top long-term performers under low/low initial conditions for each of the organizational contexts. Trace 1 shows the top long-term performer under the baseline organizational context (context 8 top long-term performer). Trace 2 shows the top long-term performer under the positive organizational context (context 12 top long-term performer). Since there is not a top long-term performer under the poor organizational context (the fall-off will result in long-term failure), an associated trace is not included. As expected, the timelines for integration decrease and the long-term integration levels increase as the organizational context improves.

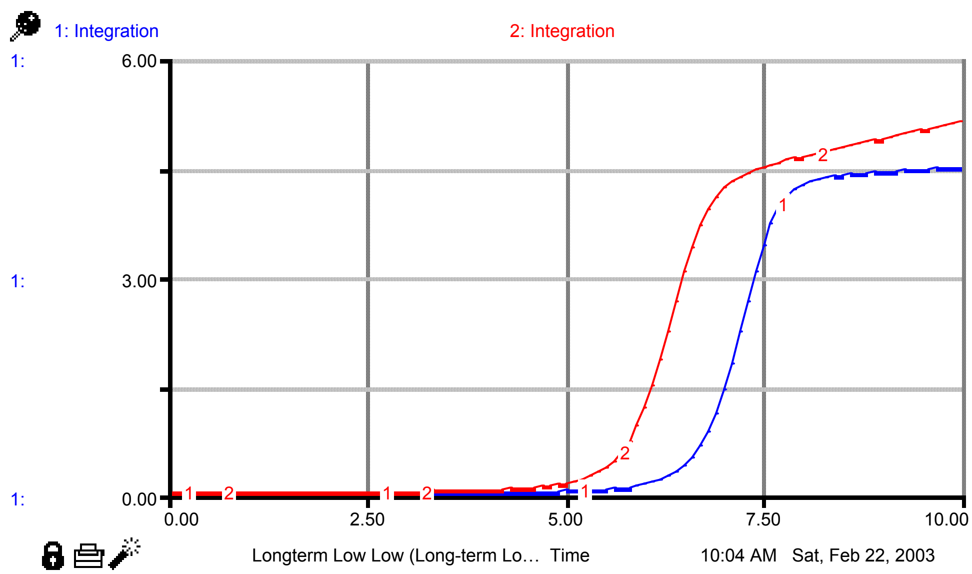


Figure 80: Top Long-Term Performer Comparison Across Contexts Under Low/Low Initial Conditions

Figure 81 compares all of the top overall performers under low/low initial conditions for each of the organizational contexts. Trace 1 shows the top overall performer under the poor organizational context (context 4 top overall performer). Trace 2 shows the top overall performer under the baseline organizational context (context 8 top overall performer). Trace 3 shows the top overall performer under the positive organizational context (context 12 top overall performer). As expected, the timelines for integration decrease and the long-term integration levels increase as the organizational context improves. Trace 1 (poor organizational context) has the expected rise and fall behavior pattern since the IT innovation is not meeting the needs of the organization.

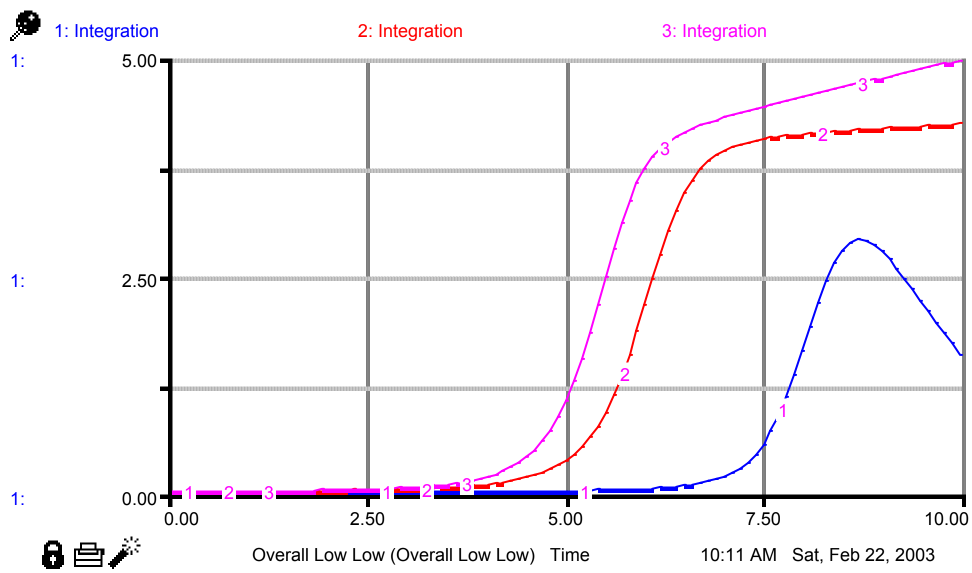


Figure 81: Top Overall Performer Comparison Across Contexts Under Low/Low Initial Conditions

Figure 82 compares all of the top short-term performers under high/high initial conditions for each of the organizational contexts. Trace 1 shows the top short-term performer under the poor organizational context (context 1 top short-term performer). Trace 2 shows the top short-term performer under the baseline organizational context (context 5 top short-term performer). Trace 3 shows the top short-term performer under the positive organizational context (context 9 top short-term performer). For the most part, the timelines for integration decrease and the long-term integration levels increase as the organizational context improves. Trace 2 slightly outperforms Trace 3 for the first portion of the simulation period – this is due to the different percentages for the management interventions. The top short-term performer for context 5 (baseline/high/high) was measured at the 1.5-year point, whereas the top short-term performer for context 9 (positive/high/high) was measured at the 2-year point. At the 2-year point in Figure 82, Trace 3 outperforms Trace 2, which makes sense.

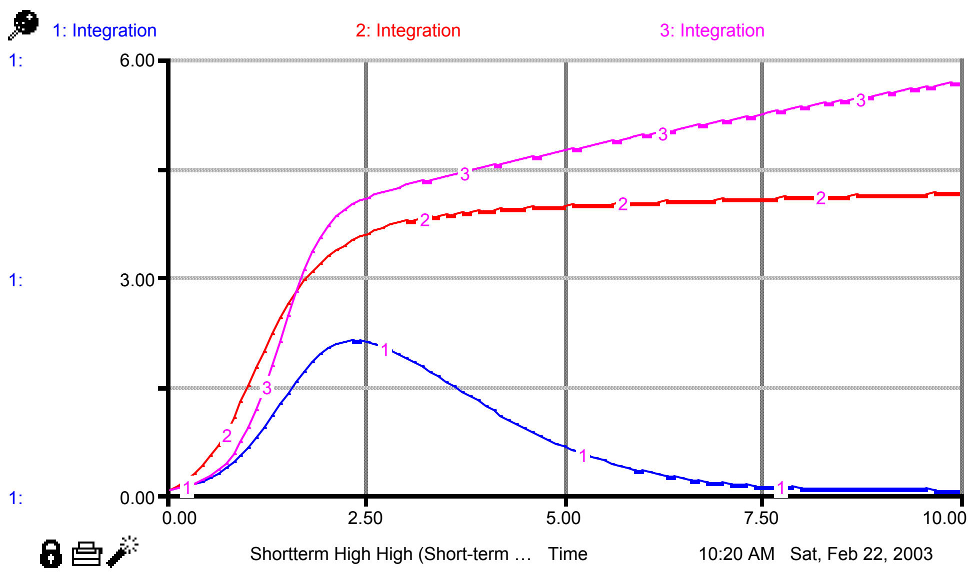


Figure 82: Top Short-Term Performer Comparison Across Contexts Under High/High Initial Conditions

Figure 83 compares all of the top long-term performers under high/high initial conditions for each of the organizational contexts. Trace 1 shows the top long-term performer under the baseline organizational context (context 5 top long-term performer). Trace 2 shows the top long-term performer under the positive organizational context (context 9 top long-term performer). Since there is not a top long-term performer under the poor organizational context (the fall-off will result in long-term failure), an associated trace is not included. As expected, the timelines for integration decrease and the long-term integration levels increase as the organizational context improves.

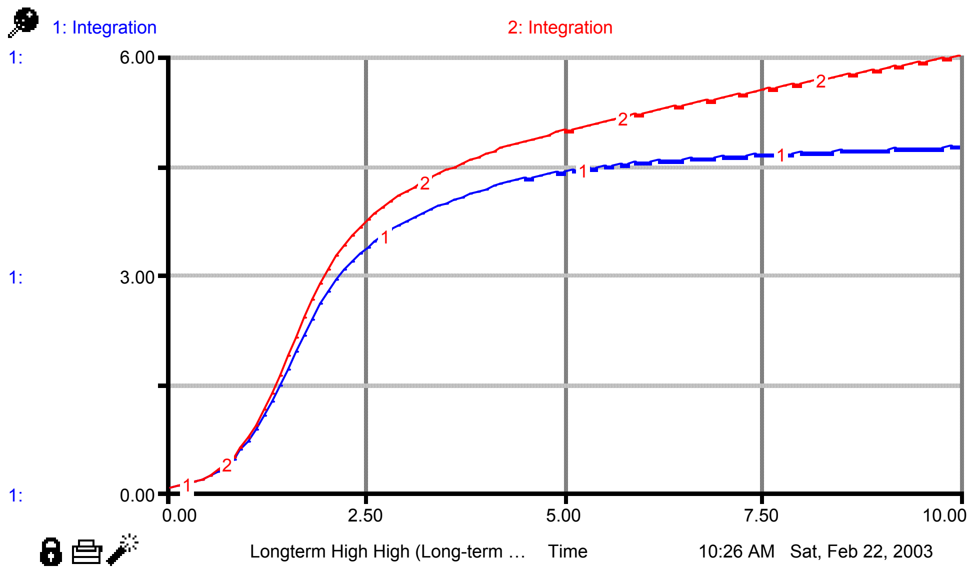


Figure 83: Top Long-Term Performer Comparison Across Contexts Under High/High Initial Conditions

Figure 84 compares all of the top overall performers under high/high initial conditions for each of the organizational contexts. Trace 1 shows the top overall performer under the poor organizational context (context 1 top overall performer). Trace 2 shows the top overall performer under the baseline organizational context (context 5 top overall performer). Trace 3 shows the top overall performer under the positive organizational context (context 9 top overall performer). For the most part, the timelines for integration decrease and the long-term integration levels increase as the organizational context improves. Trace 2 slightly outperforms Trace 3 for the first portion of the simulation period – this is again due to the different percentages for the management interventions. The composite values to determine the top overall performer for context 5 (baseline/high/high) were computed at earlier points in time initially when compared to context 9 (positive/high/high). This earlier measurement biases the baseline values in the short-term (context 5), so it is not unexpected that the short-term baseline performance is slightly better than the positive context (context 9) short-term performance.

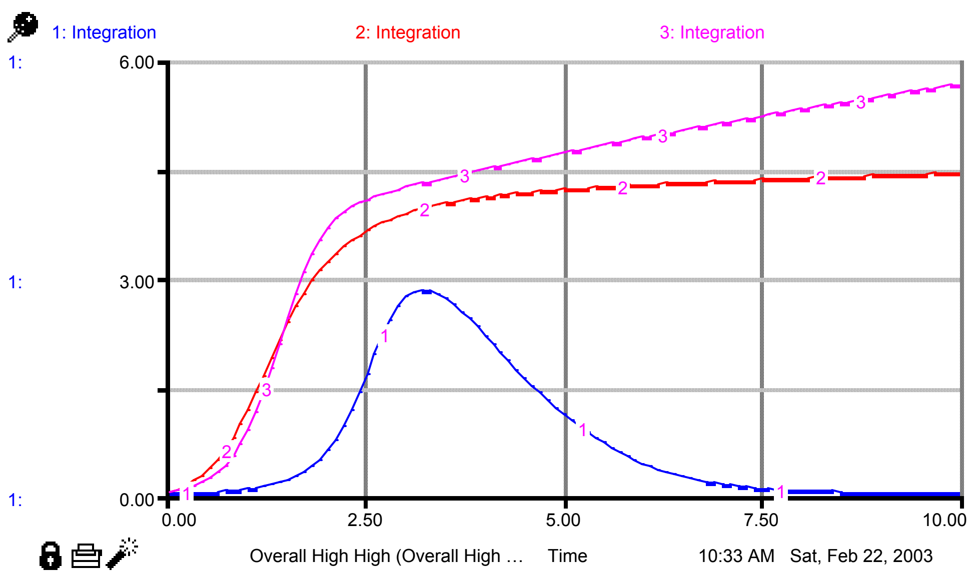


Figure 84: Top Overall Performer Comparison Across Contexts Under High/High Initial Conditions

Overall Analysis.

The main pattern to note is that for the most effective management mix, continuity management should not be exercised. This is not to say it is not of value, but the other management interventions have more "bang for the buck." In each of the overall best performers for each context, learning management is the most common. In the baseline and positive contexts learning management is always present at 0.50, meaning half of the manager's available time should focus on this important intervention.

Change process management and reward system management are also dispersed throughout the best context management intervention packages.

Generally, when there were a high number of adopters initially, the system favored a mix of learning management and reward system management. When the number of adopters was initially low, the system favored a level of change process management to move adopters from the potential adopter pool to the adopter pool. This result makes sense in the real world because change process management is focused on preparing personnel for change and moving them through the change process. When a high number of personnel are already bought-in to the change, the manager can focus on other things to increase system performance more effectively.

Reward system management was very correlated with the speed at which the system accumulated integration. In many of the contexts, there were two sets of simulations: those that rose faster and those that rose slower. Usually the simulation rising to the greatest overall level of integration was in the later-to-rise group however. Reward system management was present in all of the contexts under the best short-term performer to some level. A lack of reward system management focus was usually the factor that separated the early from the late risers. This result makes sense in the real world because personnel will usually get things done faster if there is a reward, but the long-term quality may not be as good (from a lack of focus on other types of management interventions).

Learning management was always present in high proportion in all of the best long-term results for the baseline and positive contexts. However, the best long-term simulation usually had very mediocre short-term performance. This result makes sense in the real world because learning management is the key to long-term success. The short-term results from increased learning are minimal because it takes time for increased learning to have an effect in the system. In the best long-term management scenarios under the baseline and positive contexts, learning management had at least three quarters of the management focus.

In the model analysis, the poor organizational context held the stigma of not only a rigid organization, but also the concept of the IT innovation not meeting the needs of the organization (resulting in the rise and fall behavior pattern). A rigid organization can still implement IT innovations without the rise and fall behavior pattern, but it will take longer when compared to more innovative organizations. The fact that the IT innovation is not meeting the needs of the organization, which is not initially known, only becomes apparent after actually integrating the IT innovation into organizational business processes; hence the need for good initial planning at a strategic level (HAF GIO) to assure the IT innovation will meet the needs of the organization when it actually begins the implementation process. The rise and fall behavior pattern can occur for any of the contexts (baseline and positive included), but is aggregated into the poor organizational context for analysis (and as much brevity as possible).

V. Discussion

Discussion of Results

At this point, the reader may be wondering how the research results can be applied in the field for actual practitioners. To better outline the conclusions from this research, two tables have been included. Table 36 identifies general conditions and contexts, signs that may elucidate which context one is working in, and what management intervention is best applied under the applicable conditions. Table 37 disaggregates each of the management interventions to a certain degree to show some ways managers can actually intervene according to the best long-term strategy. Chapter 2 includes a more exhaustive discussion on each of the management interventions.

Table 36 refers to opinion leaders as a distinguishing factor among various contexts. It is usually relatively easy to identify the type of organization one is working in based on the characteristics of opinion leaders (also known as graybeards). Opinion leadership is defined as "the degree to which an individual is able to influence other individuals' attitudes or overt behavior informally in a desired way with relative frequency" (Rogers, 1995:27). Opinion leadership is earned and maintained by an individual's technical competence, social accessibility, and conformity to the system's norms; not by their ranked authority (though they typically have somewhat higher social status than their peers). Innovative organizations tend to foster opinion leaders that display innovative qualities (accepting of change, willing to try new approaches, wanting to make a large impact, etc.). On the other hand, rigid organizations tend to foster opinion leaders that display rigid tendencies (opposing change, cynical, etc.).

As shown in Table 36, under every context, when there are a low number of initial adopters, the manager should focus on change process management until a fairly sizeable number of adopters build up. If there are already a relatively high number of initial adopters, then the manager should use the management intervention associated with their particular context. After the initial build-up, in the baseline and positive contexts, the manager should gradually transition his or her efforts to a learning management intervention. Under poor conditions, it is usually better to continue the adoption-integration process using change process management techniques. Under every context, there is also the possibility of using reward system management to create an initial spark of interest. For long-term performance, however, the manager should transition away from placing his effort in reward system management after the initial spark period has passed (probably when personnel stop referring to the IT innovation as an initiative).

It is important to understand that during the course of the implementation process, the manager should continue investing time in the technology portion of the system. The historical implementation problem has not been restricted to technology issues alone – it has been an <u>overemphasis</u> on the technology issues over time that has caused the problems. A fair way to approach the technology portion is to get the system to an initial operating capability (focusing full time and effort on this technology function at the start) and then transitioning effort to the adoption-integration management interventions as the technology management needs diminish over time. Operating capability, adoption, and integration are all simultaneous processes, so the manager has to balance his or her effort throughout the implementation period to achieve the desired sustainment objectives.

Kotter's and Armenakis' change process management recommendations and Cunningham's ideas on learning management seemed to be the most applicable and beneficial for the Air Force practitioner. Starting a GeoBase version of the Air Force Idea Program (reward system management) was also impressive -- individuals could win cash awards for ideas leading to time/money savings as a result of GeoBase. The best place to focus effort in a GeoBase Idea Program would be how best to integrate GeoBase into the business processes of the organization (leading to time and money savings). There are many business processes that occur simultaneously in any organization – a common organizational problem is personnel not viewing organizational business as process related. Each organization is designed to take some kind of input and create an output of value to a customer – without an output of value to a customer, the organization probably would not exist at all. Learning to view this input-output stream as a process is one of the keys to understanding how to integrate GeoBase effectively. A good process view mixed with the need for major performance improvements usually leads organizations to business process reengineering (not a trivial undertaking in itself), which, for those who learn and make substantive attempts in this area, can achieve great ends.

The reader should reference the Chapter 2 discussion concerning Cunningham's learning set idea for a good understanding of this innovative learning construct. The learning set approach seems to fit in best with IT implementation efforts and the Air Force way of operating. The Air Force is primed for major changes in how its personnel learn and accomplish professional military education, so a general approach using learning sets would bring many benefits to the GeoBase system as well as the Air Force as a whole. Team learning allows personnel from different organizational units to communicate more effectively and spread the GeoBase initiative message. In this context, organizational resistance to both continued learning and GeoBase induced organizational change are reduced. In this learning environment, personnel can also collaborate for ways to integrate GeoBase into their business processes.

From this research, generally, managers must take a cosmopolitan managerial intervention approach, which is to say, managers need to use a variety of management interventions to be the most effective. In this research model, focusing on change process management, learning management, and reward system management tended to have the most positive effects. There are major differences in how much time to spend on each under different conditions, but the manager who works diligently on these should find very positive organizational performance effects from the IT innovation. The manager attempting to start these programs in his organization will probably run into obstacles and resistance if this is the first time something like this has been done in his organization. It is important for the manager to first attempt to gain buy-in from the opinion leaders in the organization and, if this is successful, the manager will be in a much better position to get things done. The manager must also consider what he is most effective at doing. If he were a people-person, he would probably enjoy the change process management and learning management interventions. If he is less inclined towards these types of interventions, he can also work on continuity or reward system management. This research assumes the manager is equally proficient at all interventions, but this is probably not a great assumption for the practitioner.

Table 36: Organizational Description, Helpful Identification Signs, and Relevant Management Interventions

Organizational Description	Signs	Long-Term Management Intervention	For Short-term Spark
Initially Low Level of Adoption	-- Probably Poor or Baseline Organizational Context -- Low Initial Interest -- General Cynicism About GeoBase -- Personnel Delaying Implementation	Change Process Management	Reward System Management
Poor (Rigid) Organizational Context	-- Opinion Leaders are Cynical -- Opinion Leaders Resistant to New Ideas -- Organization Rejects Sell-out Opinion Leaders -- Complaining About Change -- Delaying Implementation -- Not a Large Number of Organizational Awards -- Low Turnover (same people have been around for awhile) -- Stagnant IT History -- Poor Inter-departmental Communication -- Unfavorable Perceptions of IT	Change Process Management	
Baseline Organizational Context	-- Opinion Leaders Will Adopt Good Ideas if Sold Well -- A Few Organizational Awards -- Some IT Success, Some Failure -- Limited Initial Resistance -- Decent Perceptions of IT	Learning Management	
Positive (Innovative) Organizational Context	-- Opinion Leaders are Innovative -- Opinion Leaders Want to Make an Impact -- Many Organizational Awards -- Other IT Integrated into Business Processes -- Good Inter-departmental Communication -- Organization is Ready to Begin Implementation -- Favorable Perceptions of IT	Learning Management	

Table 37: Disaggregated Management Interventions

Management Intervention	Management Actions
Reward System Management (Tailor to Individuals)	-- Highly Individualistic (based on individual motivation) -- Time-off Awards -- Monetary Awards (AF Idea Program) -- Public Recognition -- Great Performance Evaluation -- Managerial Attention -- Emphasize Enhanced Job Security -- Emphasize Future Career Opportunities

Change Process Management (Don't Skip Steps)	-- Analyzing and Planning Change
	  -- Implementation Plan Based on Strategy
	-- Communicating the Change
	  -- Building Self-Efficacy
	  -- Explaining Change Plan and Why Change is Necessary
	-- Changing from Status Quo to Desired State
	  -- Remove Obstacles
	  -- Successful Pilot Project
	-- Institutionalizing New Approaches
	  -- Integrate IT into Business Processes
	  -- Foster Further Innovation

Learning Management (Education, Opposed to Training, is Focus)	-- Team Learning
	  -- Teams Composed of Adopters
	  -- Learning Sets and Learning Contracts (Cunningham)
	  -- Circular Structures (making mental models explicit) (Kim)
	-- Structured Training Experiences
	-- Vicarious Learning Programs
	-- Personnel Rotation Programs

The most important point to make, as far as management intervention strategy is concerned, is that the manager must be actively engaged in the adoption-integration process for anything substantive to happen. Without carefully thought-out and constructed management intervention, the IT implementation system is bound to repeat the terrible historical performance of GIS systems in the Air Force. If the system manager uses this research as one of many tools to guide his system management plan, then this research has made a positive contribution to the GeoBase implementation effort.

Managerial Issues

It is interesting to note that most of the integration curves, even under highly positive initial conditions, did not really take off until a few years had passed at the beginning of the simulation run. The problem with this realistic initial lag for managers is that they usually have a limited amount of time to make an impact in an organization (typically three years at the most for military personnel), so they may not see the fruits of their labors. Poor early performance makes it difficult for the manager to weather the early storms in hopes for a bright future. It is all the more relevant to stress the importance of not jumping to conclusions about system performance too early in the process. If the early performance is low, the manager may still have effective policies in place for great long-term performance. If the early performance is high, this may not mean that the best management policy is in place for sustained performance in the long-term. It takes more courage and is more difficult to manage a system for better long-term performance, especially in the face of dubious short-term performance.

Managerial performance evaluations are usually linked to system performance, which, in this research, could be measured by the level of integration in the system. However, the truly short-term performance measure would typically be the level of operating capability. Most managers intuitively understand this concept, so it is easier to manage, quantify, and discuss on a performance evaluation. An underlying cause for the historical technology overemphasis problems could be partially attributable to the performance appraisal system currently in place.

Monetary figures and technology performance are more easily discussed and quantified in a performance evaluation than are people issues (adoption and integration). For this reason, the current performance appraisal system works against long-term sustainment because it does not reward the manager according to a successful long-term strategy.

One way to combat this problem is to keep a manager in place for a longer period of time and change the appraisal system to support the long-term sustainment strategy. Unfortunately, the government is not about to change the appraisal and transfer system, so a solution to this problem may come from outside the government – contractor personnel with longer time horizons (to allow the dynamics of the system to play out) and an adjusted performance appraisal system that rewards based on strategic policy implementation, as opposed to an unbalanced focus on the short-term technology issues.

Top-level Leader Issues

If a manager desires long-term performance, he may have to convince his boss that his approach, while maybe not achieving the best short-term results, will bring better long-term performance. Top-level leaders have to understand the nature of IT implementation systems to have the required patience to allow successful integration to occur. Based on the reference mode and simulation output for this model, IT integration will not initially respond for a number of years. Hence, in line with this and other research in change management, top leaders must reserve judgment on system performance until enough time has passed to allow the system to mature to the point where it can perform well. System managers and top-level leaders should also understand that in a forced adoption context, potential adopters (even innovative potential adopters) often become cynical about the innovation and resist further implementation. This research outlines the importance of managers gaining buy-in from potential adopters, making them adopters, and reaping the fruit of that action in the form of better integration performance. One hundred heads working to integrate the IT innovation is better than one or two. By the same token, one hundred heads with a personal stake in the outcome of the IT innovation also makes for a powerfully positive integration strategy since personnel will actively support the system.

Top-level leaders also have to make the decision on what level of patience they are willing to endure while the implementation dynamics play out. From these research results, poor contextual organizations take a longer period of time for substantial integration to occur, whereas the baseline and positive contexts provide a shorter timeline for integration. The concept of a performance pay-back period should be ascertained at the beginning of the investment period – will the IT innovation bring the desired performance within the longest time horizon the leader is willing to wait? If not, either the complexity of the IT innovation should be decreased (stripped-down version of the planned IT product) to spur faster integration or the leader should not invest in the IT innovation in the first place. The main determiner of long-term sustainment, regardless of the context in which the IT implementation is occurring, is whether or not the IT innovation is meeting the needs of the organization. If the up-front planning for the architecture, technology, functionality, etc. (outside the control of the organizational IT manager) is not performed properly, resulting in an obsolete product that does not meet organizational needs, the long-term prospects for sustainment are not good.

Value of Client Interaction

The system dynamics approach allows the modeler to work with a client in the modeling process. Based on feedback from the modeler-client meetings, the clients valued the discussion that resulted from the system dynamics approach because it forced both the modeler and clients to think differently about the system. Viewing the system from a system dynamics perspective allowed those involved in the process to envision the feedback loops and other aggregated portions of the system in new ways. In the aggregate, the system is not overly complex, so managers can see how their interventions affect system function. Simulation may also uncover other behavior that was not expected at the forefront of the modeling process.

Research Limitations

Certain issues were screened from this model to allow a parsimonious answer to the research problem to develop, with as little befuddled complexity as possible. There are a multitude of influences that exist in any organizational system, so the focus must be constrained to those variables of greatest importance and aggregate or screen other points of complexity. Hence, there are some limitations that are inherently part of this research effort. The following list outlines a few of these:

- This model does not address some issues associated with manager personality (such as level of charisma, predisposition towards job or people-centered management techniques, level of education, experience and knowledge with GIS innovations, etc.)
- This model does not address some issues associated with personnel (collective knowledge level of GIS, remote sensing, and imagery, impacts of job security, such as A-76 studies, aggregate age of personnel, etc.)

- This model is not quantitatively precise (typical of system dynamics models), but focuses more on behavior patterns and causal relationships that generate performance differences over time

This model's system boundary is constrained to those organizational elements that the system manager can more easily control using management interventions focused on operating capability and adoption-integration. Hence, the contextual variables, such as top-level support, organizational culture, and database quality (all focused on whether the IT innovation is meeting organizational needs or not), are unchangeable by the system manager. Expanding the system boundary would allow these contextual variables to also fall under the system manager's control, but this system boundary expansion is unrealistic because changing the operating context would usually require intervention from a manager at a higher level in the organization.

Thoughts on Follow-on Research

There are many areas for follow-on research associated with this modeling effort. Using the system dynamics approach for a management-related problem is a first for a student at AFIT, so there should be ample problems in this field amenable to student research using a system dynamics approach. Using the system dynamics approach is very applicable in many different situations, but the researcher must assure the research problem is a good system dynamics problem. This research is very general and could guide other system dynamics approach research focused on IT implementation or organizational change initiatives.

For more research on GeoBase specifically, follow-on research could either shrink or expand the system boundary used here to allow the researcher to focus on different questions. With a different system boundary, different elements of the system could be studied either more specifically or more generally. Expansion of the system boundary may encompass more than one squadron or organization and focus more on the wing or larger organizational level. Shrinking the system boundary may allow the researcher to explore questions on how the management interventions are done more specifically or to disaggregate many of the aggregated concepts in this model.

The model used for this research is also robust enough to allow a variety of different contextual levels to change over time or to use a time-phased implementation approach, where the manager can allocate different percentages of time to various management interventions at various points in time. An organizational system dynamics learning intervention could help personnel better understand the dynamics of their organization and how they can affect it. Outlining an analysis methodology where system dynamics is used as a learning tool would be interesting.

The opportunity also exists for research on an organizational business process reengineering (BPR) study, using GeoBase as a technology enabler. BPR has an associated analysis methodology that could be used to help organizations better direct their efforts in the technology integration process.

Value of Dynamic Approach to Understanding an IT Implementation System

This research has presented a fresh, new, dynamic way to view and understand IT implementation and sustainment without compromising the proven principles found in the research literature. IT implementation and sustainment are dynamic concepts that have not been adequately addressed in the research literature, so this research makes a significant contribution to this growing and expanding field. A dynamic view of this process is very important and helps managers understand what to expect and how to manage a system for either short-term or long-term good. The conclusions presented in this research were only made possible by the use of a dynamic methodology grounded in principles from the literature and historical behavior.

Appendix A: History of GIS

Geographic Information Systems (GIS) are the technological impetus for GeoBase since they provide the necessary software for working with and displaying spatial data. Without GIS technical capabilities, GeoBase would not be a viable program. To understand how the development of GIS has unfolded over time and how this history affects its and GeoBase's future potential, this section of the appendix will elucidate the historical roots of GIS and how its growth is being managed.

Clarke provides a relatively brief history of cartography and discusses the main events leading to the current state of GIS. Cartography dates back centuries with an initial focus on general-purpose maps. General-purpose maps tended to focus on topography, the lay of the land, and transportation features such as roads and rivers. Within the last century, thematic maps have come into use. Thematic maps contain information about specific subjects or themes, such as surface geology, land use, soils, etc. Although both of these maps are compatible with a GIS, thematic maps led cartography toward GIS (Clarke, 2001).

The field of planning was the first to extract data from one map and place it on another. As an example, in 1912 the German city of Dusseldorf was mapped at differing time periods to show the progressive expansion of the geographic extent of the city (time-series maps). Other maps focusing on traffic circulation and land use were also developed in the United States and England in the 1920s (Clarke, 2001).

In the 1950s and 1960s map overlay techniques were created to assist planners in land analysis and siting considerations. In 1950, the publication of the *Town and Country*

Planning Textbook included a chapter entitled "Surveys for Planning" where various themes, such as land elevation, surface geology, hydrology/soil drainage, etc., were combined onto one map. Later in 1969, Ian McHarg published a book entitled *Design with Nature* where he discussed the use of blacked-out transparencies overlaid on one another to assist in finding suitable locations in New York's Staten Island where siting control problems could be avoided. These mapping techniques were beneficial, but very time intensive for the production of maps (Clarke, 2001).

As early as 1959, models were being created to apply the use of computers to cartography. Throughout the 1960s programmers were using languages such as FORTRAN to draw maps and print them out. As modular computer programming languages improved during the 1960s, the process of writing integrated software became easier. Researchers developed a few early mapping packages, such as SURFACE II, IMGRID, and CAM, in the 1960s that were based on modular languages (Clarke, 2001).

At about this same time, the first systematic map databases began to appear. The first of these was the Central Intelligence Agency's World Data Bank showing coastlines, rivers, and national boundaries. CAM software was used to project this information onto maps at different scales (Clarke, 2001).

The breakthrough for today's GIS was the U.S. Census Bureau's dual independent map encoding (DIME) project. The DIME and its associated files, called geographic base files (GBF), not only were able to display map information, but also combine map attribute information with computer maps and perform searches for geographic patterns and distributions (Clarke, 2001).

Researchers at Harvard University created the arc/node (vector) data structure in 1975, which drove the later development of the GIS packages we have today. The premise for this structure was that all geographic shapes (points, lines, and polygons) could be described using only points and lines. Polygons could be specified using a start node (which was also the end node) and the shape was determined by the interconnected arcs and nodes (lines and points) that eventually ran back to the origin of the polygon (Clarke, 2001).

GIS package development continued through the 1970s and early 1980s based on mainframe computers and FORTRAN. As computers branched-out from mainframes to PCs and workstation platforms (UNIX), some of the GIS packages using the arc/node system (Arc/Info) were also able to make the same transition to the much more widely dispersed desktop computers. Other software packages such as IDRISI and GRASS started after this transition. GIS packages that did not make the transition eventually died-out (Clarke, 2001).

As computers became more powerful through the 1980s and early 1990s, GIS was able to take advantage of the capabilities of the more powerful systems. The first generation of GIS graphical user interface (GUI) software made GIS much easier to use, based on the addition of menus, on-line manuals, and context-sensitive help. The creation of the Internet and GIS infrastructure (journals, conferences, etc.) also allowed GIS to rapidly expand (Clarke, 2001).

The 1990s saw remarkable growth in the GIS field as new computer products and other technologies, such as the more precise Geographic Positioning System (GPS) and high resolution satellite maps, emerged. GIS has expanded into new fields such as geology, archeology, epidemiology, and criminal justice. Currently, it is a multibillion-dollar business with large continuing growth prospects (Clarke, 2001).

There are four main reasons for the success of GIS. First, the industry was founded on vast amounts of inexpensive government data from the U.S. Geological Survey and the U.S. Census Bureau. Second, the GIS community created the infrastructure for self-support, user groups, network conference groups, etc. Third, the addition of GUIs and software features, such as help screens and automatic installation routines, have allowed the worldwide dispersion of software to users in an array of fields. Fourth, GIS has integrated itself successfully with emergent technologies, such as GPS and satellite remote sensing. The overall growth of the GIS field could not have emerged without the advent of desktop computers and their amazing increases in power and capability (Clarke, 2001; Cullis, 2000).

GIS is a multibillion-dollar industry. Groups monitoring the industry estimate the total value of the hardware, software, and services conducted by the private, governmental, educational, and other sectors that handle spatial data to be billions of dollars a year. For the last half of the 1990s, the GIS industry saw double-digit annual growth. The transition from mainframe computers to desktop computers drove the price of computers down so more people had easier access to GIS applications. Now, most major academic institutions teach at least one class in GIS. Most local, state, and federal agencies use GIS, as well as businesses, planners, architects, geologists, etc. The exponential growth in the number of users, as well as the growth in system sophistication by way of increased computer power, speed, and storage, is the main ingredients for the big business aspect of GIS (Clarke, 2001).

GIS now has a plethora of journals, books, professional societies, and conferences to add to the growth of the field. Some of the journals include the *International Journal of Geographic Information Systems*, *Geographical Systems*, *Transactions on GIS*, *Business Geographics*, and *GIS Law*, among many others. Some related professional societies include the *American Congress of Surveying and Mapping*, the *American Society for Photogrammetry and Remote Sensing*, and the *Association of American Geographers*, among others. Some of the conferences in this field include the URISA annual conference, which has a GIS application focus, the ACSM/ASPRS technical meetings, which have both a research and applications orientation, and the GITA conference, which is mainly for municipalities and industrial GIS users (Clarke, 2001). These organizations and journals drive GIS forward with success stories, standards, technical support, ongoing professional training, data sharing collaborations, interest groups, credentialing committees, and a host of other services, membership offers, and products.

Appendix B: Additional Testing

Extreme Conditions, Sensitivity Analysis, and Behavior Anomaly Tests

The purpose of the extreme conditions test, as stated by Sterman (2000), is as follows:

> **Does each equation make sense, even when its inputs take on extreme values?**
>
> **Does the model respond plausibly when subjected to extreme policies, shocks, and parameters?**

The purpose of sensitivity analysis testing, as stated by Sterman (2000), is as follows:

> ***Numerical sensitivity*: Do the numerical values change significantly?**
>
> ***Behavioral sensitivity*: Do the modes of behavior generated by the model change significantly?**
>
> ***Policy Sensitivity*: Do the policy implications change significantly?**
>
> **…when assumptions about parameters, boundary, and aggregation are varied over the plausible range of uncertainty?**

The purpose of the behavior anomaly testing, as stated by Sterman (2000), is as follows:

> **Do anomalous behaviors result when assumptions of the model are changed or deleted?**

These tests are all interrelated, so the model will be tested concurrently with these questions in mind. The main goal for these tests is to determine if the model responds as expected under abnormal conditions and if the model responds (or does not respond) when variables are changed from their baseline values. Tests for effects from extreme policies will be performed in the next section.

During these tests, the integration variable will be the sole focus, since this is the focus of the research. Comparative traces of baseline, minimum, and maximum values on each associated graph will be performed.

STELLA software allows the modeler to simulate the same variable multiple times under differing conditions for each simulation run to allow comparison. Testing will consist of multiple simulation runs (and, as a result, multiple traces) of the same variable, Integration, graphed under different model conditions. Hence, each of the variable names across the top of each figure will be Integration, but each simulation run and trace will represent different behavior based on the extreme points for the variable being studied. In these cases, the variable scale will be the same throughout each figure (since Integration is the lone output).

Operating Capability.

Funding.

Funding: Scale (0 to 1)

Baseline condition (funding at a reasonable level): Funding = 0.2

MIN: No funding for program: Funding = 0

MAX: Unobstructed funding for program: Funding = 1

Figure 85 shows the baseline and extreme conditions for the funding variable to show the range of values that integration will take as it varies over its range. Trace 1 is the baseline condition (funding = 0.2) with all other variables in their baseline conditions as well. The output for integration (Trace 1) is the same as the integration output in Figure 57 (Trace 4). Trace 2 shows integration stays close to zero when funding is non-existent (funding = 0). Trace 2's largest value is 0.04, essentially meaning there is no integration when there is no funding. Trace 3 shows integration rises relatively quickly, but its long-term level after ten years is not significantly different than the baseline. Trace 3 rises quickly and levels-off at approximately four years (at four years, integration = 3.74). After ten years, trace 3 comes to a value of 3.98. The reason for these behavior patterns is based on how quickly the system builds-up operating capability. In the baseline condition, operating capability gradually rises over ten years, whereas in the maximum funding environment, operating capability rises to its maximum value very quickly. This sharp rise drives the other system components (adoption and integration) much more quickly. Based on the extreme conditions testing for funding, these behavior patterns are realistic and the model does not do anything unexpected in these scenarios. The model is sensitive to the funding variable and there is no associated anomalous behavior.

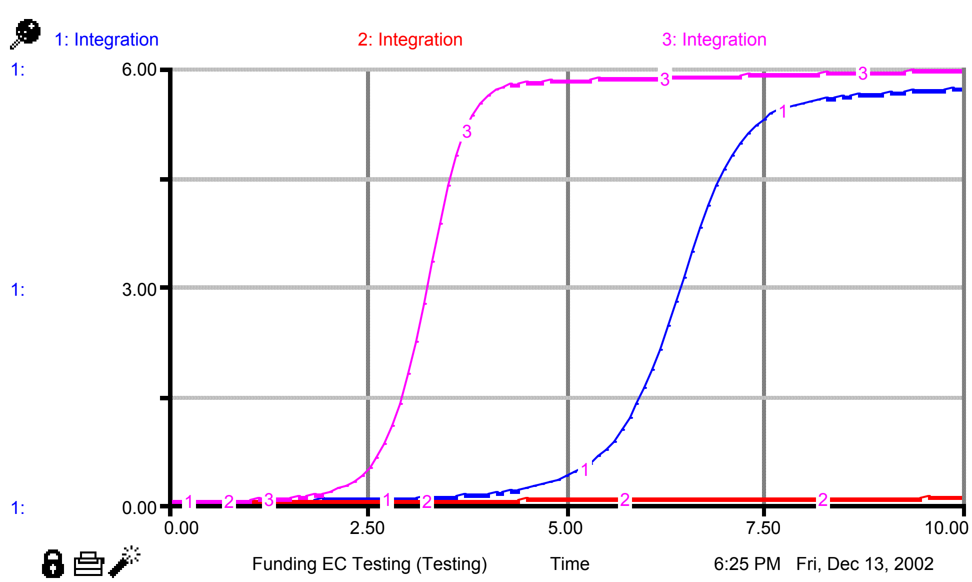


Figure 85: Extreme Conditions Test for the Funding Variable

Operating Capability Goal (OC Goal).

Operating Capability Goal (OC Goal): Scale (0 to 1)

Baseline condition (manager wants top operating capability): OC Goal = 1

MIN: No operating capability goal (representing manager having no interest in having any GeoBase operating capability): OC Goal = 0

MAX: Manager wants GeoBase operating capability at peak capability:
OC Goal = 1

Figure 86 presents the extreme conditions testing for OC Goal. Trace 1 is the baseline. Trace 2 gradually rises to a value of 0.73 after ten years. With a constantly low value of OC, the manager focuses all of his time on the adoption and integration process, which still provides some growth potential for integration. Though there is still growth in integration, as shown in Trace 2, it does not compare to the growth when the manager puts effort into increasing operating capability. It is interesting that during the first five years of the system, Trace 2 slightly outperforms Trace 1. At five years though, the S-shaped growth takes off for Trace 1 while Trace 2 just keeps gradually increasing at a much smaller pace. This is explained by the fact that the manager's effort is completely focused on adoption and integration throughout the simulation period, so slightly greater early gains in integration are expected. The model is sensitive to the OC goal variable and there is no associated anomalous behavior after the adjustment.

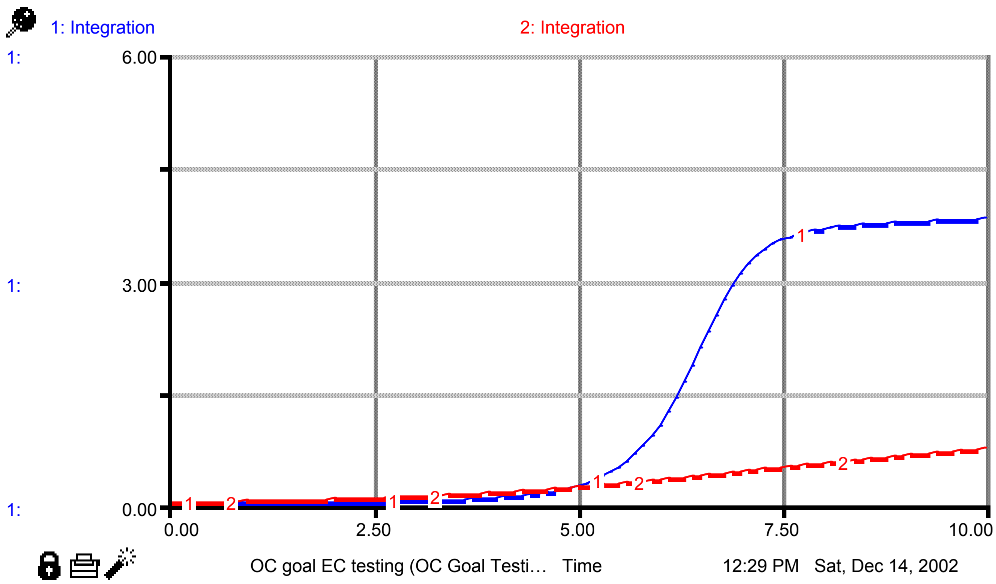


Figure 86: Initial OC Goal Extreme Conditions Test

Operating Capability (OC).

Operating Capability (OC): No Scale – will come to static steady state value based on OC Goal (baseline of OC goal = 1) – constrained by not being able to be less than zero.

Baseline condition (assuming there is small initial level of OC): OC = 0.05

MIN: There is no initial operating capability whatsoever: OC = 0

MAX: Manager has maximum initial operating capability: OC = OC goal = 1

Figure 87 presents the results of the extreme conditions testing for the OC stock. Trace 1 is the baseline trace. Trace 2 is the minimum condition trace (OC = 0 initially). It is very similar to Trace 1, but slightly lags it. They both come to the same value of 3.81 after ten years. Trace 3 is the maximum condition trace for OC. Having OC maximally in place at the beginning allows the manager to focus his complete effort on adoption and integration, which allows very rapid integration to occur with the strong impetus of complete OC to back up his efforts. Trace 3 rises quickly and levels-off at about 3 years (at 3 years, Integration = 3.86). After ten years, Trace 3 Integration equals 4.01. The model is sensitive to the OC variable and there is no associated anomalous behavior.

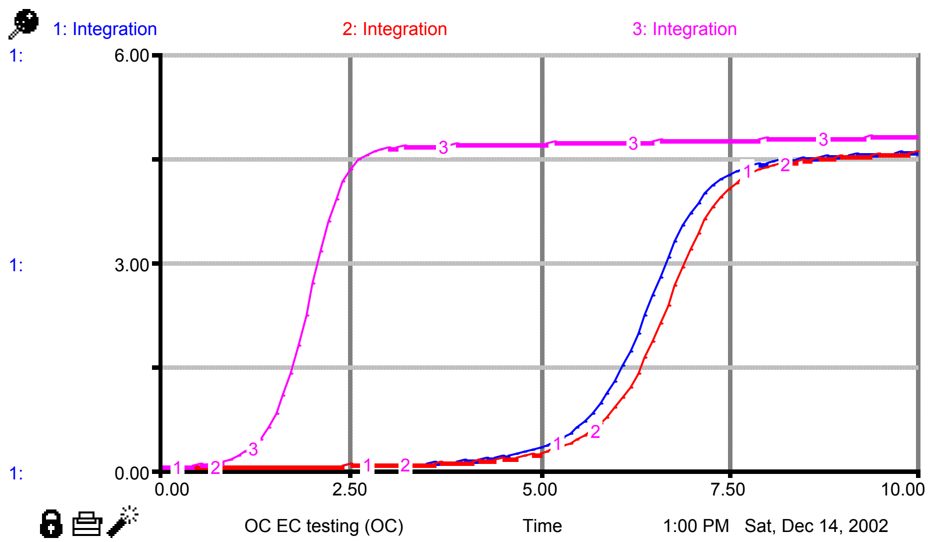


Figure 87: OC Extreme Conditions Test

Adoption.

Potential Adopters.

Potential Adopters: Scale (0 to 1)

Baseline condition (hypothetically, this means in an organization of 100 potential adopters, there are all but 2 individuals that have the potential to adopt GeoBase): Potential Adopters = 0.98

MIN: No potential adopters scenario #1 (meaning all potential adopters are already adopters, so adopters = 1): Potential Adopters = 0 and Adopters = 1

No potential adopters scenario #2 (meaning there is no pool of potential adopters to transfer to adopters, so adopters = 0): Potential Adopters = 0 and Adopters = 0

MAX: No initial adopters (there is no one in the organization that has any initial interest in GeoBase): Potential Adopters = 1 and Adopters = 0

Figure 88 presents the results of the potential adopters and adopters extreme conditions testing. Trace 1 is the baseline condition. Trace 2 is the minimum condition for potential adopters, but the maximum condition for adopters (potential adopters = 0, adopters = 1). With all potential adopters in the organization being pushed over to the adopters stock initially, there is a strong impetus for integration to take-off early in the simulation period. Trace 2 does display early-S-shaped behavior gains and levels-off the exponential growth portion at about 2.5 years. After ten years, Trace 2's value is 3.89 (which does not differ much from the baseline condition in the long-term). Trace 3 represents the no potential adopter scenario #2. This is where there are no potential adopters and no adopters (potential adopters = 0, adopters = 0). In this scenario, one would expect integration to be close to zero, which in fact it is throughout the simulation period. Trace 4 is the maximum condition for potential adopters and the minimum condition for adopters (potential adopters = 1, adopters = 0). If there is no one in the organization that has any interest in GeoBase from the beginning, then there will be no one to get the adoption and integration processes started. In this scenario, one would expect that integration would stay close to zero, which it does throughout the simulation period. It is extremely important to have at least one person in the organization (probably the GeoBase champion) that can get things started. These extreme conditions tests represent expected behavior under such conditions. The model is sensitive to the potential adopters/adopters variables and there is no associated anomalous behavior.

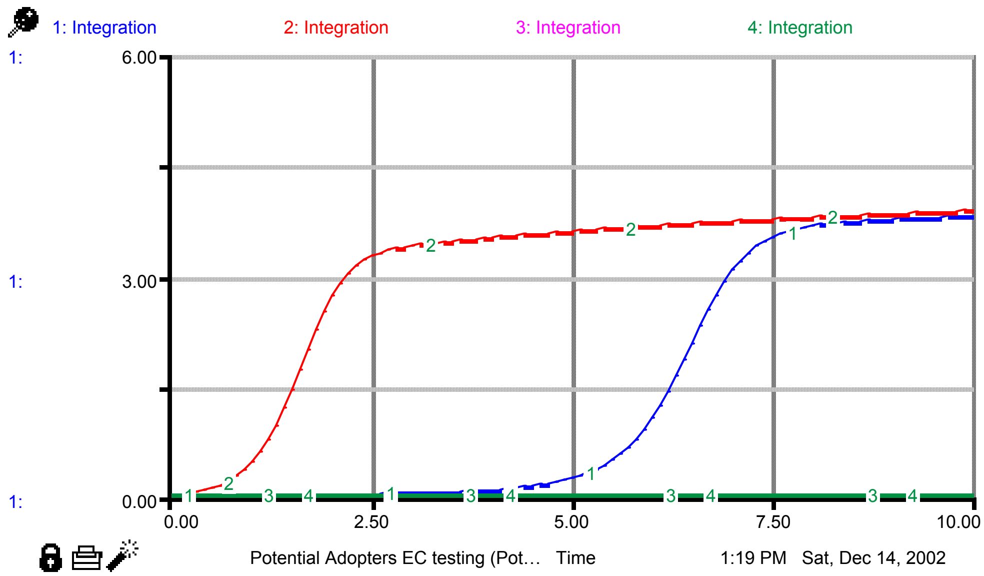


Figure 88: Potential Adopter/Adopter Extreme Conditions Test

Adopters.

Adopters: Scale (0 to 1)

Baseline condition (hypothetically, this means in an organization of 100 potential adopters, there are 2 individuals that have adopted): Adopters = 0.02

Reference Potential Adopters section for extreme conditions.

Baseline Quality of Communication Channels (Baseline QoCC).

Baseline Quality of Communication Channels (Baseline QoCC): Scale (0 to 1)

Baseline condition (individuals in the organization are adequately connected by interpersonal communication channels, but there is much room for improvement): Baseline QoCC = 0.5

MIN: Communication channels are very poor – both interpersonal and inter-organizational communication is non-existent: Baseline QoCC = 0

MAX: Excellent communication channel linkages exist – natural interpersonal and inter-organizational communication is superb: Baseline QoCC = 1

Figure 89 presents the extreme conditions test for the Baseline Quality of Communication Channels (QoCC) variable. Trace 1 shows the baseline condition. Trace 2 shows the minimum condition. Integration takes a long period of time to develop, but eventually rises to a level of 1.31 after ten years. The reason there is some gain in integration is due to the management interventions for change process management and learning management. The baseline for these interventions is 0.25 each, so individuals will still move from the potential adopters stock to the adopters stock, albeit at a much slower rate than if there were some level of communication channel quality. Trace 3 presents the results of the maximum condition for Baseline QoCC. There is a fairly substantial rise in speed of integration, but the long-term results after ten years are the same as the baseline condition (Integration = 3.81). The model behaves as expected when this variable changes over its extreme range. The model is sensitive to the QoCC variable and there is no associated anomalous behavior.

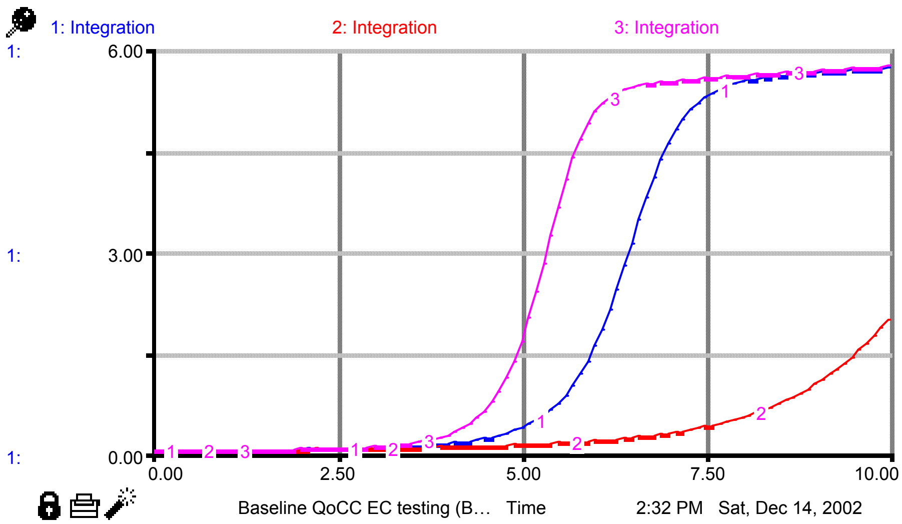


Figure 89: Baseline Quality of Communication Channels (QoCC) Extreme Conditions Test

Relative Advantage.

Relative Advantage: Scale (0 to 10)

Baseline condition (Model assumes GeoBase is highly beneficial for personnel to adopt and implement. Personnel perceive that adopting and using GeoBase will give advantages in job performance and potential rewards based on that performance. Personnel perceive using GeoBase to be a much better way to accomplish relevant portions of their jobs): Relative Advantage = 9

MIN: Poor perceived relative advantage (GeoBase provides no personal impetus for adoption): Relative Advantage = 0

MAX: Outstanding perceived relative advantage (GeoBase maximizes personal impetus for use): Relative Advantage = 10

Figure 90 presents the simulation results for relative advantage at its extreme conditions. Trace 1 shows the baseline condition (relative advantage = 9). Trace 2 shows the minimum condition for relative advantage (relative advantage = 0). It is appreciably smaller than the baseline condition, which is understandable. In this extreme conditions test, the other factors are all set to their baseline values, so the reason anything builds up in integration is a result of the other two adoption factors (ease of use and compatibility) allowing individuals to still move from the potential adopters to the adopters stock, which drives integration (albeit at a much slower pace). Trace 2's value after ten years is 1.37. Trace 3 presents the maximum condition (relative advantage = 10). It is closely related to the baseline condition, but is slightly better in terms of speed of integration. This closeness is expected since 1 unit only separates the maximum and baseline conditions for relative advantage. Trace 3 comes to a value of 3.81 after ten years, just as the baseline condition. These results were expected. The model is sensitive to the relative advantage variable and there is no associated anomalous behavior.

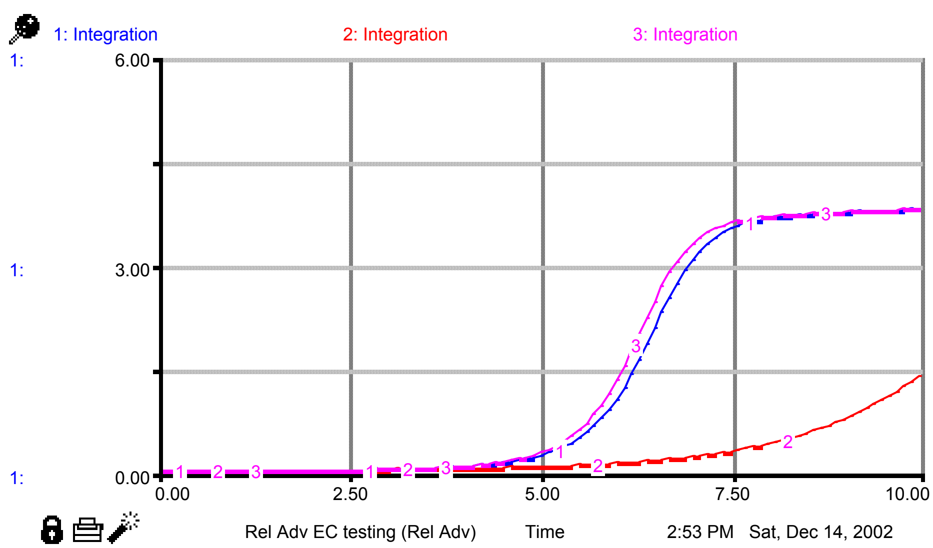


Figure 90: Relative Advantage Extreme Conditions Test

Ease of Use.

Ease of Use: Scale (0 to 10)

Baseline condition (Model assumes GeoBase is fairly difficult to learn and will take some effort to learn effectively): Ease of Use = 3

MIN: Perception of GeoBase as very difficult to use and learn: Ease of Use = 0

MAX: Perception of GeoBase as very easy to use: Ease of Use = 10

Figure 91 presents the simulation results for ease of use extreme conditions. Trace 1 is the baseline condition (ease of use = 3). Trace 2 is the minimum condition (ease of use = 0). Trace 2 lags the baseline as expected, but is not significantly different. Trace 3 is the maximum condition (ease of use = 10). Trace 3 has slightly better short-term integration performance, but has the same long-term result after ten years. All three traces intersect at 10 years at the integration value 3.81. The model is not extremely sensitive to this variable alone, but it is sensitive to the combination in which ease of use resides. There is no associated anomalous behavior.

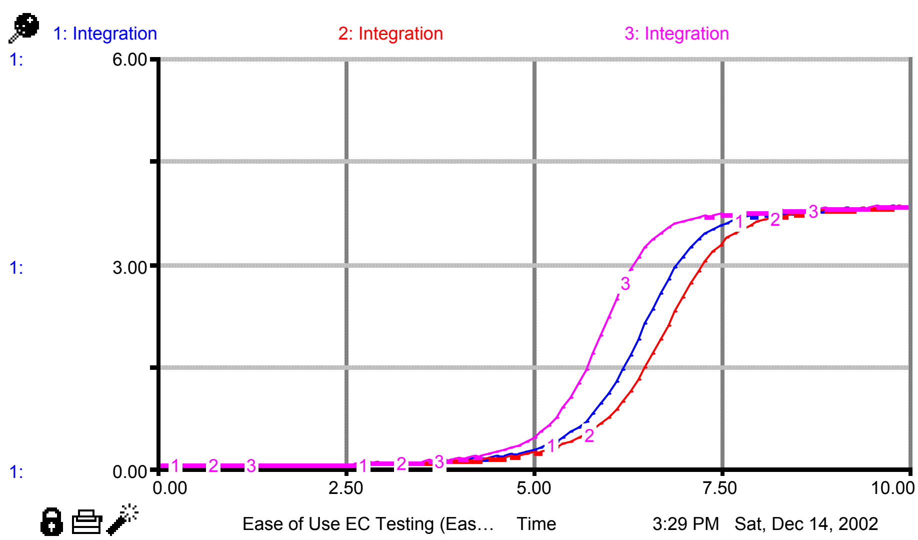


Figure 91: Ease of Use Extreme Conditions Test

Compatibility.

Compatibility: Scale (0 to 10)

Baseline condition (Model assumes GeoBase is in line with the existing values, needs, and past experiences of potential adopters): Compatibility = 5

MIN: Perception of GeoBase as totally not in line with existing values, needs, and past experiences of potential adopters: Compatibility = 0

MAX: Perception of GeoBase as totally in line with existing values, needs, and past experiences of potential adopters: Compatibility = 10

Figure 92 presents the extreme conditions test for compatibility. Trace 1 is the baseline condition. Trace 2 is the minimum compatibility condition, which slightly lags the baseline condition. Trace 3 is the maximum compatibility condition, which slightly improves integration performance. All three traces intersect at the ten-year value of 3.81. The model is not extremely sensitive to this variable alone, but it is sensitive to the combination in which compatibility resides. There is no associated anomalous behavior.

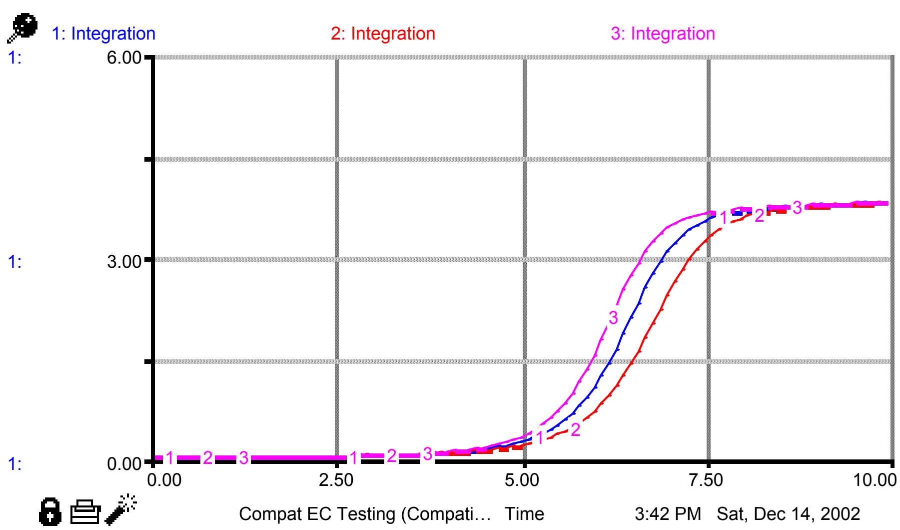


Figure 92: Compatibility Extreme Conditions Test

Technology Adoption Factors.

Technology Adoption Factors**: Scale (0 to 1)**

Note: The weighting factors for relative advantage, ease of use, and compatibility were derived from the literature review as outlined in Chapter 4, so they will not be changed during extreme conditions testing.

For extreme conditions testing purposes, the technology adoption factors (relative advantage, ease of use, and compatibility) will be combined at their extreme points. Since these three factors have 2 sampling points each, the complete combination set will consist of eight combinations as shown in Table 38.

Table 38: Combinations of Technology Adoption Factors at Extreme Points

Simulation	Relative Advantage	Ease of Use	Compatibility
1 (Baseline)	9	3	5
2	0	0	0
3	0	0	10
4	0	10	0
5	0	10	10
6	10	0	0
7	10	0	10
8	10	10	0
9	10	10	10

The number of simulation runs was too numerous to number and track on a graphical output. The model was sensitive to the combination of the three technology adoption factors at their extreme points (0,0,0) and (10,10,10).

Integration.

Integration Stock.

Integration: No Scale – constrained by not being able to be less than zero

Baseline condition (Model assumes there is a very small level of GeoBase/GIS integration initially – Integration structure requires an initial value greater than 0 to function properly): Integration = 0.01

High Value: Organization has a great history with GIS-related applications and has integrated GIS applications into the organizational business processes that have a great impact on efficiency and effectiveness: Integration = 1

Figure 93 presents the extreme conditions test for Integration. Trace 1 is the baseline condition (as well as the minimum condition). Trace 2 is a high initial value condition. It is interesting to note that the integration curve in Trace 2 actually depletes before it starts climbing. This dip means the artificially high initial value for integration was not supported by the system until it started to climb again after the dip. The compensating loops in the system were able to dominate the integration stock until the reinforcing loops were able to build up enough power to overcome the compensating loops. In the real world, if a system has a high initial value for a parameter, it probably has enough support behind it to sustain that value. Since only one parameter was changed in the system and left the rest at their baseline values, the system took awhile to come to point where it could sustain that level of performance (approximately 3.5 years). The high value scenario captured in Trace 2 still outperformed the baseline condition, but came to the same steady state point after ten years (Integration = 3.81).

A real-life scenario where this could play out would be the personnel in a well-established organization being fired and new personnel with limited experience coming in to replace them. It would take a while for the new personnel to attain the same level of performance as the old personnel. There would probably be a drop in performance in the short-term until the new personnel could develop the necessary competence to sustain the previous level of performance. Indirectly, this model, through simulation, is showing analogous behavior as described in the scenario above. This behavior is not anomalous, but it was not expected before testing. This behavior pattern does provide some additional insight into the system. The model is fairly sensitive to the integration level initially.

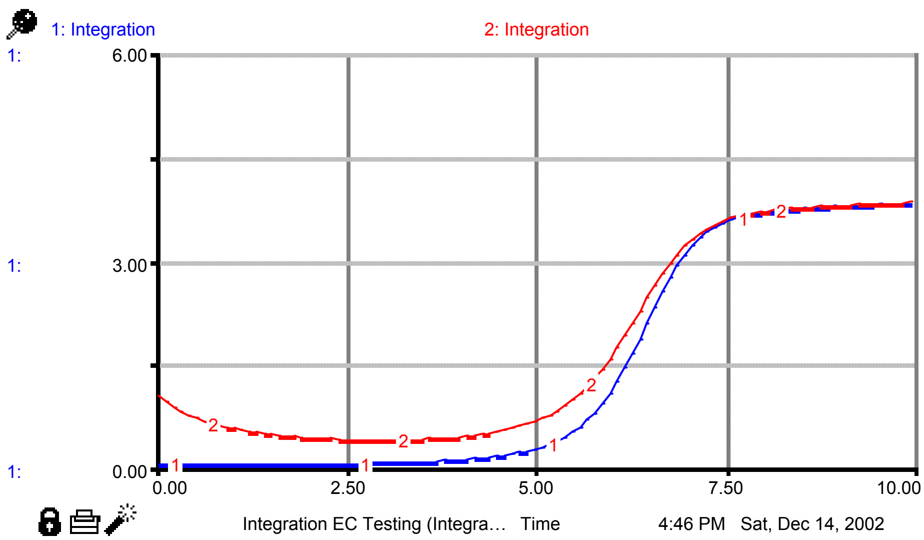


Figure 93: Integration Extreme Conditions Test

Reengineering Effectiveness.

Reengineering Effectiveness: Scale (0 to 10)

Baseline condition (Model assumes the organization has an adequate level of reengineering experience and understanding to be able to effectively reengineer organizational business processes): Reengineering Effectiveness = 3

MIN: Organization has no experience with business process reengineering and does not know how to begin the process: Reengineering Effectiveness = 0

MAX: Organization is totally versed in business process reengineering and always looks for opportunities to improve business processes to the highest degree possible: Reengineering Effectiveness = 10

Figure 94 presents the results of extreme conditions testing for reengineering effectiveness. Trace 1 shows the baseline condition. Trace 2 shows the minimum condition (reengineering effectiveness = 0). Trace 3 shows the maximum condition (reengineering effectiveness = 10). This is obviously an important variable in the system because integration will tend to approach this value. Trace 2 rises to 0.51 after ten years. The only reason simulation 2 allowed anything to build-up in integration is largely the result of ambient positive organizational inertia building up the integration stock. Trace 3 rises to 10.85 after ten years. This is a very good result, but in the real world, this level of organizational integration effectiveness would not be expected in an organization. These results were expected. The model is sensitive to the reengineering effectiveness variable and there is no associated anomalous behavior.

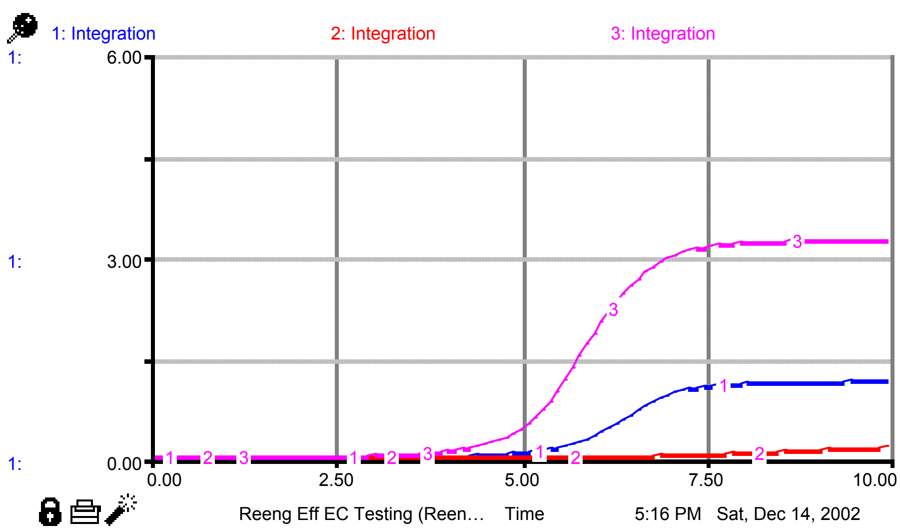


Figure 94: Reengineering Effectiveness Extreme Conditions Test

Baseline Continuity.

Baseline Continuity: Scale (0 to 1)

Baseline condition (Model assumes the organization has a typical level of continuity occurring – leaving personnel sometimes write continuity files for incoming replacements and there are plans on the shelves, but they are rarely read and usually collect dust): Baseline Continuity = 0.25

MIN: Organization does absolutely no continuity work and there are no written files for how to do anything – when individuals leave, all of the knowledge stored in their heads is lost to the organization, resulting in a lot of fragmentation, as described by Kim in Chapter 2: Baseline Continuity = 0

MAX: Organization has a wonderful continuity program established – personnel always write continuity files, incoming personnel always review, in full, all recorded information about their responsibilities, and plans are continually written and updated as information changes: Baseline Continuity = 1

Figure 95 presents the extreme conditions test for baseline continuity. Trace 1 is the baseline condition (baseline continuity = 0.25). Trace 2 is the minimum condition (baseline continuity = 0). Trace 3 is the maximum condition (baseline continuity = 1). Each of the traces are very similar and do not differ very much from one another. The reason for this occurrence is do to the issue of minimal baseline inertia. When inertia in the system builds up to greater values, there is much more of an impact on integration. However, in the baseline condition, only ambient inertia is building up, so the effect from continuity is small. The results would change significantly if there were more positive inertia in the system. There is no associated anomalous behavior.

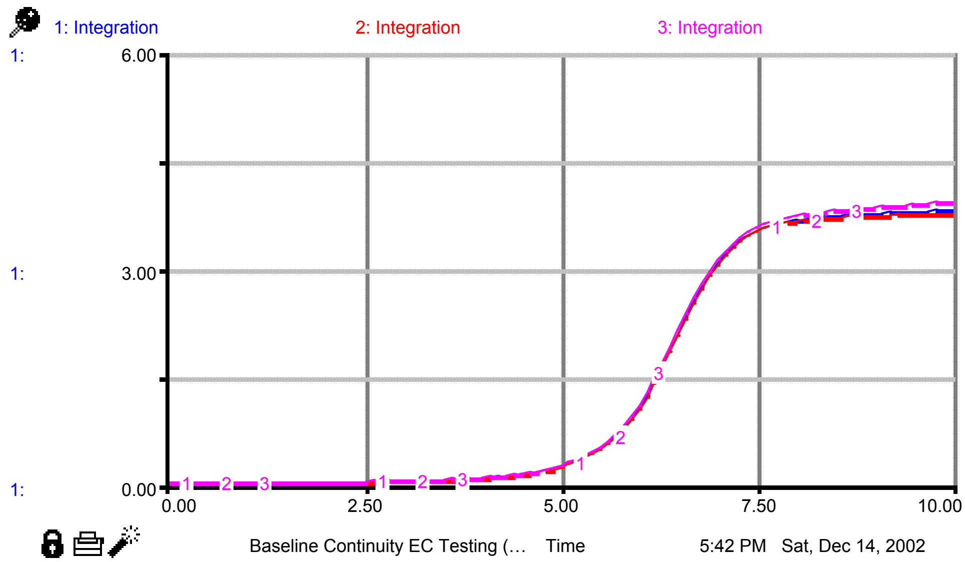


Figure 95: Baseline Continuity Extreme Conditions Test

Organizational Inertia.

Note: Only the constant parameters in this section will be analyzed for extreme conditions testing.

Continued Use Inertia.

Continued Use Inertia: No Scale – will steadily rise as inflow is active – constrained by not being able to be less than zero.

Baseline condition (Model assumes there has not been any positive GeoBase-related inertia building up in the system): Continued Use Inertia = 0

High Value: High level of initial positive GeoBase-related inertia exists in the system: Continued Use Inertia = 1

Figure 96 presents the continued use inertia extreme conditions test. Trace 1 shows the baseline condition (initial continued use inertia = 0). Trace 2 shows a high value condition (initial continued use inertia = 1). Trace 2 outperforms the baseline condition and gives a short-term boost to integration over approximately the first six years. Trace 2, after ten years, comes to a value of 3.92, whereas the baseline condition comes to a value of 3.81. The main difference is the higher short-term growth as a result of high initial continued use inertia. The model is fairly sensitive to the continued use inertia variable and there is no associated anomalous behavior.

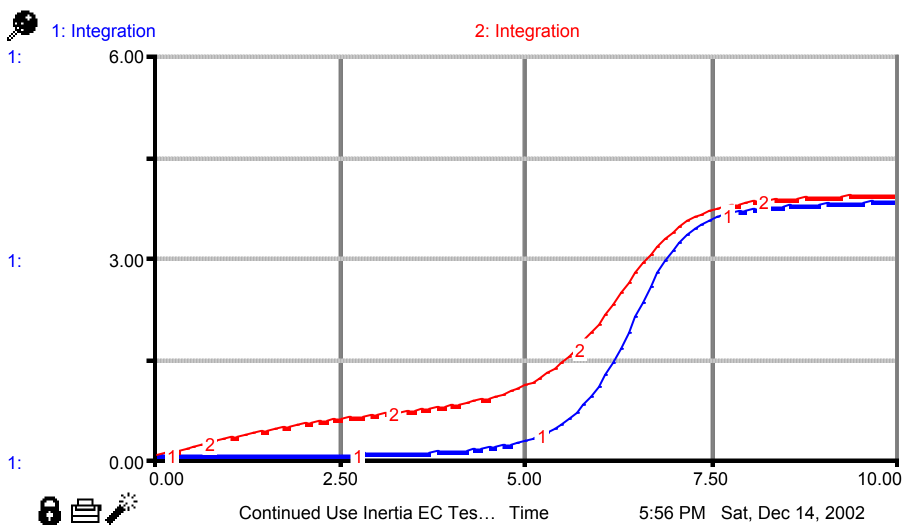


Figure 96: Continued Use Inertia Extreme Conditions Test

<u>Discontinued Use Inertia.</u>

Discontinued Use Inertia: No Scale – will steadily rise as inflow is active – constrained by not being able to be less than zero.

Baseline condition (Model assumes there has not been any negative GeoBase-related inertia building up in the system): Discontinued Use Inertia = 0

Mid-high Value: Mid-high value of initial negative GeoBase-related inertia exists in the system initially: Discontinued Use Inertia = 0.5

High Value: High level of initial negative GeoBase-related inertia exists in the system initially: Discontinued Use Inertia = 1

Figure 97 presents the extreme conditions tests for discontinued use inertia. Trace 1 is the baseline condition (discontinued use inertia = 0). Trace 2 is the mid-high value for discontinued use inertia (discontinued use inertia = 0.5). Trace 3 is the high value for discontinued use inertia (discontinued use inertia = 1). Typically inertia builds up in the system gradually over time, but a high initial value serves to act as a powerful compensating loop in the system. As such, the strengthening of the system reinforcing loops in the baseline condition is insufficient to overcome the compensating loops from the discontinued use inertia. In the extreme case of high discontinued use inertia, the integration stock never is able to adequately build up over time. This is the expected result. The model is very sensitive to the discontinued use inertia variable and there is no associated anomalous behavior.

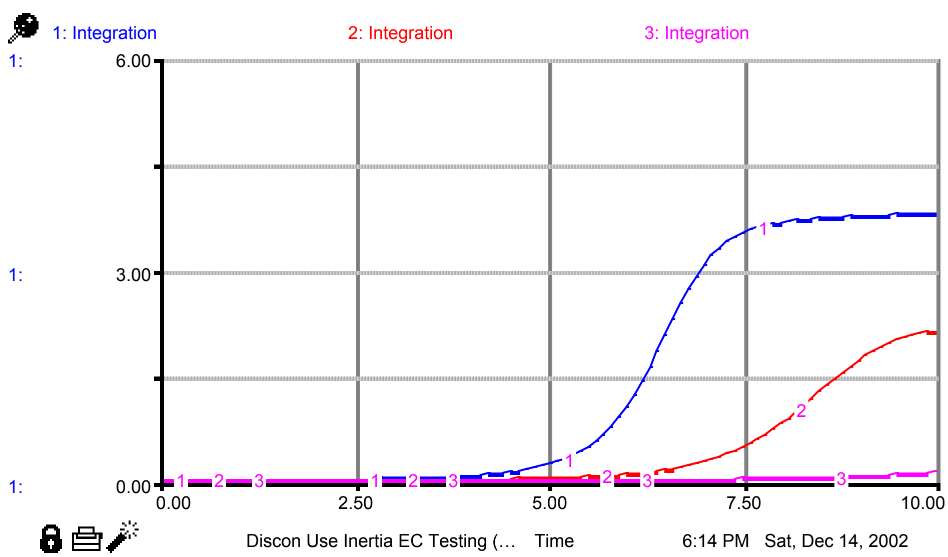


Figure 97: Discontinued Use Inertia Extreme Conditions Test

Top Level Support.

Top Level Support: Scale (-1 to 1)

Baseline condition (Model assumes top level organizational leaders are neither overly supportive or obstructive to GeoBase): Top Level Support = 0

MIN: Top level organizational leaders are highly obstructive and critical of GeoBase and act as extreme detriments to the innovation: Top Level Support = -1

MAX: Top level organizational leaders are highly supportive of GeoBase and act as extreme champions of the innovation: Top Level Support = 1

Figure 98 presents the extreme conditions test for top-level support. Trace 1 shows the baseline condition. Trace 2 shows the minimum condition (top level support = -1). In the minimum condition, top-level support makes discontinued use inertia very powerful in the system and the compensating loops begin to dominate as discontinued use inertia builds up to high levels. Since there are a number of stocks in series, there are inherent delays in the system that allow integration to build up to a point and then dramatically decline as the discontinued use compensating loops dominate the system. At its peak, integration in Trace 2 is 2.6 after 7.3 years; after ten years it is 0.89. Trace 3 shows the maximum condition, which is not significantly different from the baseline condition. After ten years, the value for integration is 3.99 as opposed to 3.81 for the baseline condition. Based on the structure of the model, this is the expected behavior pattern. In a context of top-level support, the system will behave well, but not significantly differently from the baseline. In a context of top management discontent, the system shows marked declining effects. In reality, in this context, other factors in the system would also be lower, which would not allow the integration in the system to build up.

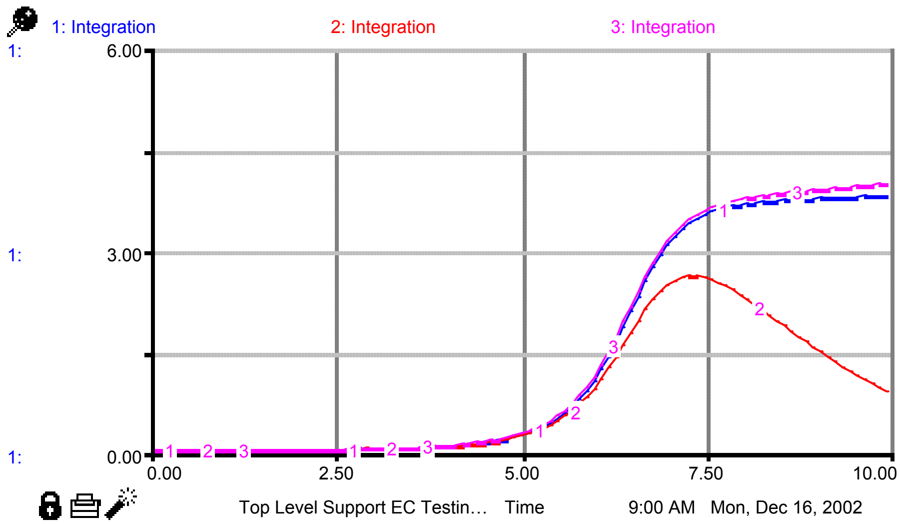


Figure 98: Top Level Support Extreme Conditions Test

<u>Database Quality.</u>

Database Quality: Scale (-1 to 1)

Baseline condition (Model assumes database quality is neither good nor bad): Database quality = 0

MIN: Database is absolutely unreliable – none of the information is correct and the database management teams never update any of the information as changes occur: Database Quality = -1

MAX: Database is absolutely outstanding – database management team keeps it perfectly updated when any changes occur and it never has any problems: Database Quality = 1

Figure 99 presents the database quality extreme conditions test. Trace 1 shows the baseline condition. Similar things are happening in Figure 18 as in Figure 17. Trace 2 shows the minimum condition (database quality = -1). Trace 2 peaks at 2.48 after 7.3 years; after ten years it is 0.69. Trace 3 is similar to the baseline, but comes to a value of

4.04 after ten years. Database quality is an important influence in the system, especially when it contributes to discontinued use inertia. Database quality has slightly more influence in the system than top-level support. The model behaves as expected in each case of minimum and maximum values for database quality.

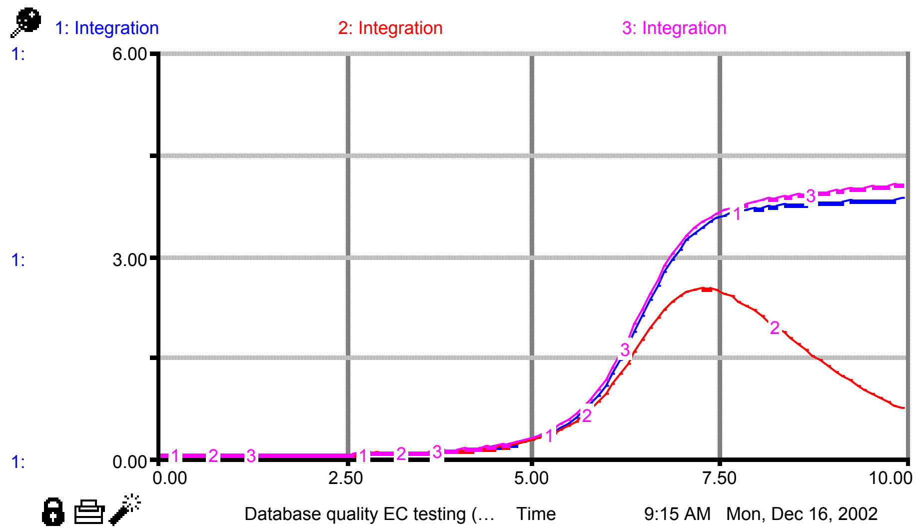


Figure 99: Database Quality Extreme Conditions Test

Culture Fit.

Culture Fit: Scale (-1 to 1)

Baseline condition (Model assumes the organizational culture is neither rigid nor innovative as far as GeoBase is concerned): Culture Fit = 0

MIN: Organization is totally rigid and unsupportive of GeoBase: Culture Fit = -1

MAX: Organization is totally innovative and accepting of GeoBase: Culture Fit = 1

Figure 100 presents the results from the extreme conditions test for culture fit. Trace 1 shows the baseline condition. Trace 2 shows the minimum condition (culture fit

= -1). Trace 3 shows the maximum condition (culture fit = 1). Trace 2, showing the minimum condition, peaks at 1.83 at 7.1 years; after ten years it is 0.17. Trace 3 reaches 4.36 after ten years. Of the three organizational inertia factors, culture fit is the most important. The mechanism for the behavior patterns shown in Figure 100 is the same as for the other inertia factors (shown in Figures 4-47 and 4-48). The behavior shown in Figure 100 is expected.

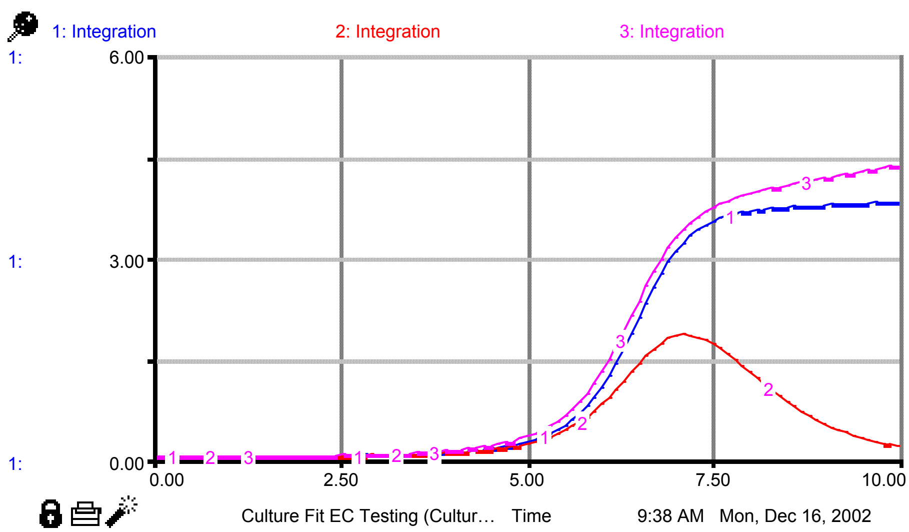


Figure 100: Culture Fit Extreme Conditions Test

Organizational Inertia Factors.

Organizational Inertia Factors: Scale (0 to 1)

Note: The scale factors were derived from the literature review outlined in Chapter 4, so they will not be changed during extreme conditions testing.

For extreme conditions testing purposes, the organizational inertia factors (top level support, database quality, and culture fit) will be combined at their extreme points. Since these three factors have 2 sampling points each, the complete combination set will consist of nine combinations (including baseline) as shown in Table 39.

Table 39: Combinations of the Organizational Inertia Factors at Extreme Points

Simulation	Top Level Support	Database Quality	Culture Fit
1	0	0	0
2	-1	-1	-1
3	-1	-1	1
4	-1	1	-1
5	-1	1	1
6	1	-1	-1
7	1	-1	1
8	1	1	-1
9	1	1	1

The number of simulation runs was too numerous to number and track on a graphical output. The model was sensitive to the combination of the three organizational inertia factors at their extreme points (-1,-1,-1) and (1,1,1).

Extreme Policy Test

Management Interventions.

Note: The weighting factors for learning management factor, reward system management factor, change process management factor, and continuity management factor were derived from the literature review as outlined in Chapter 4, so they will not be changed during extreme conditions testing. The actual variables for learning management, reward system management, change process management, and continuity management are functions of the percentages and management effort allocator, so cannot be directly tested. Instead, testing the extreme conditions for each of the management intervention percentages will achieve the desired testing objective.

Management Capacity.

Management Capacity: Scale (0 to 1)

Baseline condition (Model assumes the manager is using all of his time as the GeoBase manager and consistently exerts maximum effort on improving GeoBase operating capability and managing the GeoBase integration process): Management Capacity = 1

MIN: Manager only spends a percentage of his time increasing the operating capability of GeoBase and gives no heed to managing the GeoBase integration process beyond operating capability: Management Capacity = 0

MAX: see baseline condition

Figure 101 presents the results of the management capacity extreme conditions test. Trace 1 shows the baseline and maximum condition (management capacity = 1). Trace 2 shows the minimum condition (management capacity = 0). Trace 2 shows Integration stays at zero throughout the simulation, as is to be expected when there is no management effort whatsoever.

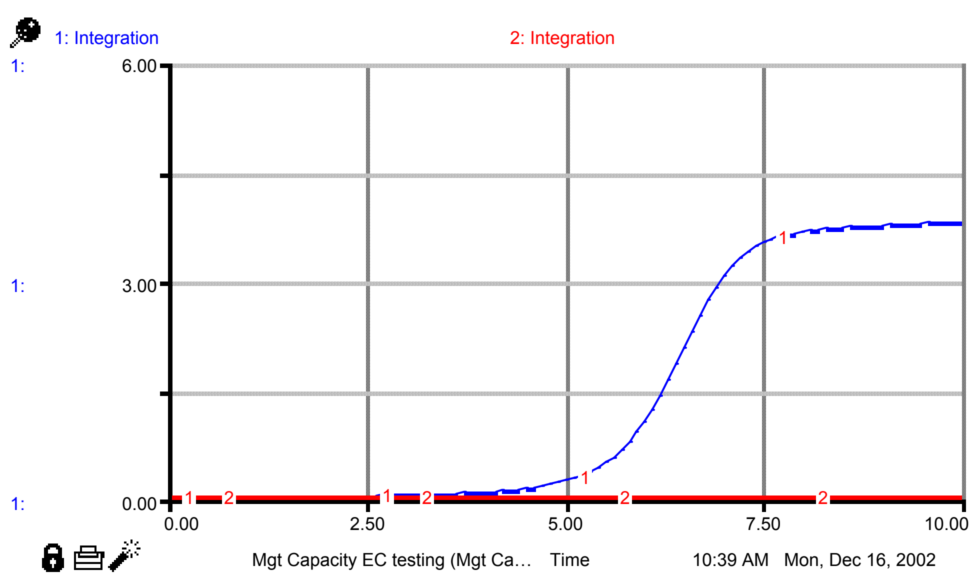


Figure 101: Management Capacity Extreme Conditions Test

Learning Management Percentage.

Learning Management Percentage: Scale (0 to 1) – with constraint that all management intervention percentages must sum to 1

Baseline condition (Model assumes manager equally partitions his time between each of the four management interventions, outside of increasing operating capability): Learning Management Percentage = 0.25

MIN: Manager focuses no time on learning management and focuses the rest of his time on a combination of the other three management interventions:
Learning Management Percentage = 0
Reward System Management Percentage = 0.333
Change Process Management Percentage = 0.333
Continuity Management Percentage = 0.333

MAX: Manager focuses all of his time on learning management and no time on any of the other three interventions: Learning Management Percentage = 1

Figure 102 presents the results of the extreme conditions test for learning management percentage. Trace 1 shows the baseline condition (all management intervention percentages equally weighted at 0.25). Trace 2 shows the minimum condition for learning management percentage (learning management percentage = 0 with the other three management interventions equally weighted at 0.333 apiece). Trace 3 shows the maximum condition for learning management percentage (learning management percentage = 1 and the others equal zero). It is interesting to note that when the manager is completely fixated on learning management, integration stays close to zero throughout the simulation period. The reason for this result is due to the fact that the manager never applies effort to move potential adopters to adopters. The adopter stock never increases, so integration never increases. For any potential adopter to move from the potential adopter stock to the adopter stock, the manager must focus some effort on either change process management or reward system management. Comparing Traces 1 and 2, there are also some interesting observations. When learning management is non-existent, in favor of other management interventions, there is slightly better performance in the short-term, but the longer-term performance is lower. The ten-year integration value for Trace 2 is 3.47 (as opposed to the baseline value of 3.81). This result shows that including some level of learning management is beneficial in the system, but a cosmopolitan management intervention approach is better.

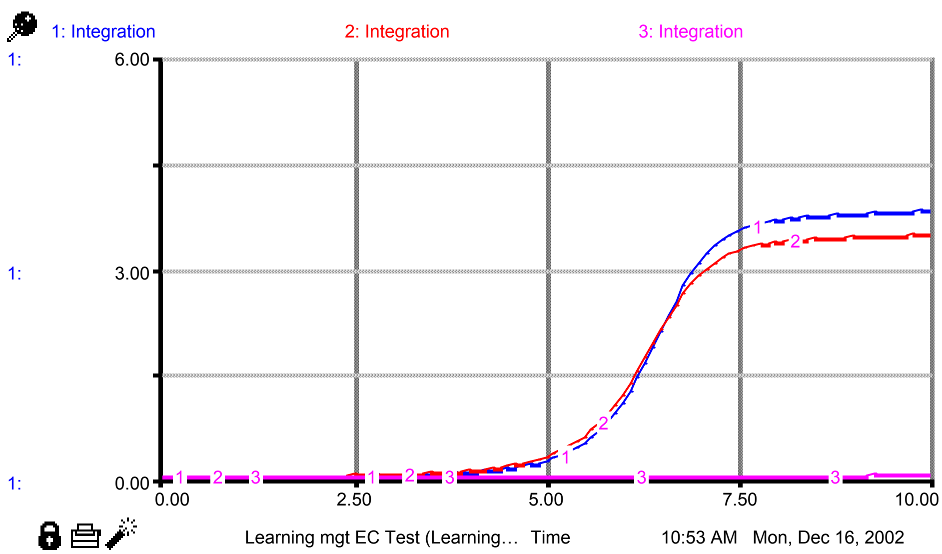


Figure 102: Learning Management Percentage Extreme Conditions Test

Reward System Management Percentage.

Reward System Management Percentage: Scale (0 to 1) – with constraint that all management intervention percentages must sum to 1

Baseline condition (Model assumes manager equally partitions his time between each of the four management interventions, outside of increasing operating capability): Reward System Management Percentage = 0.25

MIN: Manager focuses no time on reward system management and focuses the rest of his time on a combination of the other three management interventions:
Reward System Management Percentage = 0
Learning Management Percentage = 0.333
Change Process Management Percentage = 0.333
Continuity Management Percentage = 0.333

MAX: Manager focuses all of his time on reward system management and no time on any of the other three interventions:
Reward System Management Percentage = 1

Figure 103 presents the results of the reward system management percentage extreme conditions test. Trace 1 shows the baseline condition (all management intervention percentages equally weighted at 0.25). Trace 2 shows the minimum condition for reward system management percentage (reward system management percentage = 0 with the other three management interventions equally weighted at 0.333 apiece). Trace 3 shows the maximum condition for reward system management percentage (reward system management percentage = 1 and the others equal zero). It is interesting to note that without any management focus on reward system management (Trace 2), integration significantly lags the baseline but eventually rises to approximately the same long-term value. Trace 3 shows that a complete focus on reward system management speeds integration in the short term, but the long-term performance is slightly lower (3.74 after ten years as opposed to 3.81 after ten years for the baseline).

These results show that the manager should focus some percentage of his effort on reward system management.

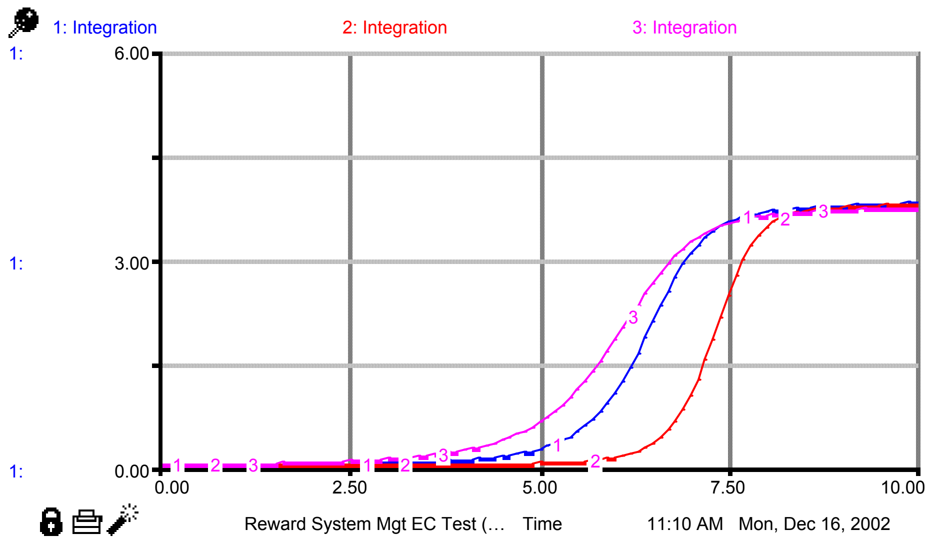


Figure 103: Reward System Management Percentage Extreme Conditions Test

<u>Change Process Management Percentage.</u>

Change Process Management Percentage: Scale (0 to 1) – with constraint that all management intervention percentages must sum to 1

Baseline condition (Model assumes manager equally partitions his time between each of the four management interventions, outside of increasing operating capability): Change Process Management Percentage = 0.25

MIN: Manager focuses no time on change process management and focuses the rest of his time on a combination of the other three management interventions:
Change Process Management Percentage = 0
Learning Management Percentage = 0.333
Reward System Management Percentage = 0.333
Continuity Management Percentage = 0.333

MAX: Manager focuses all of his time on change process management and no time on any of the other three interventions:
Change Process Management Percentage = 1

Figure 104 presents the results of the change process management percentage extreme conditions test. Trace 1 shows the baseline condition (all management intervention percentages equally weighted at 0.25). Trace 2 shows the minimum condition for change process management percentage (change process management percentage = 0 with the other three management interventions equally weighted at 0.333 apiece). Trace 3 shows the maximum condition for change process management percentage (change process management percentage = 1 and the others equal zero). When the manager focuses no effort on change process management, integration significantly lags the baseline integration performance in both the short-term and long-term. The ten-year integration value for Trace 2 is 3.55. When the manager focuses complete attention on change process management (Trace 3) to the exclusion of the other factors, there is better short-term performance, but less long-term performance. The ten-year integration value for Trace 3 is 3.48 (compared to the baseline ten-year value of 3.81). These results show that managers should focus some of their effort on change process management.

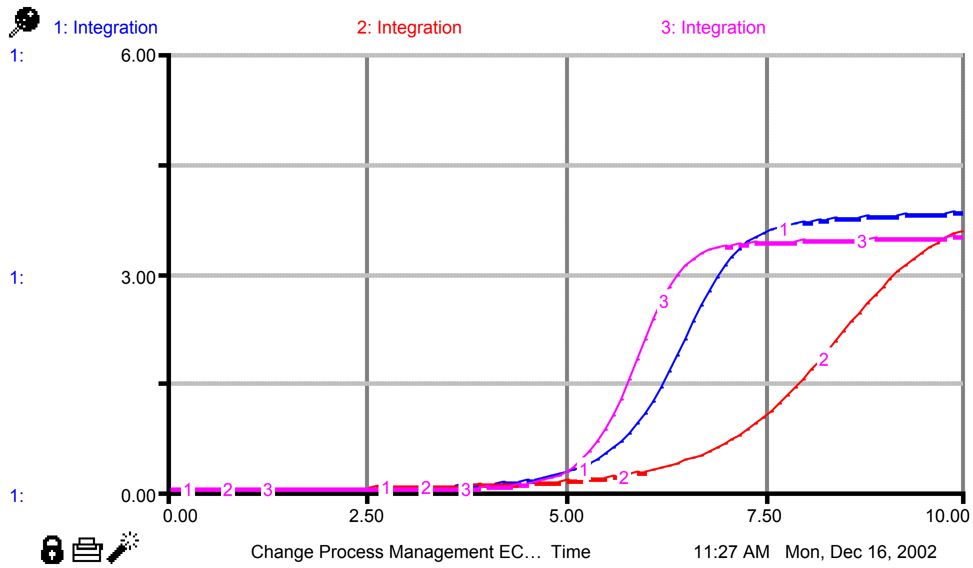


Figure 104: Change Process Management Percentage Extreme Conditions Test

<u>Continuity Management Percentage.</u>

Continuity Management Percentage: Scale (0 to 1) – with constraint that all management intervention percentages must sum to 1

Baseline condition (Model assumes manager equally partitions his time between each of the four management interventions, outside of increasing operating capability): Continuity Management Percentage = 0.25

MIN: Manager focuses no time on continuity management and focuses the rest of his time on a combination of the other three management interventions:
Continuity Management Percentage = 0
Reward System Management Percentage = 0.333
Change Process Management Percentage = 0.333
Learning Management Percentage = 0.333

MAX: Manager focuses all of his time on continuity management and no time on any of the other three interventions: Continuity Management Percentage = 1

Figure 105 presents the results of the continuity management percentage extreme conditions test. Trace 1 shows the baseline condition (all management intervention percentages equally weighted at 0.25). Trace 2 shows the minimum condition for continuity management percentage (continuity management percentage = 0 with the other three management interventions equally weighted at 0.333 apiece). Trace 3 shows the maximum condition for continuity management percentage (continuity management percentage = 1 and the others equal zero). It is interesting to note that under the baseline condition, the manager actually harms both short and long-term integration performance by focusing any effort on continuity management. Trace 2 shows that integration rises sooner and comes to a higher ten-year value of 4.05 (as opposed to 3.81 for the baseline). When the manager focuses all attention on continuity management (to the detriment of the other management interventions), integration stays close to zero. This occurs for the same reason complete focus on learning management does not allow integration to build-up over time. There has to be some level of reward or change process management in the system or none of the potential adopters will flow to the adopter side. Without adopters, integration goes nowhere. The reason the system actually performs better without any management focus on continuity is due to the weak baseline values for continued use inertia. Investing managerial time in continuity management will only out-produce the other management interventions if there is a significant level of continued use inertia building up. Otherwise, the manager would be wise to accept the baseline continuity contribution and focus his efforts elsewhere.

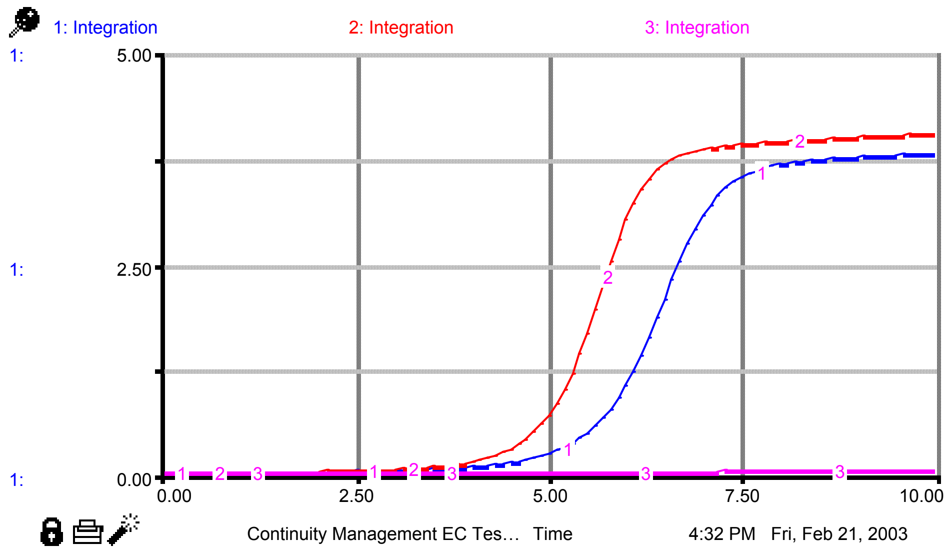


Figure 105: Continuity Management Percentage Extreme Conditions Test

Bibliography

Agarwal, Ritu and Jayesh Prasad. "A Field Study of the Adoption of Software Process Innovations by Information Systems Professionals," *IEEE Transactions on Engineering Management*, 47(3):295-308 (August 2000).

Armenakis, Achilles A. and Arthur G. Bedeian. "Organizational Change: A Review of Theory and Research in the 1990s," *Journal of Management*, 25(3):293-315 (1999).

Armenakis, Achilles A., Stanley G. Harris, and Kevin W. Mossholder. "Creating Readiness for Organizational Change," *Organization Development and Transformation: Managing Effective Change*. McGraw-Hill Higher Education. (327-341). 2000.

Beer, Michael and Russell A. Eisenstat. "Developing an Organization Capable of Implementing Strategy and Learning," *Human Relations*, 49(5):597-619 (1996).

Clarke, Keith C. *Getting Started with Geographic Information Systems*, Upper Saddle River, NJ, Prentice Hall, Third Edition, 2001.

Cullis, Brian A. "Compass Plenary Session Presentation." Address to 2002 CADD/GIS Geospatial Technology Symposium. San Antonio, TX. http://www.il.hq.af.mil/geobase. 20 August 2002.

Cullis, Brian A. *Geospatial IT Adoption Trends on DOD Installations*. Institute for Information Technology Applications. USAF Academy, http://www.geobase.org/Library/index.cfm?cat=2. (May 2000).

Cunningham, Ian. *The Wisdom of Strategic Learning*. 2nd Edition. Hampshire, England: Gower Publishing Limited, 1999.

Davis, Fred D., Richard P. Bagozzi, and Paul R. Warshaw. "User Acceptance of Computer Technology: A Comparison of Two Theoretical Models," *Management Science*, 35(8):982-1002 (August 1989).

Department of the Air Force. *IT Summit Meeting Minutes*. (September 2002).

Department of the Air Force, Office of the Civil Engineer, Headquarters Air Force Geo Integration Office (HAF GIO). *FY02 Strategic Plan*. January 2002.

Department of the Air Force, Office of the Civil Engineer, Headquarters Air Force Geo Integration Office (HAF GIO). *USAF GeoBase Concept of Operations*, January 2002.

Department of the Air Force, Office of the Civil Engineer, Headquarters Air Force Geo Integration Office (HAF GIO). https://www.il.hq.af.mil/geobase. (October 2002).

Fisher, Donna K., Jonathon Norvell, Steven Sonka, and Mark J. Nelson. "Understanding Technology Adoption through System Dynamics Modeling: Implications for Agribusiness Management," *International Food and Agribusiness Management Review*, 3:281-296 (2000).

Fox-Wolgramm, Susan J., Kimberly B Boal, and James G. Hunt. "Organizational Adaptation to Organizational Change: A Comparative Study of First-order Change in Prospector and Defender Banks," *Administrative Science Quarterly*, 43:87-126 (1998).

Garvin, David A. "Building a Learning Organization," *Harvard Business Review*, 71: 78-91 (July-August 1993).

Geo InSight International, Inc., "Policy Issues in GIS Development", http://www.geoinsight.com/Knowledgebase/GeoExpo99/PolicyIssues.cfm, 1999.

Hammer, Michael and James Champy. *Reengineering the Corporation: A Manifesto for Business Revolution*. New York, New York: HarperCollins Publishers, Inc., 2001.

Huff, James O., Anne S. Huff, and Howard Thomas. "Strategic Renewal and the Interaction of Cumulative Stress and Inertia," *Strategic Management Journal*, 13:55-75 (1992).

Hopper, Samuel W. "GeoBase: Critical Elements for Success." Address to CADD/GIS Geospatial Technology Symposium, San Antonio, TX, August 2002.

Isabella, Lynn A. "Evolving Interpretations as a Change Unfolds: How Managers Construe Key Organizational Events," *Academy of Management Journal*, 33(1):7-41 (1990).

Jaffe, Dennis, Cynthia Scott, and Glenn Tobe. *Rekindling Commitment: How to Revitalize Yourself, Your Work, and Your Organization*, San Francisco, CA, Jossey-Bass Inc., 1994.

Kim, Daniel H. "The Link Between Individual and Organizational Learning," *Sloan Management Review*, Fall:37-50 (1993).

Kotter, John P. "Leading Change: Why Transformation Efforts Fail," *Harvard Business Review*, 73(2):59-67 (March-April 1995).

Liberatore, Matthew J., Armand Hatchuel, Benoit Weil, and Antonis C. Stylianou. "An Organizational Change Perspective on the Value of Modeling," *European Journal of Operational Research*, 125:184-194 (2000).

Meadows, Donella M. "The Unavoidable A Priori," *Elements of the System Dynamics Method*. The MIT Press. Cambridge, Massachusetts. (23-57). 1980.

Moore, Gary C. and Izak Benbasat. "Development of an Instrument to Measure the Perceptions of Adopting an Information Technology Innovation," *Information Systems Research*, 2(3):192-222 (September 1991).

Ram, S. and Hyung-Shik Jung. "'Forced' Adoption of Innovations in Organizations: Consequences and Implications," *The Journal of Product Innovation Management*, 8:117-126 (1991).

Rogers, E.M. *Diffusion of Innovations*, New York, NY, Free Press, Fourth Edition, 1995.

Romme, Georges and Ron Dillen. "Mapping the Landscape of Organizational Learning," *European Management Journal*, 15(1):68-78 (February 1997).

Sastry, M. Anjali. "Problems and Paradoxes in a Model of Punctuated Organizational Change," *Administrative Science Quarterly*, 42:237-275 (1997).

Sterman, John D., *Business Dynamics: Systems Thinking and Modeling for a Complex World*, Kingport, McGraw-Hill Companies, Inc., 2000.

Tornatzky, Louis G. and Katherine J. Klein. "Innovation Characteristics and Innovation Adoption Implementation: A Meta-Analysis of Findings," *IEEE Transactions on Engineering Management*, EM-29(1):28-45 (February 1982).

Tushman, Michael L. and Elaine Romanelli. "Organizational Evolution: A Metamorphosis Model of Convergence and Reorientation," *Research in Organizational Behavior*, 7:171-222. Greenwich, CT: JAI Press, 1985.

Van de Ven, Andrew H. and George P. Huber. "Longitudinal Field Research Methods for Studying Processes of Organizational Change," *Organization Science*, 1(3): 213-219 (1990).

Vita

Captain Nathan W. Fonnesbeck graduated from Castro Valley High School in Castro Valley, CA. He entered undergraduate studies at Brigham Young University in Provo, UT where he graduated with a Bachelor of Science degree in Civil Engineering in December 1998. He was commissioned through the Detachment 855 AFROTC at Brigham Young University.

His first assignment was at Laughlin AFB, TX as an officer in the 47th Civil Engineer Squadron in February 1999. While at Laughlin AFB, he worked in the Environmental Flight where he managed various environmental programs. During his stay at Laughlin AFB, he obtained a secondary AFSC as a foreign area officer for Eastern Europe. As such, he was able to spend a month in Krakow, Poland in a Polish language immersion program during June 2000. In August 2001, he entered the Graduate School of Engineering and Management, Air Force Institute of Technology. Upon graduation, he will be assigned to Andersen AFB, Guam.

REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 074-0188*

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From – To)*
25-03-2003	**Master's Thesis**	August 2001 – March 2003

4. TITLE AND SUBTITLE

A SYSTEM DYNAMICS APPROACH FOR INFORMATION TECHNOLOGY IMPLEMENTATION AND SUSTAINMENT

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Fonnesbeck, Nathan W., Captain, USAF

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(S)

Air Force Institute of Technology
Graduate School of Engineering and Management (AFIT/EN)
2950 P Street, Building 640
WPAFB OH 45433-7765

8. PERFORMING ORGANIZATION REPORT NUMBER

AFIT/GEE/ENV/03-08

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

HQ AF/ILA
Attn: Colonel Brian Cullis
1030 Air Force
Pentagon, Washington, DC 20330-1030 Commercial: (703) 604-3468

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The goal of this research is to bring a new, dynamic modeling perspective to organizational information technology (IT) implementation systems (using the Air Force GeoBase initiative as a real-world example) without compromising principles from the research literature. Undesired behavior patterns, from historically poor IT implementation performance, versus desired behavior patterns are incorporated into the model structure.

Using a system dynamics approach, multiple simulation runs under various initial conditions and organizational contexts are performed and compared over a short-term versus a long-term period of time. Based on these simulation runs, various mixes of management interventions, under varying conditions, are recommended to improve IT implementation performance based on organizational goals.

Generally, for better long-term system performance, learning management, with a focus on team learning, is the best single IT implementation tool. With a low level of organizational buy-in at the beginning of the IT implementation effort, change process management should be the initial focus of management effort. Reward system management provides a short-term spark, but its implementation effects are not carried over for long-term sustainment as readily as learning management or change process management. Continuity management, though beneficial, does not provide as much "bang for the buck" as the other management interventions.

15. SUBJECT TERMS

Geographical Information Systems, Business Process Reengineering, Dynamics, Learning

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Michael L. Shelley, PhD (ENV)
					19b. TELEPHONE NUMBER *(Include area code)*
U	U	U	UU	336	(937) 255-3636, ext 4594; e-mail: Michael.Shelley@afit.edu

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39-18