ABSTRACT

Title of Document:	METHODOLOGY FOR DETECTION AND ASSESSMENT OF THE IMPACT OF INFORMAL PROCESSES ON ORGANIZATIONAL OUTPUT
	Lesa Moore Ross, Doctor of Philosophy, 2009
Directed By:	Professor Ali Mosleh, Department of Mechanical Engineering

This research focuses on the detection and assessment of informal processes within an organization. Informal processes are defined as activities that are not formalized with respect to the inputs, resources, and/or controls; or an activity that deviates from a formal process. Informal processes affect all aspects of an organization's business. Informal processes cannot be eliminated (nor should they necessarily be). The question becomes how can we identify the informal processes and assess their impact on our system's safety? The research reported in this paper is aimed at providing an answer to this question. A theoretical foundation in the area of organizational culture, structures and practices culminating in the SoTeRiA (Socio-Technical Risk Analysis) framework provides the general model for this research. A comprehensive methodology for the detection, identification and assessment of informal processes is

presented which will allow an organization to benefit from positive informal

processes, while resolving detrimental informal processes to preclude their use. Two

detection methods have been developed – an indirect detection method (questionnaire

completed by a management representative) and a direct detection method (process

audit). A methodology has been developed to be utilized as a guideline in the

performance of process audits that encompasses process element identification,

process interactions, and the usage of document trees. A methodology for the

assessment of the impact of informal processes on an organization has been

developed that will enable businesses and organization's to have more accurate and

complete data from which to make their decisions regarding the state of the

organization. To assess the impact of informal processes, Bayesian Belief Networks

were utilized to determine the probability of the process output failure with the

inclusion of informal processes and then after the informal processes were brought

into the formal system. The application of this methodology has proven that when

either informal processes that are beneficial to an organization are brought into the

formal system, or detrimental informal processes are eliminated, the probability of the

output failure decreases. The methodology presented provides a comprehensive

approach to the understanding, detection, and assessment of informal processes in an

organization.

METHODOLOGY FOR DETECTION AND ASSESSMENT OF THE IMPACT OF
INFORMAL PROCESSES ON ORGANIZATIONAL OUTPUT.

By

Lesa Moore Ross.

Dissertation submitted to the Faculty of the Graduate School of the
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Advisory Committee:
Professor Ali Mosleh, Chair
Professor Jeffrey Herrmann
Professor Emeritus Marvin Roush
Professor B.D. Youn
Professor Gregory Baecher

Dedication

I dedicate this work in loving memory of my dad, William Frank "Tom" Moore,

who always told me I could be whatever I wanted to be, and whose love,

support, wisdom, and kindness has guided me throughout my life.

Thank you Daddy – I love you.

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The journey involved in completing this research has given me the opportunity to meet wonderful people and to reconnect with old friends. There are so many people that have been there to provide encouragement, support, and assistance.

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always ready and willing to listen, and who can always cheer me up and make me laugh no matter the circumstances. Everyone should be so lucky as to have a "Doris" in their lives.

A journey such as this cannot be undertaken without a solid background in both one's education and personal life. I am truly blessed to have the best parents in the world – Tom and Carolyn Moore. My dad always believed that I could do anything I desired. My mom has always been there to support me. They sacrificed so that I could have the best education possible, and never want for anything. There are no words to convey my gratitude and love to Mom and Dad.

The strongest supporters along this journey have been my wonderful husband Mark, and my daughters Sarah and Jacquelyne. Jacquelyne wrote sweet notes every time I traveled to Maryland to let me know how proud she was of me and offering her encouragement. Sarah made it a point to call me and offer her support, love, and encouragement while I was away from home. My girls are wonderful cheerleaders for their Mom. Last, but no means least, I want to attempt to express my gratitude to my husband. Since 1977, Mark has been my best friend. He has always encouraged me and was beside me every step of this journey. Without his love and support none of this would have been possible. Although this particular journey in my life is over, I know that Sarah, Jacquelyne, Mark and I will have many more together. I am truly blessed to have such a wonderful family. Thank you – I love each one of you more than you know.

Table of Contents

List of Tables

List of Figures

List of Acronyms

ACCC – Australian Competition and Consumer Commission

ALPA – Air Line Pilots Association International

ASIC – Australian Securities and Investment Commission

ASQ – American Society of Quality

ASQC – American Society of Quality Control

ASRS – Aviation Safety Reporting System

ASTM – American Society for Testing and Materials

ATOS – Air Transportation Oversight System

BBN – Bayesian Belief Network

DoD – Department of Defense

DROMĒ – Direct Representation of the Model Elements

EPA – Environmental Protection Agency

EPI – Element Performance Inspection

FAA – Federal Aviation Administration

FAR – Federal Aviation Regulations

FIPS – Federal Information Processing Standard

ICOM – Inputs, Controls, Outputs, Mechanisms

IDEF0 – Integrated Definition for Function Model

IEP – Internal Evaluation Program

IIA – Institute of Internal Auditors

ISO – International Organization for Standardization

MSBNx – Microsoft Research Bayesian network authoring and evaluation tool

NASA – National Aeronautics and Space Administration

NCL – Norwegian Cruise Lines

OP – Ground and Flight Operations

OSHA – Occupational Safety and Health Administration

PSF – Performance Shaping Factor

PSI – Pounds Per Square Inch

QA – Quality Assurance Engineer

SADT – Structured Analysis and Design Technique

SEC – Securities and Exchange Commission

SoTeRiA – Socio-Technical Risk Analysis

SME – Subject Matter Expert

Chapter 1: Introduction

Section 1.1 Motivation

A service industry launched a new product, one heralded as the best in the world. Informal processes associated with the product included the omission of required procedures, the unavailability of required equipment, ignoring vital communication, and not following standard protocol for the environment in which the product was operating. The culmination of these informal processes led to the deaths of 1,523 people. The product heralded as the best in the world, became the most infamous product as the RMS Titanic sank to the ocean floor on April 14th, 1912.

Informal processes are discussed throughout literature in varying industries (Mohieldin and Wright (2000) and Lomnitz (1988)with regards to economics; Gamas and Hilditch (1998) in the area of communication; Laubeck (2005), Beck (1986), Muller and Millen (2000) in organizational structure; and Connaster (2005), Gilpatrick and Furlong (2004), and D'Souza and Williams (2000) regarding manufacturing operations). The fact that informal processes exist is not questioned. The effect of informal processes on an organization is discussed at a high level, but to date there has been no effort to define the term "informal process", no methodology presented regarding detection of informal processes, and no means to assess how informal processes affect an organization.

What are informal processes and how do they affect an organization? Let us first define a formal process. A formal process is an accepted collection of activities which converts inputs into outputs, utilizing appropriate, consistent resources and directed by controls. Formal processes may be documented or undocumented. An informal process, therefore, is defined as an activity that is not formalized with respect to inputs, resources, and/or controls; or an activity

that deviates from a formal process. Informal processes exist throughout industries and organizations. The reason for informal processes varies throughout the literature, but one connecting theme is that informal processes exist to fulfill a need that a formal process does not with respect to the achievement of the process objective. The informal processes may be to the advantage or detriment of the enterprise. The issue is that industries and organizations are depending on the actual data to make decisions on the effectiveness and efficiency of their processes, which processes are stable, and which processes are at risk. The presence of informal processes will affect the data, meaning that the businesses are basing their decisions on inaccurate data.

Let us look at an example where informal processes are present and the informal processes are detrimental to the organization's output. In the mid 1980's a defense contractor supplied reconnaissance analysis equipment to the United States government. The contract was completed, and the defense contractor was supplying spare parts on an as-needed basis. During production, a machined plate was manufactured, and then installed on the system, with an inspection being performed after the system was assembled. A spares part order came in for the machined plate. The spare parts order was filled, the machined plates inspected to the specification, and shipped to the customer. All of the plates passed inspection; there was no waste, so the process was thought to be efficient and effective. Several weeks later the customer called to inform the defense contractor that the plates did not fit on the system. While waiting for the plates to be returned, the defense contractor began investigating the process to determine what had gone wrong. The original machinist (who had since retired), was contacted by the program Quality and Reliability Engineer to see if the machinist could help in gaining an understanding of the problem. The machinist began laughing and stated that the specification

2

had never been correct – if the plates were machined per the drawing they would not fit on the system. The drawing had been incorrect all during the production phase, but no one other than the machinist was aware of this because the machinist never told anyone, and utilized an informal process (i.e. deviated from a control) in order to produce the correct output. The process, as defined, was not effective. In this example, the informal process cost the contractor in terms of wasted material, labor, equipment demand, and their relationship with the customer.

In contrast, an informal process was the salvation for the Apollo 13 crew. Apollo 13 launched on April 11, 1970 with a mission of landing on the moon and returning the astronauts and their samples from the moon safely to Earth. Two days after the launch, Apollo 13 experienced an explosion of one of its two oxygen tanks resulting in a loss of power to the command module. National Aeronautics and Space Administration (NASA) engineers scrambled and "developed" an informal procedure utilizing all equipment on board the command and lunar module to support the three astronauts over a four day period and bring them home safely. The informal process was to use the lunar module as a "life boat" for three astronauts over a four day period. The lunar module was designed and carried the necessary life support for two men over a two day period. In this example, the informal process allowed the safe return of the Apollo 13 astronauts.

Informal processes are an inherent part of any organization, and affect all aspects of an organization's business. Informal processes can vary from day to day and can have both a positive and negative impact on the effectiveness and efficiency of the organization's processes in many areas (financial, safety, compliance, etc.). Informal processes cannot be eliminated (nor should they necessarily be). However, a methodology for the detection and assessment of the impact of informal processes can be developed that will enable businesses and organization's to

have more accurate and complete data from which to make their decisions regarding the effectiveness and efficiency of their processes.

As seen in the two brief examples above, there are informal processes that have positive contributions (these are advantageous to the organization) and informal processes that have negative contributions (these have disadvantages for the organization). Table 1 summarizes the advantages and disadvantages of informal processes.

Table 1. Advantages and Disadvantages of Informal Processes

Advantages	Disadvantages
Improved efficiency – process may be completed in less time	Does not allow for corrective action for what is actually occurring
Improved communication – employee newsletter put out by employees that is not sanctioned by organization	Can affect the true measurement results of the process
Improved morale – one-on-one meetings with supervisor/management	Lacks accountability
Improved effectiveness – use of a different tool yielding better results	Generally not repeatable/sustainable
Promotes continuous learning	May detract from the intent of the formal system
Promotes continuous improvement	Requires tribal knowledge
Meets a perceived/actual need	Reactive
Adaptive	

If an informal process is advantageous to the organization, the organization will want to bring the informal process into the formal system so that the benefits of the informal process can be known and achieved by everyone, improving the efficiency and effectiveness of the associated process. Conversely, if an informal process is detrimental to an organization, it must be identified and action taken to revise the formal process to preclude the use of the informal process. The ultimate goal is to have a methodology to identify the informal processes, asses the impact of the informal processes, utilize the positive informal processes by bringing them into

the formal system, and preclude the use of negative informal processes by modifying the formal system, thus improving the overall effectiveness and efficiency of an organization's process outputs.

Section 1.2 Research Objectives

The principal objective of this research is to develop a methodology for the identification and assessment of informal processes. The identification of informal processes will consist of two methods. The first method is an indirect detection methodology consisting of a questionnaire that will identify the potential for informal processes occurring within the organization. The second method of identifying informal processes is through the use of a process audit.

The assessment portion of this research will provide a methodology for assessing the impact of informal processes within an organization at any given time. The assessment is a two-part process, in which an initial assessment will be made prior to any treatment of the informal processes (i.e. positive informal processes being incorporated into the formal system or modification of the formal system to preclude the use of detrimental informal processes). The second assessment will be conducted following the treatment of the informal processes. The objective is to show that the inclusion of positive informal processes within the formal system is advantageous to the overall output of the organization.

There are six (6) objectives that must be met in order to develop the identification and assessment methodologies of informal processes. These objectives are as follows:

1. Modeling of the organization from a process perspective,
2. Modeling of the processes,

3. Development of a process taxonomy, to include both a generic process taxonomy and a taxonomy of informal processes,

4. Determination of the causes of informal processes,

5. Identification and detection of informal processes, including both an indirect methodology and a direct methodology, and

6. Development of the methodology for assessing the impact of informal processes with respect to the overall output of an organization.

These objectives must be cohesive with respect to one another and the overall objective of this research. The following section (1.3 Research Approach) will address how the cohesiveness will be achieved. The realization of these objectives, coupled with their cohesiveness, will allow an organization to identify their informal processes, assess the impact of the identified informal processes on their overall output, and take appropriate action with respect to the informal processes, thus increasing the probability that the organization's overall output will improve.

Section 1.3 Research Approach

Organizations currently assess the viability of their company utilizing actual data, expert judgment, or a combination of the two. The majority of these assessments focus on "what could happen" (i.e. processes not followed) versus "what is happening" (i.e. processes not followed as documented, or as accepted as the standard). The concern that this methodology raises is that "what is happening" is not necessarily what is documented/accepted. Informal processes occur, bringing either a positive or negative bearing on the data for "what is happening".

The initial task in the research effort was to perform a literature review in regards to all areas associated with the proposed research. Thus, literature reviews were conducted in the areas

of the existence and effect of informal processes, audits, audit sample sizes, process modeling, and organizational modeling. The results of the literature reviews are found in Chapter 2 of this paper.

The objectives of this research as stated in Section 1.2 can be described as a journey along a path (refer to Figure 1), where the foundation of the path is a "process". The stones along the path are the various objectives of this research, with the destination being the ultimate objective of defining a methodology for the detection and assessment of informal processes within an organization.

Figure 1. Research Path
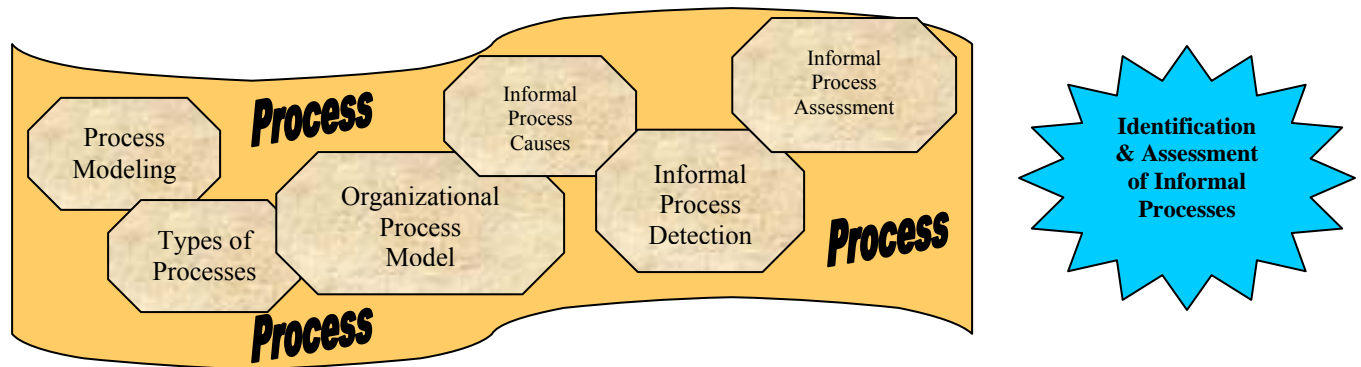
The path is laid on the foundation of a process. The first objective of this research is to define a process – the elements of a process, how these elements interact, and how the process will be modeled. The literature review found numerous process models, each with advantages and disadvantages over the others. An objective of this research is to develop a process model that will incorporate all of the beneficial elements of the current process models while addressing those elements that are disadvantageous within the current models.

After the defining of a process and developing a process model, we must ask ourselves what are the various types of processes within an organization and how are they influenced by

the other processes. This question can be answered in numerous ways based on the type of organization. The research will develop a process taxonomy that is generic to all organizations, small or large, high-tech or low-tech, manufacturing or service, or highly regulated or those with little to no regulation. The interactions of processes within the various types of organizations will be defined. The taxonomy can be utilized to categorize all processes within any organization. Additionally, a process taxonomy will be developed for informal processes that can occur within any process of an organization.

Now that the taxonomy of processes is known, how are these processes modeled within the construct of an organization? The research will develop an organizational model that is based on a process perspective rather than the traditional organizational models that are based on departments, areas of operations, or along organizational hierarchy.

As stated previously, the ultimate goal is the detection and assessment of the informal processes within an organization. We must understand the causes of informal processes for each of the process taxonomies to have a complete background prior to beginning the effort of detecting the informal processes within the organization. Therefore, the causes of informal processes will be addressed and mapped to one another to aid in the identification of the informal processes within an organization.

Utilizing all of the information above, a methodology for the detection and identification of informal processes will be developed. There will be two (2) detection methodologies. The first is an indirect methodology that consists of a questionnaire and will allow an organization to determine the probability that informal processes exist within the various process taxonomies. The advantage of this indirect methodology is that it is quick, inexpensive, and can direct an organization to the significant areas that should be examined further utilizing the direct detection

methodology. The direct detection methodology is a process audit of an area of interest, or may be expanded to encompass the entire organization. To date, there are guidelines for the performance of compliance audits, but guidelines for process audits are not available. An objective of this research is to develop guidelines for the performance of a process audit – the direct methodology approach.

The final aspect of this research is the development of a methodology for the assessment of the impact of informal processes on an organization. The assessment should be performed twice. The first assessment is scheduled to be completed during or immediately upon completion of the direct detection (process audit). At this point, the assessment will show an organization the probability of the output in question being deficient. After the completion of the process audit, an organization should take the appropriate action to rectify the effect of the informal processes. If the informal process contributes positively to the formal process, the informal process should be incorporated into the formal system. For an informal process that is detrimental to the organization, the formal system should be modified to preclude the use of the informal process. Once the formal system has been modified as above, then a second assessment should be performed to determine the probability of the output in question being deficient. The modification of the formal system should create a positive effect within the organization.

The viability of the developed methodologies will be examined at an individual level as well as being applied to an organization.   Data will be obtained over a range of manufacturing and service organizations from various sources that we will classify as:

- First-person, unlimited access

- First-person, limited access

- Third-party

First-person, unlimited access refers to data collected from organizations by the researcher, with no restrictions placed on the type or amount of data gathered. First-person, limited access is specific data authorized by the organization that is directly collected by the researcher. Third-party data is data that is collected through various databases. Only databases with sufficient quality data relevant to the research will be utilized.

Organizations that agreed to provide first-party, unlimited access data for this research include a small chemical manufacturer, and a small service industry. First-party limited access data was obtained from a large design and manufacturing organization.

Industries that maintain databases used in third-party data include nuclear and transportation. The Nuclear Regulatory Commission has documents residing on their database (http://www.nrc.gov/reading-rm/doc-collections/enforcement/) that contain enforcement actions related to required processes that are not followed at various nuclear facilities. The data gathered from this site is limited, as the actions and causes are summarized, and comprehensive reports are not available. Processes identified are classified in accordance with the process taxonomy developed for this research. The National Transportation Safety Board website (http://www.ntsb.gov) contains numerous databases related to accidents and accident investigation for the aviation, highway, marine, pipeline, and railroad industries. The data from the aviation (limited to commercial air carriers operating in the United States) and marine (limited to commercial cruise lines operating from United Sates ports) industries are utilized in this research.

Development of the interactions of the processes within various organizations was determined utilizing subject matter experts (SME). Nine SME participated in the research, with no two being from the same industry.

Within the research, a methodology was developed for determining the probability of the system (output) failing as a result of formal and informal processes. There is no universal value associated with the failure of the output, rather it is highly product/service/process dependent. Likewise, when there is discussion of the assessment of the impact of informal processes, this can encompass impacts of a financial, safety, compliance, quality, or reliability nature to name a few. Two basic methodologies are utilized to assess the positive effect of bringing the informal processes into the formal system.

The first methodology is quantitative and involves the change in the probability of the failure of the output prior to bringing the informal processes into the formal system and after the informal processes have been accounted for in the formal system. This methodology is demonstrated with actual examples from audits.

The second methodology is more qualitative in nature due to limited data access. Real world examples of the effect of informal processes were investigated. This investigation consisted of systematically reviewing the literature/data, identifying the informal processes, directly linking the informal processes identified to the developed process taxonomy, and determining their effect on the organizational output. A review of the changes made (bringing the informal processes into the formal system) was conducted as well as a review of the organizational output afterward.

This research was approached from both an academic and practical view. The completed objectives will allow an organization to detect and assess the impact of informal processes within their company. This concept is crucial when attempting to rectify potential issues of a process, or for continuous improvement of the process. The remainder of this dissertation contains the

literature review and leads us along the path to reach the ultimate objective – the methodologies for the detection and assessment of informal processes.

Chapter 2 contains the background information and information obtained during the multiple literature reviews including the following:

- Information on informal processes – their existence in various industries and whether the authors viewed informal processes as positive or negative,

- A history of the audit process , types of audits, and the purpose of each audit type,

- Numerous methods of determining sample size for audits with a brief discussion of the applicability of having a predetermined sample size during the audit process,

- Current process models – their use, application, advantages and disadvantages of the current models, and

- The theoretical basis for the process taxonomy with respect to the SoTeRiA (Socio-Technical Risk Analysis) framework.

In Chapter 3 we will begin our journey along the path to our ultimate destination with a definition of a process and the introduction of a new process model (DROMĒ) that visually represents all aspects of a process. The basis for this model and a detailed discussion of the elements of the model and their interactions will be presented.

At the conclusion of Chapter 3, we will have an understanding of what a process is, and how the process can be modeled. The next logical question is "what are the types of processes that exist"? A process taxonomy will be presented in Chapter 4 that is inclusive of all processes within any industry.

Chapter 5 includes the use of the process taxonomy as a basis for the modeling of the organization from a process perspective. The basis of the organizational model and its elements

are discussed. Examples of organizations and their high level processes are given within Chapter 5 as well.

At this stage, we have the foundation of our path, the basic process, the process taxonomy which allows us to categorize our processes, and we can now model our organization from a process perspective. So we must now ask ourselves what are informal processes, are there specific types of informal processes, and what causes these informal processes? Chapter 6 includes the answers to the above questions with a process taxonomy for informal processes, causes of informal processes, and a mapping of the informal processes showing interrelationships of the causes of informal processes.

Chapter 7 contains a description of the methodology for detecting informal processes – both the indirect method and the direct method. The indirect method is a questionnaire that is designed to allow an organization to determine what areas of the company have the greatest probability of containing informal processes. The development of the questionnaire, justification of the questions, and how they relate to the process taxonomy introduced in Chapter 4 are presented. Additionally, data obtained from completed questionnaires are presented with the results and conclusions regarding this methodology. Once a company has completed the questionnaire, it can utilize the results to focus their efforts within an area that shows the greatest probability of containing informal processes. At this point, the direct detection methodology (process audit) will be implemented. To date, there are no generic process audit guidelines available. One objective of this research is to develop these guidelines. Within Chapter 7 the guidelines are presented, with discussion of the phases of the process audit, the tools used when performing a process audit (process model (DROMĒ), organizational model, document trees)

and basic characteristics of process auditors. Validation of this methodology is presented with results and conclusions.

Now that we have techniques to identify the informal processes, we must discuss how we will assess the impact of these processes on the overall output of an organization. Chapter 8 provides the background and theory supporting the assessment methodology and correlates all of the concepts and objectives related to this research. The results of SME are presented and linked to the overall assessment methodology.

Chapter 9 includes a qualitative review of the effect of informal processes on past and present incidents within history. Although quantitative techniques cannot be applied to the data, as it is limited, the reviews provide examples that all can recognize.

In Chapter 10 the methodologies and models presented in this research area applied to two (2) corporations. The first is a small manufacturing company, the second is a small service company. The organizational model, process models, categorization of the company processes, detection methodologies, and assessments were done for each of the companies with the results shown in the respective chapters. From both companies, we find that the inclusion of the positive informal processes in the formal system and modification of the formal system to preclude the use of negative informal processes results in an overall decrease in the probability that the company output will be deficient.

Finally, ending our journey along the path to the detection and assessment of informal processes, Chapter 11 provides a summary of the research, contributions that the research has made, and a discussion of potential future work.

Chapter 2: Background

Section 2.1 Introduction

A comprehensive literature review was undertaken in support of this research. First, we needed to determine if informal processes are recognized in various industries and areas. If so, why do informal processes exist, and do they have a positive or negative effect on the organization? It was of interest to locate any prior research in the areas of detection and assessment of informal processes within an organization. As the current research progressed, literature reviews were performed in the areas of process modeling (to provide information as to the current process models, their advantages and disadvantages), and audit history and types of audits, as this directly relates to the direct detection methodology. During the course of the research, when the determination was made that a process audit would be the tool utilized for the direct detection of informal processes, we then needed to perform an additional literature review on audit sample size to determine the proper sample size for process audits. In an effort to explain why an informal process detected using the methodologies presented in this research will impact the output of an organization, we need to associate this work with a comprehensive organizational framework. The SoTeRiA framework proposed by Mohaghegh provides the associated link to organizational performance modeling. The review of the SoTeRiA framework will highlight the theoretical justification of the process taxonomy, process model, and causes of informal processes within the current research.

Section 2.2 presents the information regarding the presence of informal processes within various industries and areas and their effect (positive or negative). Section 2.3 outlines the history of audits and describes the most recognized audit types utilized within organizations currently. A comparison between the compliance audit, the most widely used audit in industry

today, and the process audit, the proposed methodology for the direct detection of informal

processes is provided. Section 2.4 discusses the audit sample size and the various techniques

used by auditors today to determine the correct sample size. In Section 2.5 we will review the

most frequently used process models and discuss the advantages and disadvantage of each.

Finally, in Section 2.6, the theoretical basis for the SoTeRiA framework is reviewed in

preparation for linking the areas within SoTeRiA to the proposed process taxonomy.

Section 2.2 Informal Processes

Subsection 2.2.1 Informal Processes in Economics

In "Formal and Informal Credit Markets in Egypt", Mohieldin and Wright (2000) state

that the existence of both formal and informal credit markets is a widespread phenomenon in

developing economics. The informal credit market came into being to fulfill a need that was not

being met by the formal credit market. The formal credit market primarily services long-term

needs, i.e. investment services, production purposes, whereas the informal market services

smaller loans for bridging or consumption smoothing purposes. Typically, the informal market

is associated with relatively short term needs, and/or unusual circumstances. The formal market

is for the long-term norms.

Nee (1998), in "Norms and Networks in Economic and Organizational Performance"

declares that formal processes are produced and enforced by organizations such as the state and

firm, while informal norms arise out of networks and are reinforced by means of ongoing social

relationships. If the formal processes are perceived to be congruent by affected personnel, the

relationship between formal and informal processes will be closely coupled.

Lomnitz (1988) has studied the informal economy in third world countries and discusses

her findings in "Informal Exchange Networks in Formal Systems: A Theoretical Model".

16

Lomnitz sees "informality" as a residue of traditionalism as well as an intrinsic element of "formality", in that informality is a response to the inadequacies of a formal system. Informality is shown to be both an adaptive mechanism as well as a mechanism that reinforces the shortcomings of the formal system. The main points of the article are:

- The more formalized, regulated, and planned a social system is, but unable to fully satisfy social requirements, the more the social system tends to create informal mechanisms to escape the control of the system,

- Informal modes of exchange grow within the formal system, and thrive on the inefficiencies of the formal system,

- Informal activities are socially embedded transactions that differ from (and often clash with) economic rationality or the formal ideology, and

- The formality of the system, the relative degree of "inappropriateness" (illegal vs. just not a nice thing to do), the goal of the activity, and the tolerance the society has toward breaking the rules, are factors in the degree of the informal system.

Subsection 2.2.2 Informal Processes in Communication

Informal processes are prevalent in communication. Formal, documented systems are improved by the use of "informal" communication. In "Behind the Scenes: An Examination of the Importance of the Informal Processes at Work in Conciliation", Garman and Hilditch (1998) state that the documented policy-making procedure was augmented with informal discussions among members, leading to the adoption of the amendment.

Subsection 2.2.3 Informal Processes in Organizational Structure

Laubach (2005), in "Consent, Informal Organization and Job Rewards: A Mixed Method Analysis", states that informal organizations rival formal organizations in their effect on the day-to-day functioning of an enterprise. The informal organizations are the actual pattern of human interaction upon which the work of the organization is performed.

"Social Construction of Knowledge and Authority in Business Communities and Organization" by Muller and Millen (2000) hypothesize that that methodologists are designated by the authority of the organization, and are constructed as both authorities and experts. The rank and file personnel perform their work in accordance with the rules that have been authored and authorized by the designated experts. These are the formal processes. However, contends Muller and Millen, there is often an understanding that experienced staff members may have deeper knowledge than the rules, and may therefore help the business by circumventing or even breaking the rules – this would be the informal process.

Beck (1986) develops the effect of informal employee monitoring within an organization in his article titled "Internal Control Technologies within Industrial Organizations". Beck concludes that while formal monitoring (by supervisors) of employees is the mainstay of organizational control systems, informal monitoring (typically by peers), is also important.

Subsection 2.2.4 Informal Processes in Manufacturing Operations

In the book entitled, "The Elusive Lean Enterprise", Gilpatrick and Furlong (2004) discuss the agents of change within the subcultures of an organization. In addition to the subcultures, they state that you also have to be aware of the differences between the formal and informal processes. Examples are given of items that are heard when an organization attempts change that directly point to the use of informal processes:

- "Oh, we haven't followed that policy in years",

- "Our manager told us years ago to ignore that process step",

- "We have not updated that rate schedule",

- "Yeah, we knew about that policy, but we told everybody it was not workable, and no one listened".

"Transforming Tribal Knowledge into Written Instructions" Connaster (2006) states that manufacturing companies will benefit with the transformation of the tribal knowledge into written instructions in several ways. Connaster (2005) defines tribal knowledge as "any unwritten information that is not commonly known by others within a company. This term is used most when referencing information that may need to be known by others in order to produce quality product or service". So, tribal knowledge can be seen as a form of an informal process. The benefits of transforming tribal knowledge to written instructions include:

- Worker turnover will not imperil the continuous operation of the company, nor the quality of the products,

- Best practices are documented, distributed, and used by all workers, and

- During the documentation process, inconsistent or ineffective practices can be discovered, and hopefully, resolved.

Authors D'Souza and Williams (2000), in "Toward a Taxonomy of Manufacturing Flexibility Dimensions", define "process flexibility" as a dimension of the process that represents the ability of the system to adjust to and accommodate changes/disruptions in the manufacturing process". In this article, the call for the flexibility of a process will eliminate the need for an informal process for those situations that can be planned for in advance.

Subsection 2.2.5 Miscellaneous Cases of Informal Processes

Rolland, Prakash, and Benjamen (1999), in "A Multi-Model View of Process Modeling", state that while processes are prescriptive, in actual practice, departures from the prescription can occur, thus recognizing the fact of informal processes.

The idea of the informal process is brought forth by Hill, Yates, Jones, and Kogan (2006) in "Beyond Predictable Workflows: Enhancing Productivity in Artful Business Processes", when they state that there are always exceptions, and processes need to be flexible to accommodate these conditions.

Moody, Green, Muller, Tang, and Moran (2006), write that business processes are usually supported by formal workflow systems (i.e. formal processes). Workflow systems have been criticized for the strict and rigid requirements they impose on people. There is evidence that most business work is inherently different from a workflow. People engage in "artful" processes (i.e. informal processes).

"A Requirements Interaction Detection Process Guide" outlines the task of establishing guidelines in requirements engineering when determining requirements interaction. Shehata, Jiang, and Eberlein (2004) group the current practices into two categories:

- Informal techniques – achieved by hiring experts to detect interactions, and
- Formal techniques – building models of the target system and then validate the models against a set of properties.

Due to the expense and time associated with both the informal and formal methods, as well as the errors using the informal method, the authors proposed a semi-formal compromise that fills in the gap between the formal and informal method. It combines the subjectivity of the informal technique with the systematic detection process of the formal method.

McKenna (1975) in "Blending the Formal with the Informal System" states that an informal system will always exist in any organization and that the informal system emerges from the values and attitudes of the involved personnel and because the formal system does not meet the personnel's needs in the aggregate.

"IT User Learning – The Role of Informal Processes", by Kavathatzopoulos (2004) declares that organizations need informal structures, and that they emerge in all organizations. Formal structures are not sufficient to cover all problems. Kavathatzopoulos hypothesizes that informal processes are related to the nature of the work, the formal work organization frame, and the competence of the work team members.

Landvater (1993), in his book, "World Class Production and Inventory Management" states that if the formal system does not provide people with the necessary information to do their jobs, an informal one will appear. He hypothesizes that there are three basic reasons why a formal system will not work, and will therefore require an informal system to be developed:

- The formal system is based on an invalid model, or

- The formal system is based on sound logic, but the data feeding the system is inaccurate, or

- The formal system is valid, the data is valid, but the management is poor.

Subsection 2.2.6 Informal Processes as a Positive Contribution

Vollman, et.al. (2005), in "Manufacturing Planning and Control Systems for Supply Chain Management" believe that informal processes may be positive in the right environment. Specifically, "informal procedures may be quite effective for managing inventories in a small-scale warehouse; as the number of products and sales volumes increase, more formal inventory control methods are needed to assure continued growth".

Muller and Millen (2000), when describing formal and informal processes, state that there is an understanding that experienced staff members may have deeper knowledge than the rules, and therefore, may help the business by circumventing or even breaking the rules.

Subsection 2.2.7 Informal Processes as a Negative Contribution

Landvater (1993), in "World Class Production and Inventory Management", describes informal processes as reactive, focusing attention on "saving the day", and states that when informal processes are present, employees are stressed and strained. He categorizes informal processes as inefficient and costly, states that the informal processes will eventually break down because they are highly susceptible to personnel changes, and they have a long learning curve associated with them due to the fact that informal processes are based on personal knowledge and experience. Additionally, Landvater states that informal processes paralyze the ability for a company to be managed effectively because the informal processes compromise either: set objectives, accountability, the ability to provide tools, and/or the ability to measure performance.

Eckert, Clarkson, and Zanker (2004), in "Beyond Predictable Workflows: Enhancing Productivity in Artful Business Processes" state that well-defined (formal) processes help designers to work efficiently and they increase the change of successfully generating a new product. Conversely, unstructured (informal processes) which are lacking in appropriate methods can result in substandard or late products.

McCann (1999), in his article, "Watch Out for Informal Systems", has nothing positive to say about informal processes. Although he does say that production that operates outside of standard procedures may be simultaneously helpful and harmful, the positive aspects can obscure the damage that is done. McCann states that an informal process runs counter to or bypasses a standard operating procedure, has evolved over time and become habitual, is performed by one,

or at most, a handful of employees, and appears, superficially, to be functional. McCann's largest argument against informal processes in the article is that the knowledge needed to carry out the process is not available to the organization as a whole.

Subsection 2.2.8 Positive and Negative Influences from Informal Processes

McKenna (1975) theorizes that the informal process, while linked both by form and function to the formal process, can either detract from or add to the intent of the formal process. The formal process may be slow in responding to external forces, while the informal process may be adaptive and able to perform innovative functions that are not met by the formal system. However, informal processes may also operate to the detriment of goals, e.g. work slowdown, and hardware damage.

Subsection 2.2.9 Informal Processes Summary and Conclusions

Informal processes exist throughout industries and organizations. The need for informal processes varies throughout the literature, but one connecting theme is that informal processes exist to fulfill a need that the formal process does not. The informal processes may be to the advantage or to the detriment of the enterprise.

The advantages of informal processes include:

- Improved efficiency (allows processes to be completed in less time, with less steps, etc.),

- Improved communication (newsletter done by employees for employees that is not sanctioned),

- Improved morale (one-on-one meetings with management),

- Improved effectiveness (use of a different tool yields improved results),

- Promotes continuous learning,

- Promotes continuous improvement,

- Meets a perceived/actual need, and/or

- Adaptive.

The disadvantages of informal processes include:

- Does not allow for corrective action for what is actually occurring,

- Can affect the rue measurement results of the process,

- Lacks accountability,

- Generally not repeatable/sustainable,

- May detract from the intent of the formal system, and/or

- Reactive

The question now becomes, since we are aware that these informal processes exist, how do we take them into account? Obviously, if metrics are being taken, the metrics are not accurate. If a production line is yielding 98% of their product, but informal processes are being utilized, we cannot say that their formal system is effective or efficient. It becomes imperative that a methodology is developed to detect and assess the informal processes.

Section 2.3 Audits

Auditing began as early as 5000 B.C. when the Chaldaean and Babylonian empires imposed taxes on both individuals and businesses. A system of checks and counterchecks was developed to ensure that there was no misappropriation of the collected taxes by dishonest tax collectors. Likewise, in 3000 B.C., Mesopotamia had a system of ticks, dots, and checkmarks to control their tax collection audit system.

In 1934, the Securities and Exchange Commission (SEC) was established in the United States. The SEC required registered firms to provide financial statements certified by independent auditors. This requirement prompted firms to establish internal audit departments, primarily to assist the independent auditors. For this reason, internal auditing was viewed as an important function from the perspective of both the company and the independent auditors. It should be noted that at this time, the independent auditors placed emphasis on the opinion of the fairness of the financial statement versus detecting fraud or clerical errors.

In 1941, the Institute of Internal Auditors (IIA) was formed. The early to mid-40s had various inter-related forces (increased inflation, growing complexity of the business environment, decentralization and diversification of corporations) that formed the basis for the IIA Statement of Responsibilities of Internal Auditing:

> [An internal audit is] an independent appraisal activity within an organization for the review of the accounting, financial, and other operations as a *basis for protective and constructive service to management*. It deals primarily with accounting and financial matters but it may also properly deal with matters of an operating nature.

In the 1950s, after World War II, many companies were looking for ways to utilize their excess plant capacity due to the absence of military production. This absence of military production led to increase competition, with companies needing to trim their operating costs and increase their market share. Corporate management requested help from their internal audit departments, but the majority of the recommendations made by these departments were ineffective, while those recommendations that were viable were not acted upon. This travesty was due to the internal auditors not having access throughout the organization and therefore they

could not question decisions made by top management; the majority of the internal audit departments could only look at matters of finance and accounting, and they did not have trained, professional accountants; and internal audit departments typically reported to lower level management. These issues prompted the IIA to release a new Statement of Responsibilities of Internal Auditing in 1957, which stated that:

> [An internal audit is] an independent appraisal activity within an organization for the review of accounting, financial, and other operations as a *service to management*. It is a *managerial control*, which functions by *measuring and evaluating the effectiveness* of other controls.

The 1970s had an additional Statement of Responsibilities of Internal Auditing released by IIA, and a new organization began to look seriously at audits. In 1971, the IIA released the new Statement of Responsibilities of Internal Auditing:

> [An internal audit is] an independent appraisal activity within an organization for the review of operations as a service to management. It is a managerial control which functions by measuring and evaluating the effectiveness of other controls.

A steering committee was chartered by the American Society of Quality Control (ASQC) in 1975 to develop requirements for quality auditing. In 1978, IIA broadened the scope of the Statement of Responsibilities of Internal Auditing to state that an internal audit is an independent appraisal activity established within an organization to examine and evaluate its activities as a *service to the organization*.

In the 1980s, IIA once again rewrote the objective and scope of the Statement of Responsibilities of Internal Auditing to now state that the scope of internal auditing included *economy and efficiency* as well as *program evaluation audits*. ASQC's steering committee on

quality audits began development of a certification exam for quality auditors in 1984. The exam was first administered in 1987.

Prior to the 1990s, the scope of the audit functions was basically compliance and review. During the 1990s, there was a conscious effort to focus audits on processes and systems versus mere compliance.

The most frequently utilized audit type is the compliance audit, as it is the fastest and easiest type of audit to perform, and it does not interfere with an organization's activities. The process audit is utilized by industries that are on the leading edge of quality management systems. Process audits must be performed by auditors with experience and those that are capable of performing an audit without the use of a checklist. With that said, there are five (5) categories of audit types.   Audits can be categorized based on their specific function. The basic categories, or types, of audits are as follows:

- Compliance Audit - an examination of the organization's documentation, matching the documentation with actions taken, compares and contrasts written documentation to objective evidence to verify compliance with the documentation

- System Audit - addresses the who, what, where, when, and how of the organization's system to produce the product or service; macro in nature

- Product Audit - a detailed inspection of a finished product performed prior to delivering the product to the customer

- Process Audit - revolves around the verification that the resources perform according to the controls, using the specified inputs, to achieve the required output; concerned with the validity and overall reliability of the process itself; two modes – appraisal and analysis

o Appraisal: verified that personnel involved in the process are performing in accordance with the organization's documentation

o Analysis: is the documentation used in support of the process helpful or detrimental; thorough or incomplete; does duplication of effort exist between sub-functions; does the overall process complement the expressed or implied objectives of the organization?

- Follow-Up Audit - conducted to verify that corrective action commitments from a prior audit were met and the action taken eliminated the cause of the deficiency.

The two audits that will be examined further are the compliance audit and the process audit. Compliance-based audits are excellent tools if the only objective is to ascertain whether or not an organization is meeting the requirements. They do not provide any knowledge regarding if the organization has processes that support their objectives, and whether or not these processes are efficient and effective.

The compliance-based audits that will be reviewed in subsection 2.3.1 include those utilized by the Federal Aviation Administration (FAA), the Australian Competition and Consumer Commission (ACCC), the Australian Securities and Investment Commission (ASIC), and the 1994 version of the International Organization for Standardization (ISO) 9001: Quality Management Systems Requirements.

Russell (2006) states that process audits are tightly focused, but their effectiveness is often overlooked because there is no published, sanctioned process audit standard. A process audit is viable because it allows the auditor to examine the details involved with a specific process and verify that the process is effective in producing the intended output, as well as doing so efficiently. Subsection 2.3.2 reviews the ISO 9001:2000 Quality Management Systems

Requirements in terms of the shift to the process approach, presents information on a process approach checklist for manufacturing, and provides two examples of how process audits have contributed positively in two organizations (Solvay Polymers and Toronto General Hospital).

Subsection 2.3.1 Compliance Auditing

The Federal Aviation Administration (FAA) relies on compliance-based audits for their oversight of the commercial airline industry. In 1998, the FAA implemented ATOS (Air Transportation Oversight System) which grouped regulatory requirements into seven systems, fifteen subsystems, and 105 elements. This design was to "identify safety trends in order to spot and correct problems at their root cause before an accident occurs". Originally, ATOS was designed to shift the FAA inspectors away from their thirty-year inspection method focused on mere compliance to regulations to an approach that proactively assessed risks within the commercial air carrier's maintenance and operations systems.

Since the inception of ATOS, the checklists that the FAA inspectors utilize to perform their oversight activities have been updated on the average of once a year. The latest update was to contain a change from the strictly compliance-based audit to a process-based audit. However, the ATOS system is still divided into the original systems, subsystems, and elements and all responses are marked as "yes" or "no". The checklists now include questions such as, "is there a process in place at the air carrier for XYZ requirement?", but there is no means for the inspectors to go further to see what that process is, if it is effective and if the process is efficient for the required output. Even now, the information posted by the FAA regarding ATOS states, "FAA inspectors now look at an airline as a whole, to see how the many elements of its operations – from aircraft to pilots to maintenance facilities to flight dispatch to cabin safety – interact to meet federal standards" (FAA 1998). The last portion of that sentence, "to meet

federal standards", is a clear statement that the oversight activity performed by the FAA is compliance-based.

Advisory Circulars issued by the FAA are to be used by the commercial air carriers for guidance on issues that the FAA would like for the air carrier to address, but at the time there is no regulation on the issue. However, the ATOS checklists do contain questions (to be marked "yes" or "no") regarding if an air carrier has some of these "voluntary" programs. For example, one of the checklist utilized by the FAA in their oversight of the air carrier is entitled "Element Performance Inspection (EPI) Data Collection Tool, 7.2.1 Safety Program (Ground and Flight), (OP)". Question 1.4 of the May 30, 2008 released checklist asks, "Was an internal evaluation program (IEP) used?" Again, the FAA inspector must mark the checklist either "yes" or "no". FAA Advisory Circular 120-59A (released 4/17/2006) is an extensive document providing guidance for an air carrier's internal evaluation program. In Section 1.b of this advisory circular, it states, "There is no regulatory requirement for an IEP". This is an example of how compliance audits are not sufficient to verify that an organization's systems and processes are effective and efficient.

In Australia, Christine Parker (2003) examined compliance program audits to determine if the audits were capable of providing assurance that the compliance system was performing as intended. "Regulator-Required Corporate Compliance Program Audits" is the result of Ms. Parker's research. The organizations and related compliance audits reviewed were companies with questionable compliance programs, the Australian Competition and Consumer Commission (ACCC), and the Australian Securities and Investment Commission (ASIC). Both the ACCC and the ASIC require audits to monitor compliance, but neither regulator has guidance on the requirements of a compliance program audit. Consequently, there is not a common practice

between auditors, or the information that is made available to the management of the corporation being audited at the completion of the audit.

The literature by Ms. Parker suggests that a portion of the compliance audits could be labeled "desk nonaudits", in that the audits are performed solely on the review of company paperwork that is supplemented by an hour interview with the company's commissioning officer. The result of this type of audit is a management review that inspires better compliance from the company. The compliance program audit methodology noted was one that focused on management systems at the expense of investigating issues that had occurred, or were likely to occur. A critical issue with compliance audits was raised by Ms. Parker, "…the audit methodology is rarely directed towards collecting evidence about how systems relate to compliance outcomes".

In the original version of the ISO 9000 series of standards, both the internal audit function, as well as the accreditation auditors, were auditing for compliance. The 1994 version of the ISO 9001 standard contained twenty elements that required documentation. The first step in implementing the ISO standard was to document that your company had a system in place to address each of the twenty elements. The next step was to document the company's systems and related processes.

When the auditors (internal or accreditation) performed their audit, they would first review the documentation to see if the company had addressed all of the elements required by the ISO standard (typically a "desk audit"). The next step was to verify that all of the affected departments within the company performed their processes in accordance with their documentation.

Subsection 2.3.2 Process Audits

In the latest version of the ISO standard on Quality Management Systems Requirements, the standard has been revised to use a process approach during the development, implementation, and maintenance of the quality management system. The standard states: "An advantage of the process approach is the ongoing control that it provides over the linkage between the individual processes within the system of processes, as well as over their combination and interaction" (ISO TC 176, 2004). This revision to the standard has forced the audits done by both internal auditors as well as accreditation auditors to utilize process audits.

In her book, Process Approach Audit Checklist for Manufacturing, Karen Welch publishes checklists to be used during process audits in manufacturing facilities that can be used in conjunction with the ISO 9001:2000 standard. Ms. Welch states that an organization can begin the journey of process audits by first determining the key processes along with the sequence and interaction. After this is accomplished, the support processes should be determined and linked to the key processes.

Ms. Welch's book (2005) contains guidelines that are good starting points for organizations that have not performed process audits in the past. She states that although auditing by process is logical, it is not an easy task for a new auditor. Process audits require more knowledge of the overall system of the organization as well as improved communication skills. An insightful comment by Ms. Welch is that …"each organization is unique, and effective audit techniques vary widely by organization and auditor".

Let us now look at two examples where process audits have benefited an organization. Solvay Polymers is a plastics manufacturer in Deer Park, Texas. Their use of process audits was published in the article "The Process Audit: Often Ignored but Never Insignificant". A process

audit was conducted on the assessment of the melt index. The melt index is the primary measurement during the manufacturing of plastics, and is governed by the American Society for Testing and Materials (ASTM) standard ASTM D 1238-95.

The audit verified that employees were familiar with the written procedure and could readily locate and access the written procedure. The audit found that the process was effective, but when checking for efficiency, an opportunity for improvement was found. The current procedure at the time of the audit required that a sample be measured to within ± 0.1 gram. The department responsible for this measurement was the quality assurance lab, which was behind schedule. As a consequence, the processes were being held up until after the measurement was confirmed. An investigation was made to determine if a container could be used to obtain a fixed volume of sample each time to assess the melt index. A container was located, a change was made to the written procedure, and the process is now more efficient that before, saving the company and employees both time and money.

Traditional medical audits typically consist of an audit committee checking each part of a medical record to ensure that the record is complete and appropriate signatures are present. The committee does not assess whether the diagnosis is accurate, the quality of patient care, nor the outcome of the care.

In the article "Evaluating the Effectiveness of a Process Medical Audit in a Teaching General Hospital", the authors describe a process medical audit that was implemented in an attempt to overcome the deficiencies of the traditional audit. The process audit systematically evaluated patient care and established if specific actions had occurred.

As a result of the process audit, for several processes to be more effective, the audit committee recommended improving the documentation related to sleep studies, and to reduce the

use of a particular hypnotic drug. The recommendation to improve the documentation was complied with; however the recommendation to reduce the use of the hypnotic drug was not. The authors suggested the reason behind the acceptance of one recommendation and not the other was due to the groups involved. The increased documentation was a duty of the nursing staff. The nursing staff has a defined hierarchy, and the policies instituted by head nurses are followed by the nursing staff. The recommendation to reduce the use of the hypnotic drug was a responsibility of the medical staff – a loosely knit group of doctors with no specific hierarchy.

The results of this article show another instance in where a process audit contributed to the effectiveness of operations, but also highlights the issue of implementation of recommendations based on the organization's structure.

Subsection 2.3.3 Summary and Conclusions of Literature Review Regarding Auditing

Audit methods have been around for many years, and are varied, depending on the organization type and their focus. While compliance audits are certainly necessary, they do not provide an organization the opportunity to detect informal processes, nor to improve their processes. Table 2 provides a direct comparison between compliance audits and process audits. Thomas Houck, in his book "Why and How Audits Must Change: Practical Guidance to Improve Your Audits" states that fundamental changes must be made in the vast majority of auditing firms. Specifically, Houck says that the audit approaches used by the vast majority of audit firms are inadequate and out-of-date.

Table 2. Comparison of Compliance Audits and Process Audits

COMPLIANCE AUDIT	PROCESS AUDIT
Capture and document objective evidence of the level of conformance to requirements	Assess and measure the effectiveness of a process
Looks at the results of a process or activity	Looks at the inputs, controls, and resources of an activity
"Rules" are not questioned – objective is to determine compliance with the rules	Focuses on determining if the process is as effective as it could be
Outcome is binary – pass or fail	Outcome provides areas for improvement
Does not cross department or functional boundaries	Capable of showing interdependency of contributing factors across department or functional boundaries
Consists of three basic questions: 1) Tell me what you do (describe the process) 2) Show me where it says that (reference procedures/manual) 3) Prove that it happened (evidence in documented records)	Goes beyond compliance audits by: 1) Focuses on risk, status, and importance 2) Review and judgment on effectiveness of process

Section 2.4 Audit Sample Size

Prior to reviewing the information gathered from the literature, it is imperative that we have an understanding of the term "audit" and the term "inspection". Although these terms are oftentimes used interchangeably, they are not identical. An inspection is a formal or official examination that determines if the population output is of sufficient quality based on the examination of a predetermined number of samples from the given population. Whereas an audit is an independent, objective evaluation of an entity's system's processes providing evidence of the effectiveness, efficiency, and compliance of the process as it relates to the entity's objectives. An audit does not pass judgment on the quality of the output.

There is no agreement within the literature as to the correct number of samples to be taken when conducting an audit. Sample sizes can be described as either statistically valid or not valid statistically.

When audits of the state of Ohio Medicaid Cost Reports are performed, the sample sizes are determined based on data categories and are statistically valid. The samples sizes are prescribed by the Ohio Administrative Code. These categories include disability assistance versus uncompensated care charges, whether the individual was insured or uninsured, and the size of the hospital (small, medium, or large). The required sample size is thirty-two (32) for a small hospital and ninety-six (96) for a large hospital.

The University of Texas Medical Branch allows six (6) different sampling strategies, some with a statistical basis, and others that are not statistically based:

1. Systematic Sampling

    o   Requires knowledge of the population total.

    o   Dependent on the frequency of audit (annually, quarterly, monthly, etc.).

    o   Random approach of selecting items at intervals.

2. Dollar Unit Sampling

    o   Based on a probability proportional to size.

    o   Utilizes confidence levels.

3. Judgmental Sampling

    o   Nonrandom approach based on the auditor's suspicions or reasoning.

    o   Unable to statistically extrapolate the sample results to the entire population.

4. Manual Controls and Substantive Testing

o Based on frequency of audit and provides the auditor with a table that allows a choice of sample sized dependent on the level of comfort desired.

5. Automated Controls

    o Allows a sample size of one if the general computer controls and override policies and procedures are adequate.

6. Small Populations

    o Requires fifty percent (50%) sampling for populations less than 200.

As can be seen from the above information, organizations have various allowable methods for determining audit sample size. This is a common issue throughout the literature.

Moeller (2005) relates that public accounting firms have set a theoretical minimum sample size for their audits (typically between thirty (30) and sixty (60)), but states that internal auditors generally should not use a minimum sample size during an audit. Conversely, Deakin and Granof (1974) choose a strategy that borders on bias when choosing sample sizes. They propose utilizing regression analysis as a means to determine the audit sample size, stating that when regression analysis is coupled with Bayesian techniques, the auditor will select accounts for investigation that will most likely result in significant audit findings.

Carey (2003) proposes that various elements be reviewed when determining a sample size. These elements include statistical validity, time, complexity, and criticality. In internal auditing there is no requirement to have a sample size that is statistically valid. True internal auditing does not result in a statement related to the acceptance of a product/service/information.

The next element is time. Time is always a factor when conducting an internal audit, from both the standpoint of the auditor and the area/process/individual that is being audited. Time is influenced by several factors, the amount of time that you have to complete the audit,

how many auditors are on the audit team, what process is being audited (is it a lengthy process, or one that is completed in minutes?), and how often is the process audited? If a process is audited once a quarter, the process takes ten (10) hours to complete, and there is one auditor, then the sample size should be smaller than for a process that occurs once a year with the other elements being equal.

Complexity and criticality go hand-in-hand. The more complex a process is, the more samples you will want to audit. Also, the more critical a process is to the ultimate output of an organization, the more samples you will want to take during the audit.

Personal experience has allowed the researcher to observe several ISO registration organizations conduct audits. The auditors have predetermined sample sizes, some are three (3), some are five (5), and some are (7) samples. No one within the registration organizations has been able to relate the reasoning for the chosen sample size.

When conducting an audit, the elements identified by Carey should be taken into account when determining the sample size. Once the sample size is set, it should not be changed.

Section 2.5 Process Modeling

Subsection 2.5.1 Introduction

Numerous process models are utilized today. A given process model has the potential for multiple applications with the massaging of the basic conventions. To gain a basic understanding of the current process models, five of the most common are discussed within this section: flowcharts, block diagrams, cause and effect diagrams, IDEF0, and the turtle diagram. An example of the handling of a customer complaint is depicted within each section.

Subsection 2.5.2 Flowcharts

A flowchart is a graphic representation utilized to depict the steps or activities of a process using standardized symbols. The flow chart was introduced by Frank Gilbreth in 1921 to members of the American Society of Mechanical Engineers in the presentation, "Process Charts – First Steps in Finding the One Best Way".

Flowcharts are developed using standards symbols. The typical symbols are are follows:

Activity - Within the rectangle is a brief description of that activity.

Decision Point - The process branches into two or more paths at this point. The path taken is dependent on the answer to the question within the diamond. Each path is labeled to correspond to an answer to the question.

Terminal – Identifies the beginning or end of a process according to the descriptive word contained within the terminal (i.e. "start" or "end").
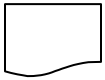
Document – Represents a document pertinent to the process.
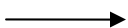
Flow Line – Represents a process path that connects the elements of the process (activities, decisions, etc.). The arrowhead on the flow line indicates the direction of the process flow.

Connector – Indicates a continuation of the flowchart.

Figure 2. Customer Complaint Flowchart

START
COMPLAINT
RECEIVED

RECORD
COMPLAINT

FORWARD
COMPLAINT

CHARTER
TEAM

REVIEW
COMPLAINT

IDENTIFY
SOLUTIONS

A

A

PROPOSE
BEST
SOLUTION

SOLUTION
APPROVED?

NO

YES

VERIFY
ACCEPTABILITY
OF SOLUTION
WITH CUSTOMER

SOLUTION
APPROVED BY
CUSTOMER?

NO

YES

DOCUMENT
SOLUTION

END
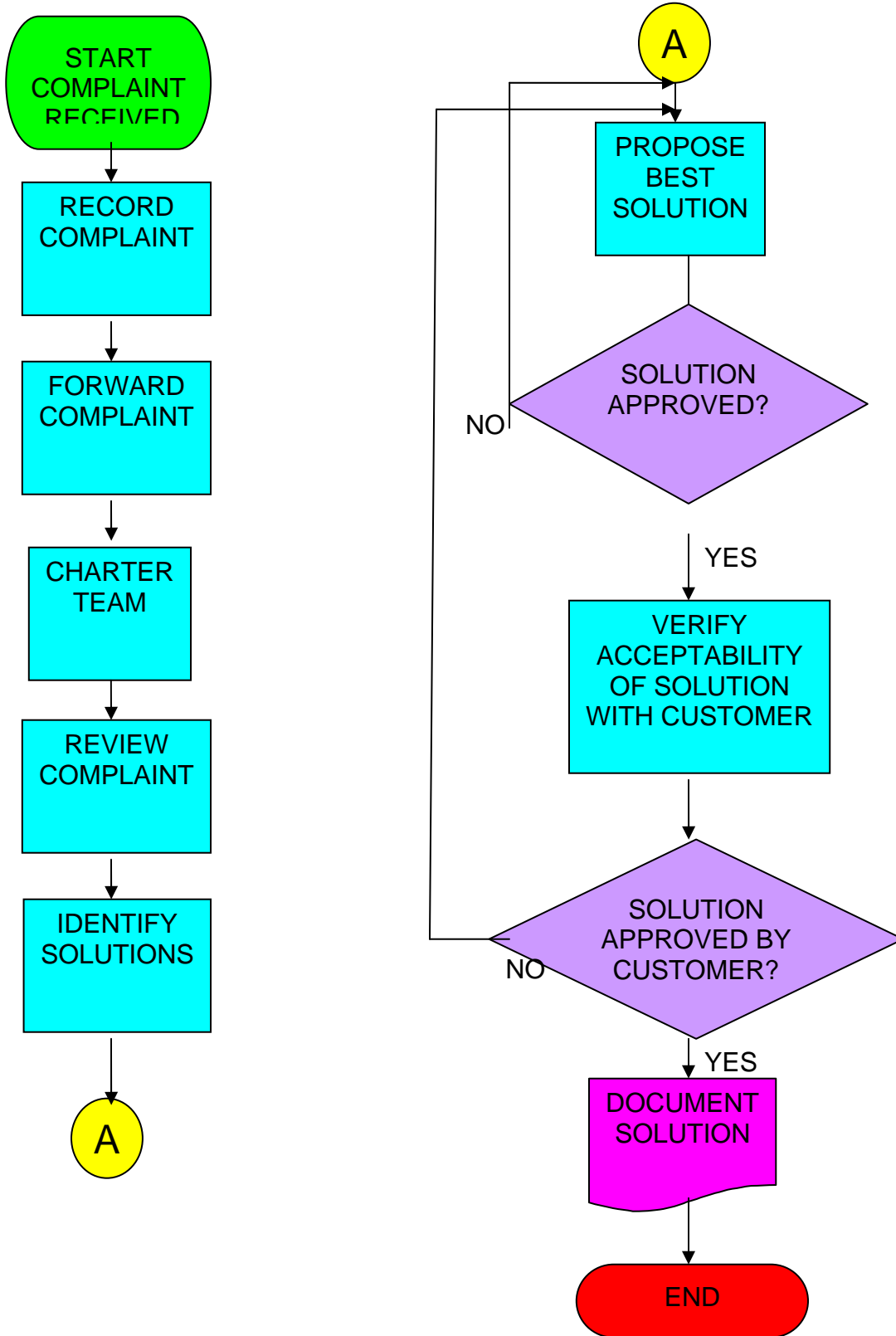
Subsection 2.5.3 Block Diagrams

Block diagrams were used beginning in the 1950s. A block diagram is a specialized, high-level flow chart that presents an overview of the flow of the major steps in a process, the key participants of the process, and any relationships and interfaces involved. A key advantage of the block diagram is that the boundaries of each organizational unit are defined.

Figure 3. Customer Complaint Block Diagram
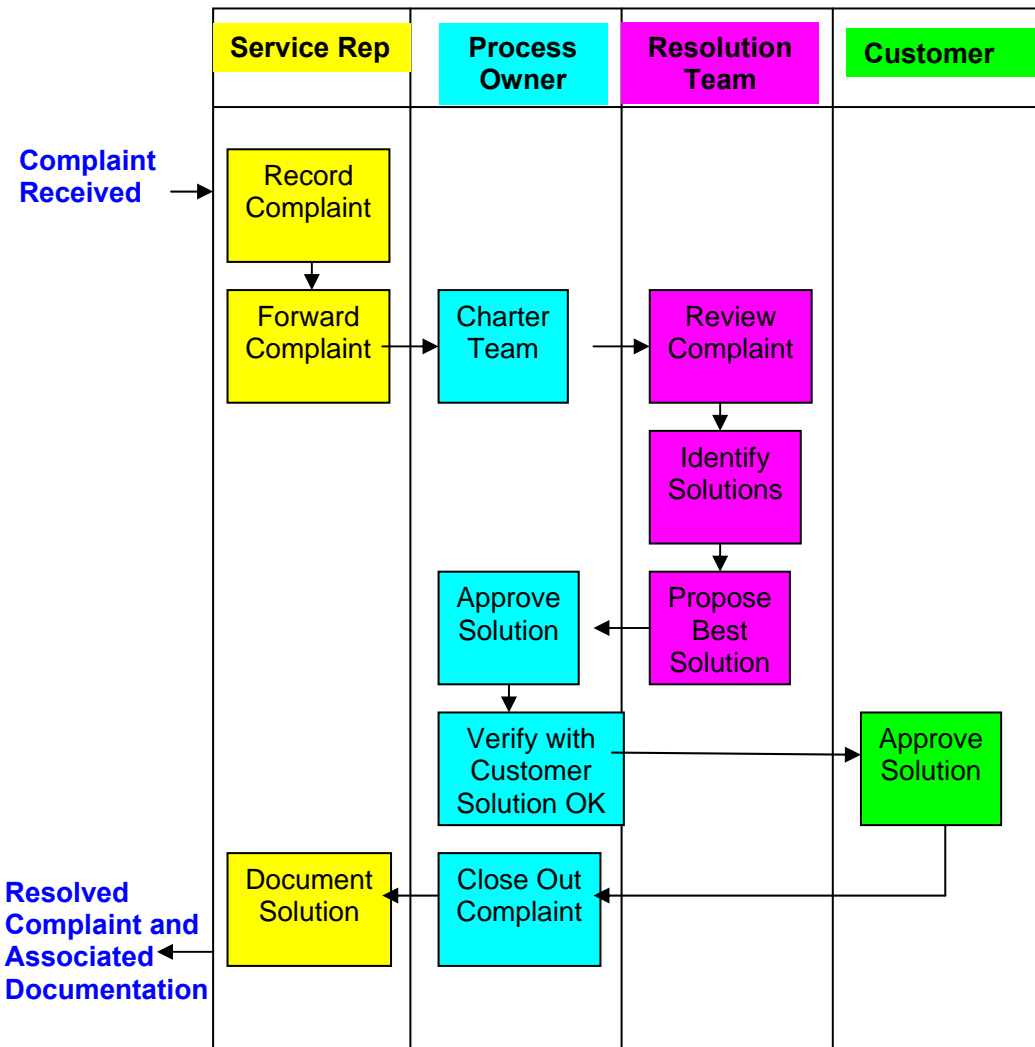
Subsection 2.5.4 Cause and Effect Diagrams

The cause and effect diagram was developed by Kaoru Ishikawa in the 1960s. The diagram is used to explore all of the inputs (potential or real causes) of a process that result in an output (effect). Inputs are arranged according to their level of importance. The basic cause and effect diagram resembles a fishbone, and, as such, is also known as the "fishbone diagram". A basic diagram with the original categories is shown in figure 4.

Figure 4. Basic Cause and Effect Diagram
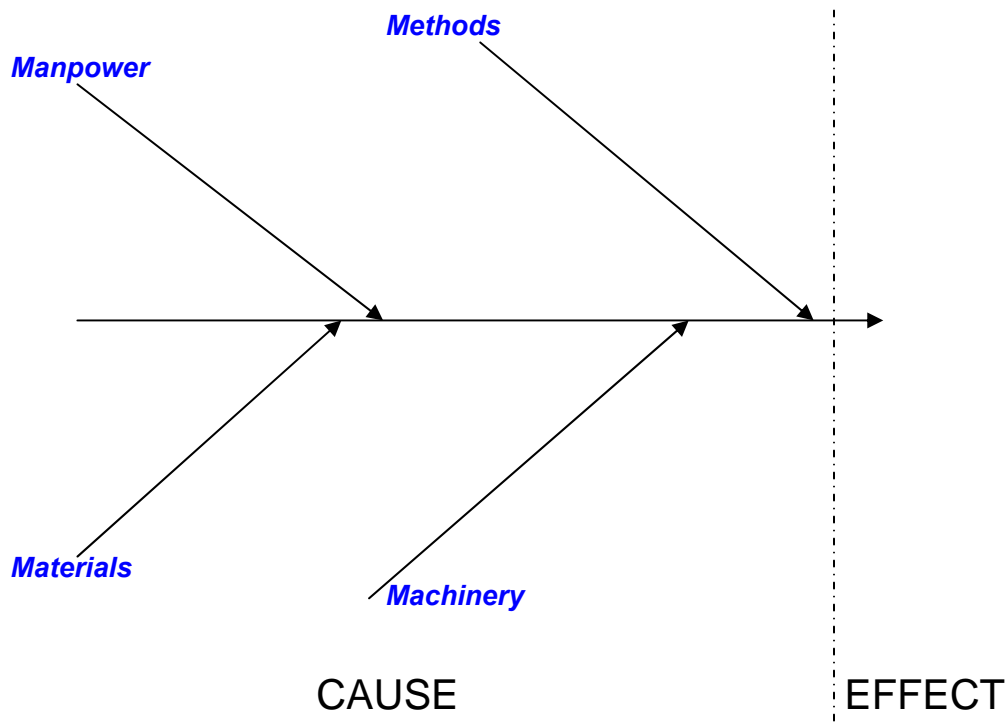
The original cause and effect diagram had four basic causes (or inputs) as shown above: manpower, methods, materials, and machinery. As an example of alternative conventions utilized within one type of process model, other inputs are defined and used such as:

- The Four P's (service industry)
  - o Policies

42

- o Procedures

- o People

- o Plant/Technology

- The Four S's (service industry)

  - o Surroundings

  - o Suppliers

  - o Systems

  - o Skills

- The Six M's (manufacturing industry)

  - o Machines

  - o Methods

  - o Materials

  - o Manpower

  - o Measurements

  - o Mother Nature (environment)

Figure 5. Customer Complaint Cause and Effect Diagram

INPUTS   OUTPUTS
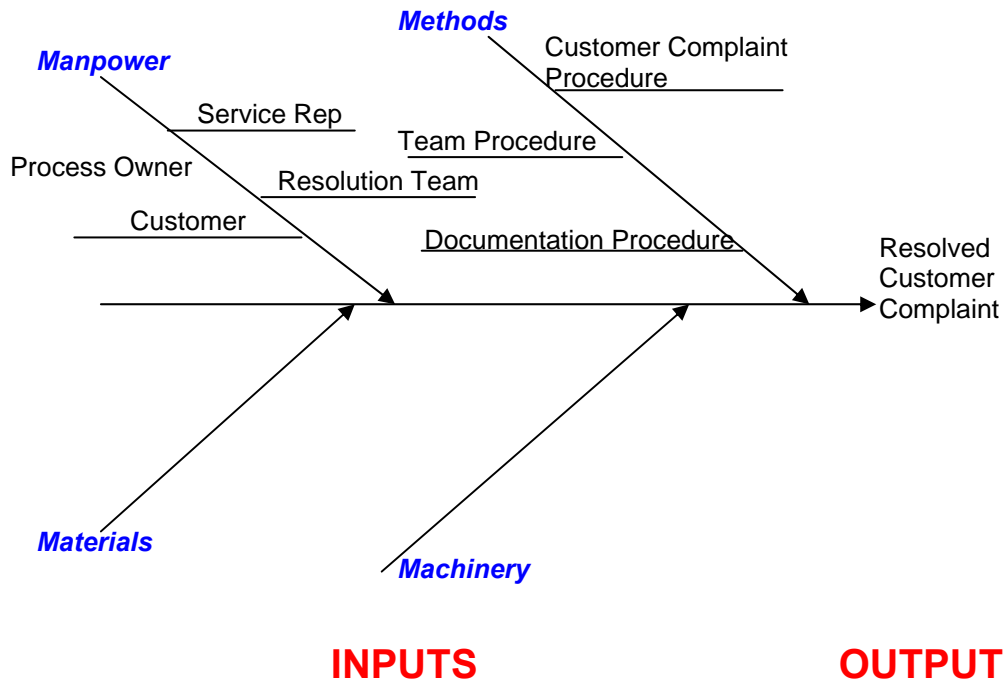
Subsection 2.5.5 Integrated Definition for Function Model (IDEF0)

The IDEF0 technique is based on SADT™ (Structured Analysis and Design Technique™) developed by Douglas T. Ross and SofTech, Inc.   In December 1993, IDEF0 was adopted as a Federal Information Processing Standard (FIPS PUB 183). This standard was a voluntary standard, and was withdrawn in 2005, due to the fact that it was voluntary and available from various standards organizations.

The IDEF0 model begins with a single box showing the ICOM (inputs, controls, outputs, mechanisms) for the overall process (refer to figure 6 for the basic IDEF0 model). A hierarchical decomposition is constructed for each box in the IDEF0 model, then for each box in the resultant model, and so forth until the process is completely described.

Figure 6. Basic IDEF0 Model
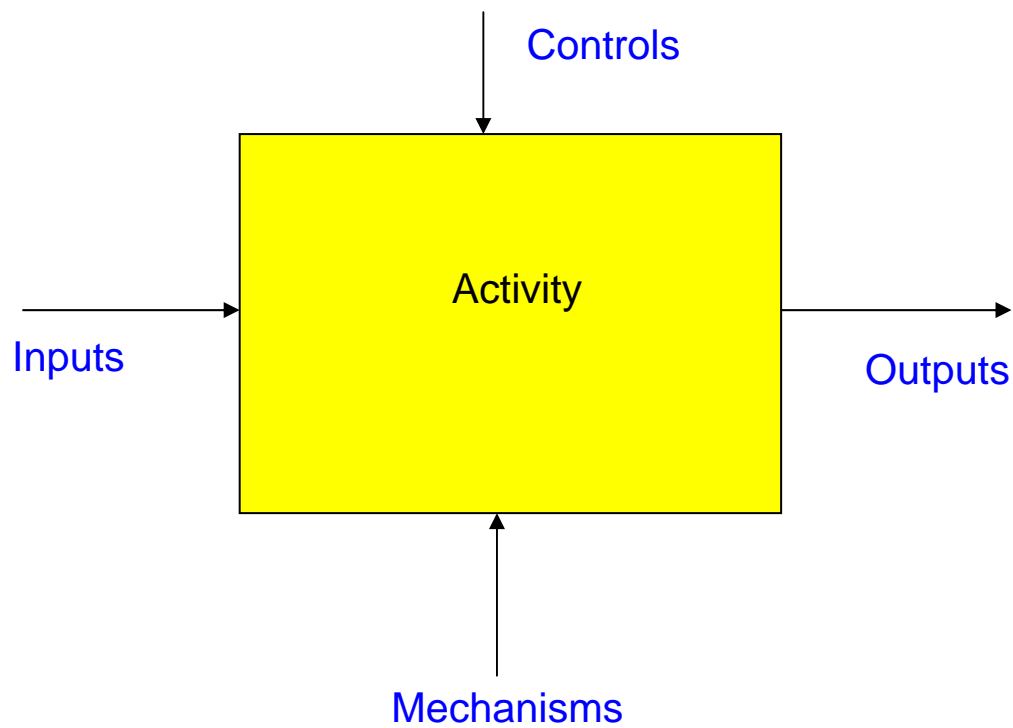
Within the IDEF0 model, the following definitions apply:

- Inputs: data or objects that are transformed by the function into outputs

- Controls: conditions required to produce correct outputs

- Mechanisms: the means used to perform the function

- Outputs: the data or objects produced by a function

Figure 7. IDEF0 Representation
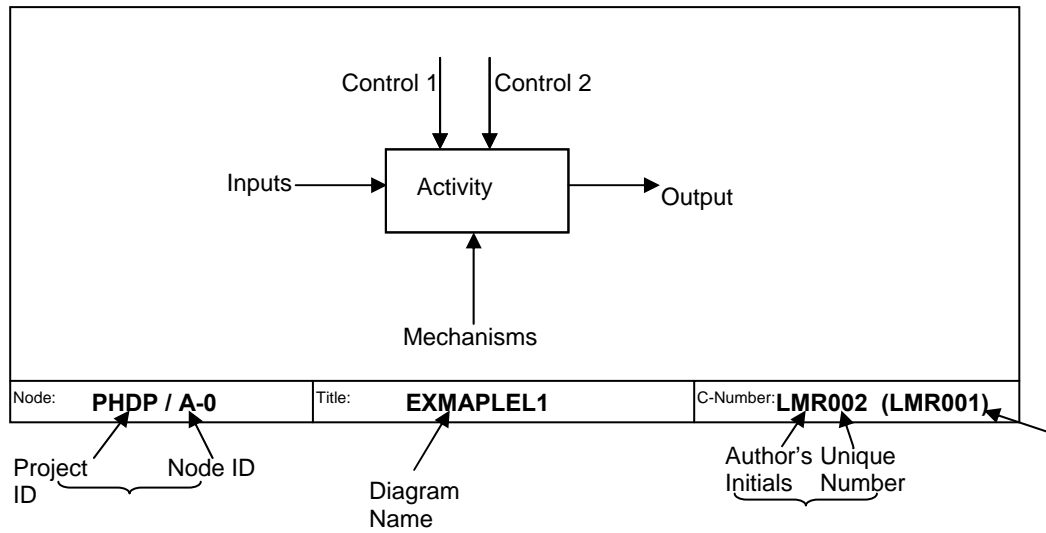
For the purpose of the example of the customer complaint, only the top level IDEF0 will be diagrammed (refer to Figure 8).

Figure 8. Customer Complaint IDEF0
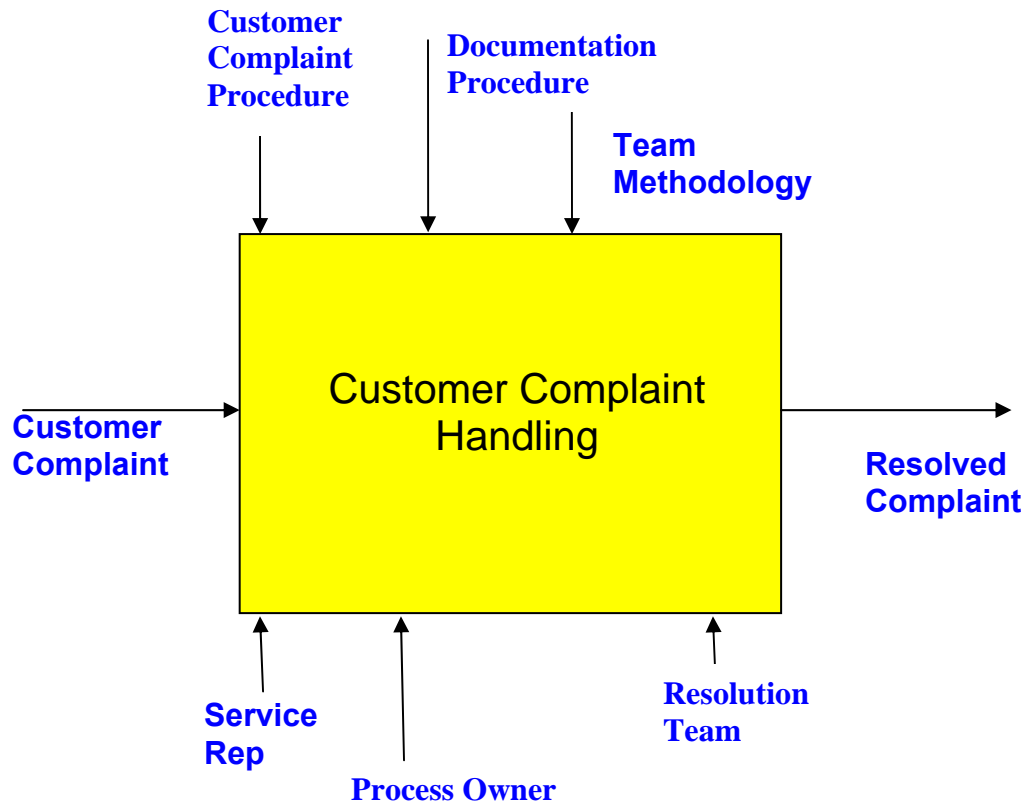
Subsection 2.5.6 Turtle Diagram

The history of the turtle diagram is not well known (who developed the methodology or when). It became widely used in the automotive industry when the standards began requiring the use of a process approach. The turtle diagram is named due to its distinct configuration (see figure 9).

Figure 9. Basic Turtle Diagram
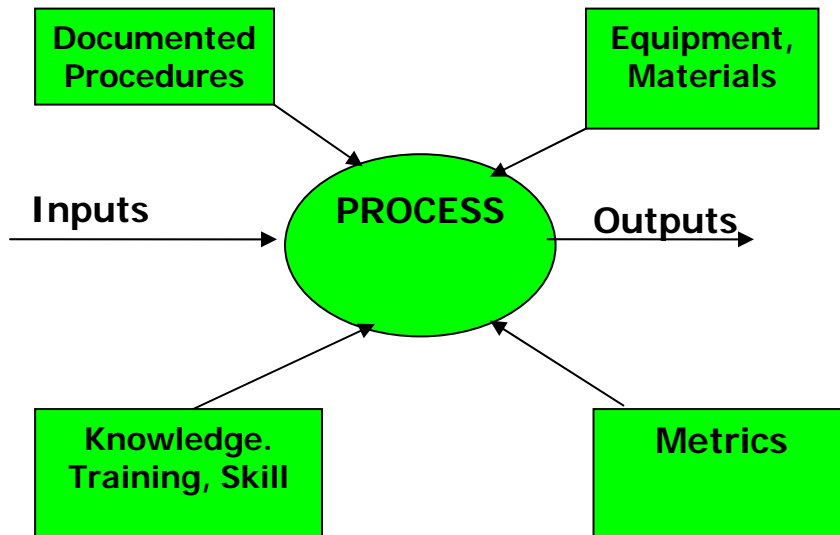
Within the turtle diagram, the following definitions apply:

- Inputs: requirements, drawings, specifications

- Documented procedures: (how) step-by-step process, procedures, standards

- Equipment, Materials: (what) defined and approved, maintained

- Knowledge, Training, Skill: (who) competence, skills, knowledge, training

- Metrics: (results) rate or units completed, rate or units defined, rate or units measured

- Outputs: completed services, finished products

The turtle diagram for the handling of a customer complaint is shown in figure 10.

Figure 10. Customer Complaint Turtle Diagram
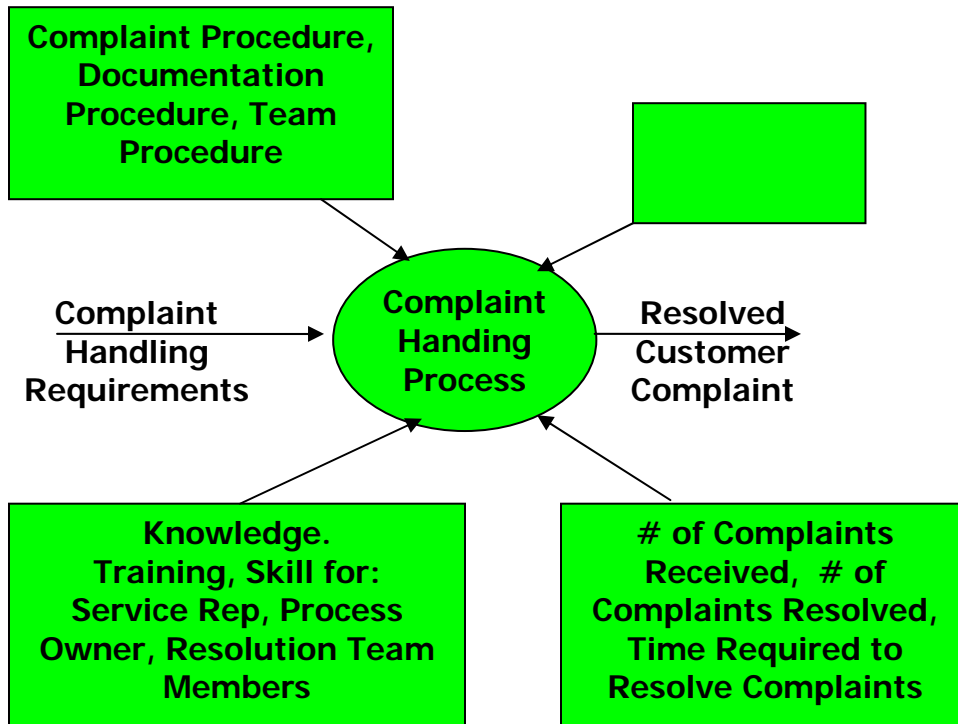
Subsection 2.5.7 Process Model Summary

Process models have become more advanced as time has progressed. Each model has advantages and disadvantages associated with it. Looking at the two most recent models developed, the IDEF0 and turtle diagram, the advantages and disadvantage can be summarized as follows:

- IDEF0
    - Advantages: mature model, well-documented, versatile
    - Disadvantages: does not display "metrics", the mechanism section is not well-defined
- Turtle Diagram

o   Advantage: displays metrics graphically

o   Disadvantages: not widely utilized, does not address "environment", required documented procedures, "knowledge, training, skill" are the only considerations for the humans involved.

Table 3 presents a comparison of the models described above.

Table 3. Comparison of Process Models

	Unique Identification of Inputs	Unique Identification of Outputs	Controls	Materials	Equipment	Environment	Humans	Metrics	Activity Progression
Flowcharts			X						X
Block Diagram	X	X					X		X
Ishikawa Diagram			X	X	X	X*	X		
IDEF0	X	X	X	X	X		X		X
Turtle Diagram	X	X	X	X	X		X	X	X

* Applicable when utilizing the Four P or Six M configuration of the Ishikawa diagram

There is a need for a comprehensive process modeling methodology to be developed that will incorporate all of the essential elements relative to a given process (any type of controls, materials, equipment, environment, all aspects of humans that are involved in the process, and metrics essential to determining the risks associated with the process elements).

SoTeRiA (Socio-Technical Risk Analysis) was developed in 2007 by Zahra Mohaghegh as a framework that integrates technical system risk models, structural aspects of safety prediction models, and social aspects. SoTeRiA provides a link between this research and the theory related to organizations and organizational behavior. Specifically, SoTeRiA is characterized by providing a theoretically supported relationship between organizational culture, organizational climate, and organizational structure and practices. Figure 11 shows the schematic representation of SoTeRiA. We will briefly look at the eight (8) major components of SoTeRiA:

- Safety Critical Tasks – these are the unit outputs of the SoTeRiA framework

- Unit Process Model – consists of the direct activities that affect the unit output (safety critical tasks)

- Individual-level Performance Shaping Factors (PSFs) – the areas in which an individual is affected

- Group Safety Climate – the perception of what happens within an organization; typically a temporary attribute

- Emergent Processes – includes social interactions, leadership and supervision, and homogeneity

- Organizational Safety Culture – relates to the ideologies of the employees, their assumptions and values; shapes the managerial decisions regarding the practices and structural features of the organization

- Organizational Safety Structure and Practices – all structures and practices that support the resources, tools/equipment, and human actions within the unit process model

- Regulatory Auditing System – external factor that affects an organization

SoTeRiA was developed to specifically address a need for a modeling technique within the safety risk analysis area that incorporates both technical and social aspects. We will utilize this model to show how the process taxonomy, process model, and causes of informal processes presented in this research can be incorporated into the SoTeRiA framework.

Figure 11. SoTeRiA Framework (Mohaghegh, 2007)
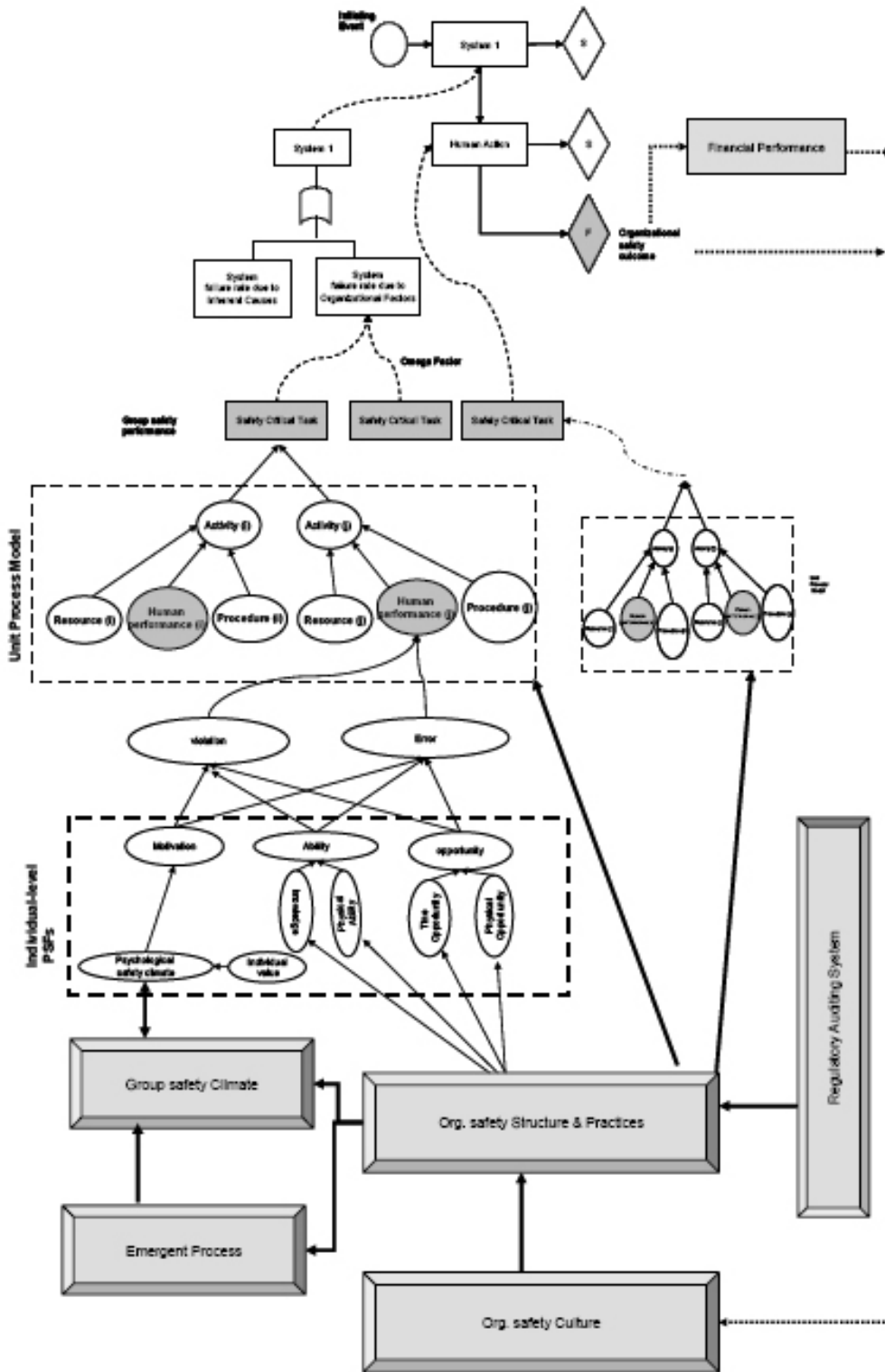
Chapter 3: The DROMĒ Process Model

Section 3.1 Introduction

The basic foundation for any organization is the processes that are performed throughout the organization. If the processes are correctly developed and executed successfully, the organization can be successful. A basic tool in the development aspect is a process model that encompasses all aspects of any processes within the organization.

As shown in Section 2.5, numerous process models are utilized today. A given process model has the potential for multiple applications with the manipulation of the principles of the basic model. As time has passed, process models have become more descriptive, with each model having advantages and disadvantages over the other models (refer to Table 3). The use of a particular model is based on the desired aspects and usage of the model, experience and preference of the organization, and the individual performing the modeling process.

Section 3.2 Basis of the DROMĒ Model

A process model has three primary functions. The model must be descriptive, prescriptive, and explanatory. The term descriptive refers to the ability of the process model to describe the basic elements of the process, prescriptive means that the process model has the capability to establish to the exact elements of the process, and explanatory refers to the ability of the process model illustrating how the process elements interact. The DROMĒ (Direct Representation of the Model Elements) process model is shown in Figure 12.

Figure 12. DROMĒ Process Model
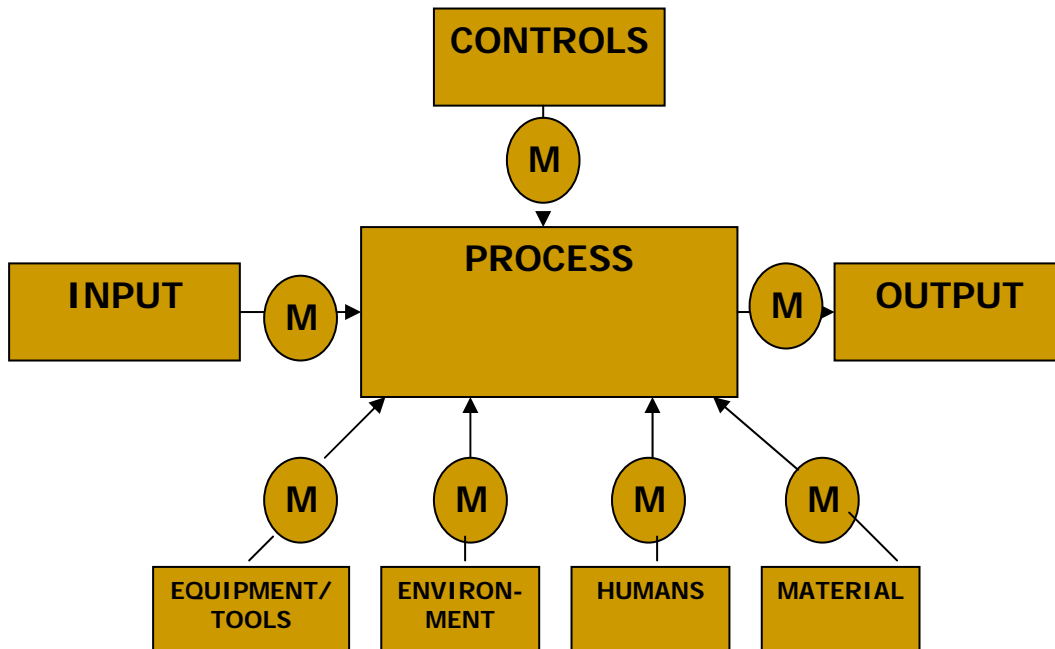
Let us verify that the DROMĒ process model contains the three required functions. Is it descriptive – does it describe the basic elements of the process? As seen, the elements of the process (input, controls, output, equipment/tools, environment, humans, material, and metrics associated with each element) are clearly identified within the model. When a process is modeled, the prescriptive function can be seen. As shown in Figure 13, the exact elements of a process are identified on the DROMĒ example. The example shown in Figure 13 is the upper level process model of the customer complaint procedure utilized throughout Section 2.5. Notice that although there are no specific requirements for equipment/tools, environment, or material for the customer complaint procedure, these elements are still shown on the model. This provides a

visual reminder for the individual performing the modeling to ensure all aspects of the model are addressed.

The third function of a model is to be explanatory – to be able to show the interactions of the elements of the process. To show this function, the customer complaint model shown in Figure 13 has been expanded to lower level models (see Figure 14).

Figure 13. DROMĒ Example for Customer Complaint Handling
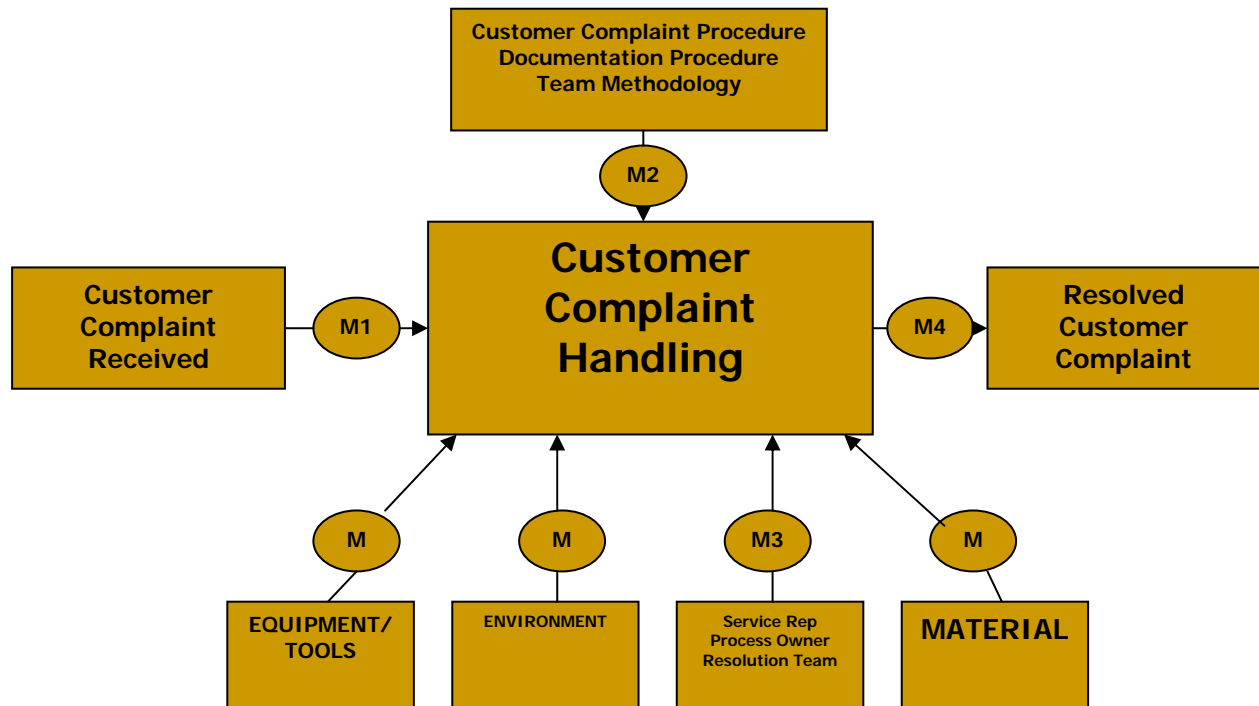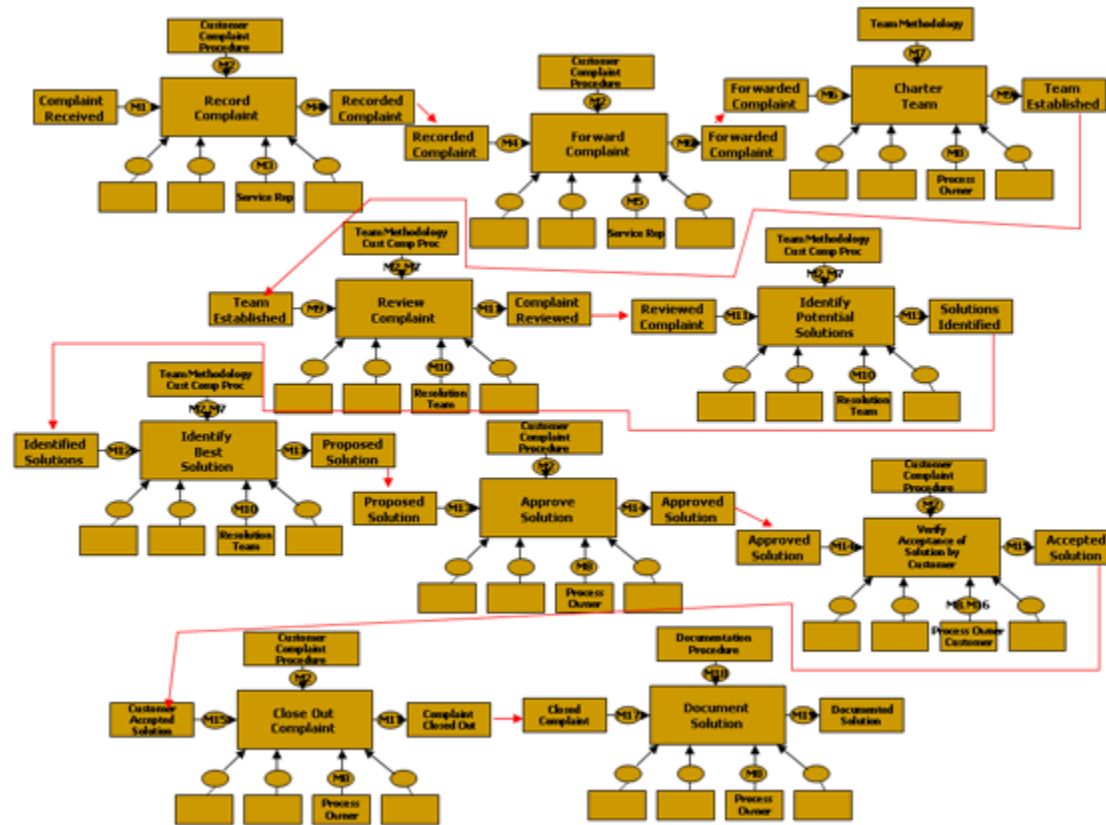
Figure 14. Expanded Customer Complaint Handling DROMĒ

Section 3.3 Elements of the DROMĒ Process Model

The DROMĒ process model was developed to represent all of the essential elements of any given process as well as metrics associated with the various elements. There are seven (7) basic elements of the DROMĒ process model:

1. Input – an event or circumstance that initiates activity required to achieve an objective. An input can take the form of a request for quote, customer complaint, or be the output of a preceding process.

2. Controls – documented or oral information that establishes the method(s) required to achieve the output; all applicable internal and external regulations, standards, specifications, etc.

3. Equipment/Tools

   a. Equipment – an item of tangible property that retains its original shape, appearance, and character with use; does not lose its identity through fabrication or incorporation into a different or more complex unit; is non-expendable

   b. Tools – devices which provide an advantage in accomplishing a physical task, or provides an ability that is not naturally available to the user.

4. Environment – physical conditions that impact or influence the activity performed in achieving the objective (temperature, cleanliness, light, etc).

5. Humans – personnel.

6. Material – tangible substance that may lose is original shape, appearance, and character when incorporated into a different item.

7. Output – the completed objective.

8. Metrics – the various parameters of a process that are to be measured to assess the performance in any given area.

Figure 12, coupled with the definitions of the elements given above; show that the DROMĒ process model contains all of the elements currently found in other process models. It has a well-defined resources area (equipment/tools, environment, humans, materials), and allows for any type of control (documented or undocumented). Table 4 shows the comparison of the DROMĒ process model to those process models reviewed in Section 2.5. As can be seen in Table 4, the DROMĒ model does have all of the characterizations of all current models, and should therefore be more effective in modeling processes when compared to the current models. A disadvantage of the DROMĒ model is that it is a new methodology and will take time for acceptance.

Table 4. Comparison of Process Models Including the DROMĒ Process Model

	Unique Identification of Inputs	Unique Identification of Outputs	Controls	Materials	Equipment	Environment	Humans	Metrics	Activity Progression
Flowcharts			X						X
Block Diagram	X	X					X		X
Ishikawa Diagram			X	X	X	X*	X		
IDEF0	X	X	X	X	X		X		X
Turtle Diagram	X	X	X	X	X		X	X	X
DROMĒ	X	X	X	X	X	X	X	X	X

* Applicable when utilizing the Four P or Six M configuration of the Ishikawa diagram

The DROMĒ process model can be directly linked to the unit process model (see Figure 15) within the SoTeRiA framework. Within the SoTeRiA framework, the unit process model is described as a group of individual performances that have a direct effect on the unit output. We notice that SoTeRiA contains only three (3) elements – resource, human performance, and procedure; in other words, the SoTeRiA framework provides a generalized model for the unit process model. The DROMĒ model introduced in this research provides a comprehensive model that could be substituted into the SoTeRiA framework as the unit process model to further define and capture all of the applicable elements of a unit process. Figure 16 shows a comparison of the SoTeRiA unit process model to the DROMĒ model.

Figure 15. SoTeRiA Unit Process Model
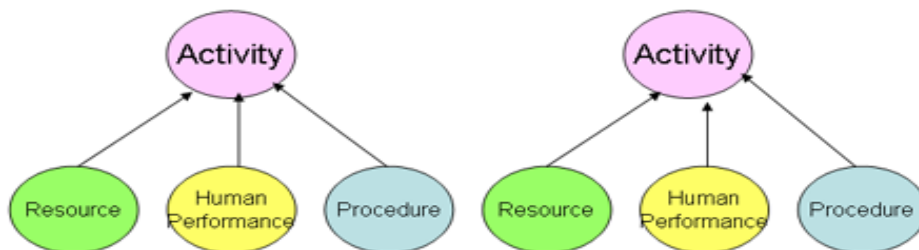
Figure 16. Comparison of SoTeRiA Unit Process Model and DROMĒ Process Model
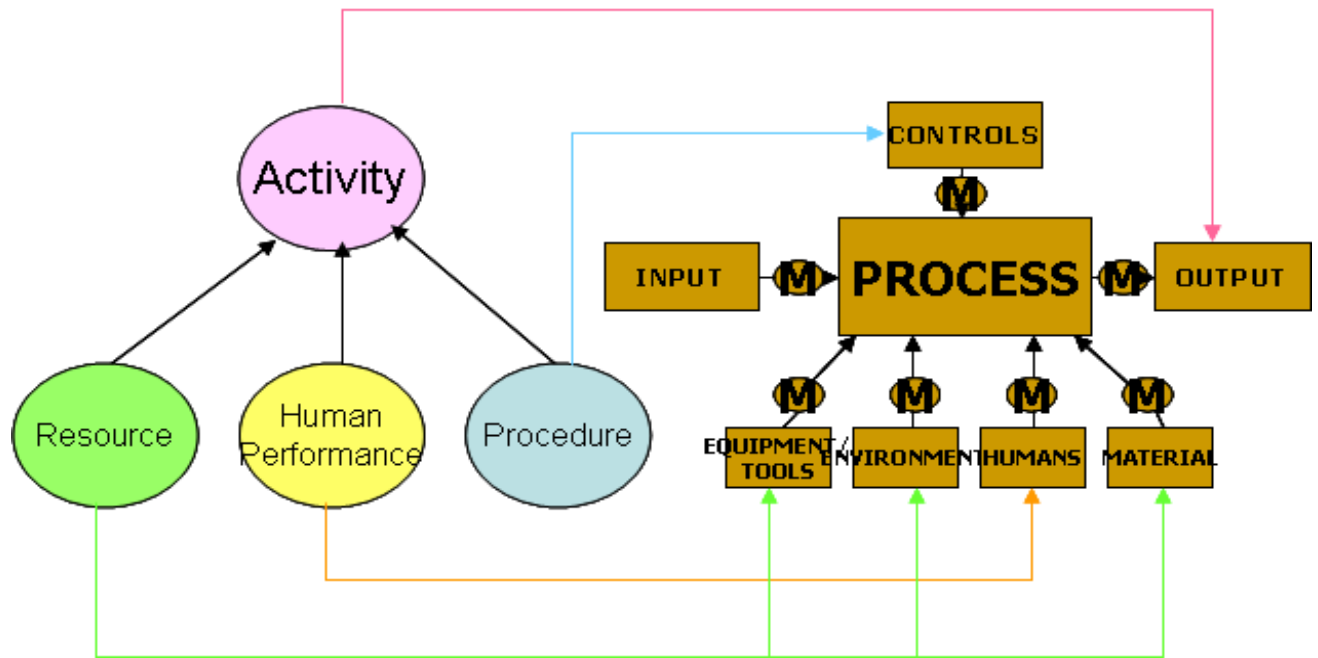
Chapter 4: Process Taxonomy

Section 4.1 Introduction

In Chapter 3, we introduced the DROMĒ process model that incorporates all the beneficial elements of the current process models while addressing those elements that are lacking in the current models. The DROMĒ process mode is the first step in this research patch. Now that we have defined what a process is (the foundation of this research) and have developed a process model structure (first step on the path), we will continue to the second step. For this step, we need to determine what types of processes exist within an organization and how they are influenced by other processes.

A generic process taxonomy has been developed and will be presented in this chapter that identifies the basic processes within any organization. The developed process taxonomy aides in the detection of informal processes and can be directly linked to elements within the SoTeRiA framework. These links allow the theoretical SoTeRiA framework to be related to actual organizational processes.

The process taxonomy consists of two (2) main process areas – strategic processes and core processes. We define strategic processes as those processes that include the organizational management processes (planning, policy establishment, determination of objectives, communication, and customer satisfaction) and resource management processes (processes for the provisioning of resources for the management of the organization, realization, monitoring, and measurement control). Strategic processes typically include human resources, training, sales, corporate policy, documentation, etc. All financial processes would be strategic processes. For the purpose of this research, financial processes were not considered. Core processes are the realization processes (those that provide the intended output of the organization) and measuring

and monitoring processes (those utilized in the measurement and gathering of data for performance analysis, effectiveness, and efficiency). Core processes include those processes that directly contribute to the overall output of an organization. In Chapter 5 we will see how these process groups form two (2) of the major areas within a process-based organizational model.

Section 4.2 Strategic Processes

The basic framework for the strategic processes is shown in Figure 17. Strategic processes consists of two (2) basic areas – organizational management processes and resource management processes. Organizational management processes are those processes that enable goals to be achieved efficiently and effectively with a collection of people working together in a planned deliberate social structure to achieve a common goal.

Figure 17. Strategic Process Taxonomy
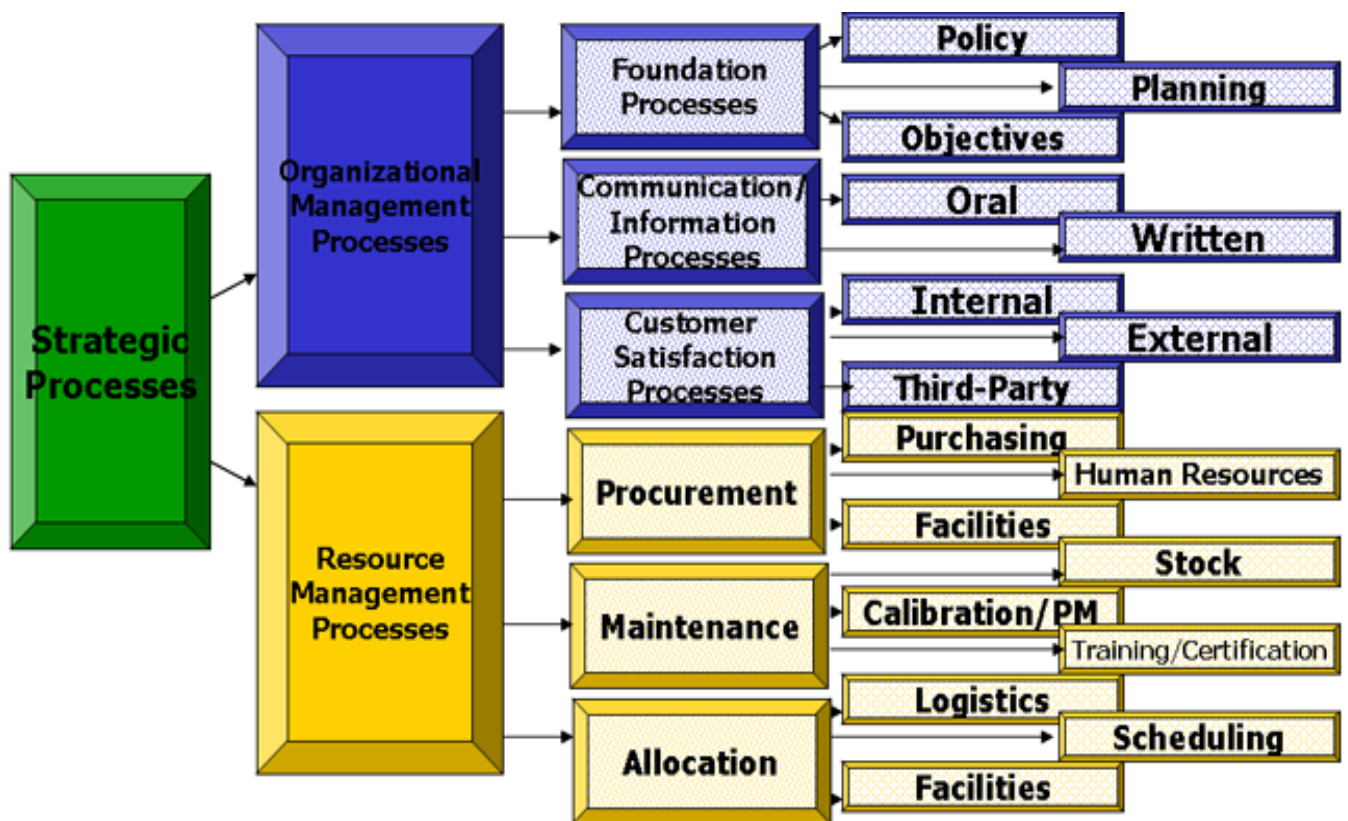
Resource management processes are those processes that enable goals to be achieved efficiently and effectively utilizing any physical or virtual entity of limited availability.

There are three (3) categories of organizational management processes. The first is foundation processes. Foundation processes are processes that determine the fundamental framework from which the goals of the organization are attained. This includes the policy which is the deliberate plan of action used to guide decisions and achieve the required outcome, planning which is the act of formulating a program for a definitive course of action, and objectives which are the goals to be attained by the organization.

The second category of organizational management processes is the communication/information processes. These processes relate to the transferring of information (organized data that has been arranged for better comprehension, understanding, and/or retrieval) from a sender to a receiver with the use of a medium in which the communicated information is understood by both the sender and the receiver. There are two types of communication – oral and written. Oral communication utilizes speech to convey a message, where written communication used letters or symbols set down in writing in any of various ways (paper, electronic, etc.) to convey a message. It should be noted that any written communication must be at a level to be understood by the receiver. As seen by the definition of written communication, there are various means for this to be accomplished. For example, a small organization was in the process of preparing for their ISO 9001 registration. They were attempting to complete all required documentation. The issue was that the majority of their work force did not speak English as their first language, nor were they able to read English. The work instructions (written communication/information) were documented utilizing pictures of the process steps. Pictures that showed what should be done were mounted on a green background.

Pictures of unacceptable steps were mounted on a red background, and pictures of issues that required a supervisor were mounted on a yellow background. This mode of communication/information was understandable to the work force.

Customer satisfaction processes are the third category within the organizational management processes. Customer satisfaction processes are those processes which measure the degree to which a product, service, or information meets the customer's expectations. There are three (3) types of customers that any organization must be concerned with. The first customer is the internal customer. An internal customer is the recipient (person or department) of another person's or department's output (product, service, or information) within an organization. If we look at figure 14, we can see that the process owner is the customer of the service rep when the complaint is forwarded. An external customer is a person or organization that receives a product, service, or information from the organization, but is not part of the organization supplying the product, service, or information. Using figure 14 again, the external customer would be the one that originally made the customer complaint. The third type of customer is the third-party. The third-party is a person or organization that is independent of both the supplier and external customer organizations, but may become involved in an indirect way or be affected by the product, service, or information.

The second area of processes within the strategic processes is the resource management processes. These processes are those that directly affect the procurement, maintenance, and distribution of limited available items. Within the resource management processes area, there are three (3) categories of processes. The first category of processes is the procurement processes. Procurement processes are those that define the acquisition of goods and/or services at the best possible total cost of ownership, in the right quantity and quality, at the right time, in

the right place, for the direct benefit or use of an organization. There are three (3) types of procurement processes:

1. Purchasing – the acquisition of materials, equipment, and tools,

2. Human Resources – the portion of the organization that deals with the recruitment and administration of employees, and

3. Facilities – the acquisition of a building, place, or service that supports said building or place that is used for a given organization.

The second category of resource management processes is the maintenance processes. Maintenance processes are the second category of processes within the resource management processes and are those which deal with the care and work put into assets to keep the assets operable and productive. There are three (3) types of maintenance processes associated with an organization:

1. Stock – caring for a supply of something available for future use (required environmental conditions, rotation of items, etc.),

2. Calibration/Preventive Maintenance – the act of checking or adjusting (by comparison with a standard) the accuracy of a measuring instrument; essential care and maintenance of an item regardless of its condition, and

3. Training/Certification – teaching if knowledge, skills, and competencies to improve an individual's capability, capacity, and performance; designation earned by a person to assure that they are qualified to perform a job or task.

The final category of processes in the resource management category is allocation processes. Allocation processes are those processes which are involved in the act of distributing

items and apportioning said items for a specific purpose. Within the allocation category, there

are three (3) types of processes:

1. Logistics – management of the flow of materials, equipment, and tools as required,

2. Scheduling – setting an order and time periods for individuals to work, and

3. Facilities – determining the use of a building, place, or service that supports said

    building or place that is used in a given organization.

The strategic processes identified above are the basis of the structure and practices of an

organization as will be shown in Chapter 5.

Section 4.3 Core Processes

The core processes consist of three (3) categories. These categories are not as detailed as

those within the strategic process area as the core processes are highly dependent on the actual

output of an organization. The three (3) categories are design/development processes, execution

processes, and measuring/monitoring processes. Figure 18 depicts the taxonomy of the core

processes.

The design/development processes are processes that bring a product or service from

conception to actualization and include three areas:

1. Design processes – those processes that originate a conceptual solution for a

    requirement and express the solution in a form from which a product may be

    produced or a service delivered,

2. Verification processes - the processes associated with the act of reviewing,

    inspecting, testing, checking, auditing, or otherwise establishing and documenting

    whether items, processes, services, or documents conform to specified requirements

    (are we building the item correctly)?, and

3. Validation processes – those processes associated with the act of confirming a

   product or service meets the requirements for which it was intended (are we building

   the correct item)?

Figure 18. Core Process Taxonomy
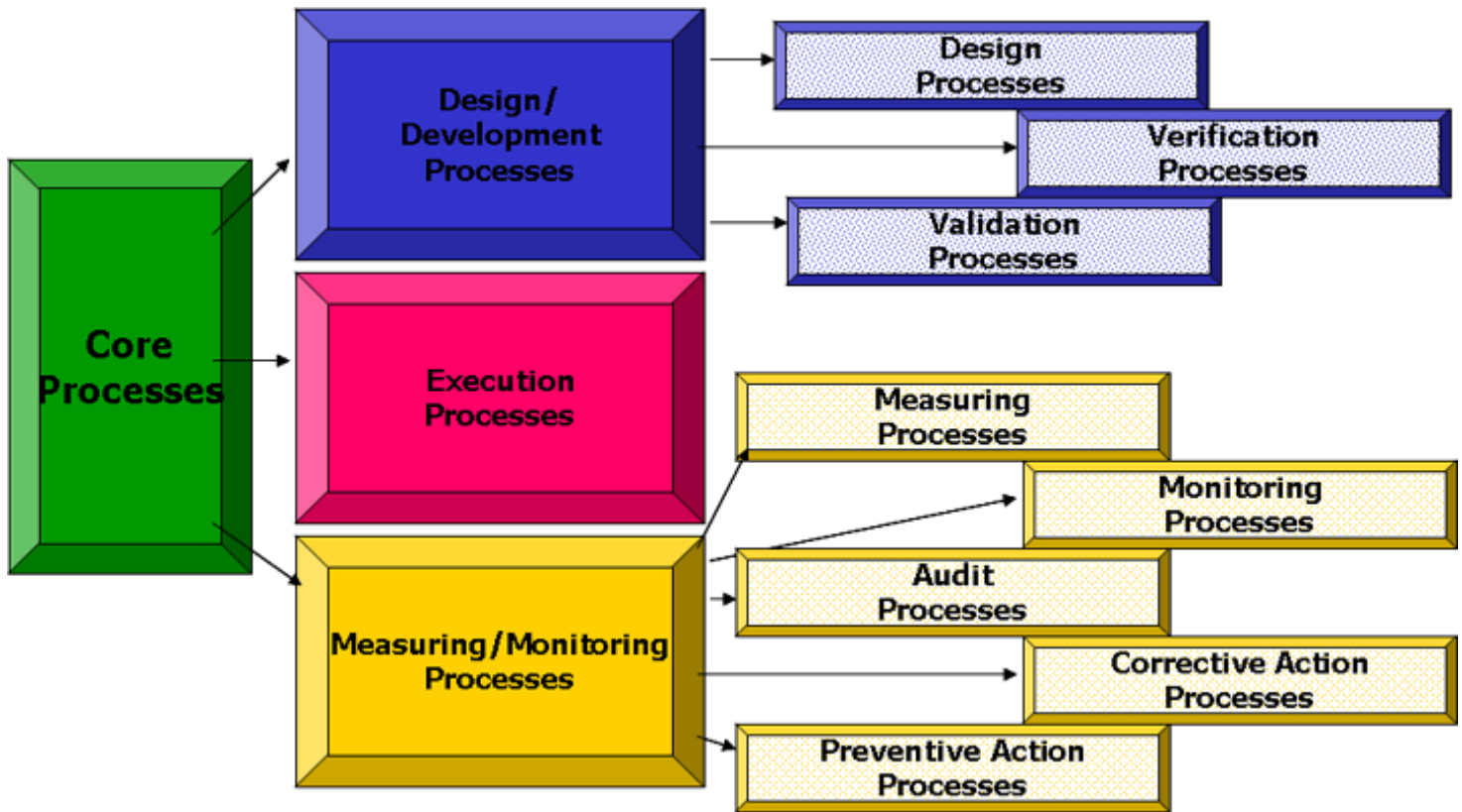
The execution processes are any of the processes related to the completion of a task. The

process taxonomy does not include a further break down of the execution processes, as these

processes are critically linked to the overall output of the organization.

The final category within the core process taxonomy is measuring/monitoring processes.

Measuring/monitoring processes are all of the processes related to the comparison of actual or

potential results with requirements. Within this category, there are five (5) distinct processes:

1. Measuring Processes – those processes related to the evaluation or estimation of a specified metric,

2. Monitoring Processes – processes associated with tracking a metric over time,

3. Audit Processes – the process related to an independent, objective evaluation of an organization's processes, products, or services providing objective evidence of the effectiveness, efficiency, and compliance of the process, product, or service as it relates to the organization's objectives,

4. Corrective Action Processes – processes related to reducing or eliminating an identified problem, and

5. Preventive Action Processes – processes associate with actions taken to remove or improve a process to prevent future occurrences of a nonconformance.

As stated in the previous section, the strategic processes are the basis for the structure and practices of an organization. The core processes are the processes that are directly responsible for the output of the organization. In chapter 5 we will utilize the strategic and core process taxonomies in the development of the process based organizational model.

Section 4.4 Process Taxonomy in Relation to SoTeRiA Framework

Figure 19 is a schematic representation of the SoTeRiA framework that differs from Figure 11 in that it is not as detailed with the technical elements of the framework. However, Figure 19 is more conducive to the purpose of showing how the process taxonomy presented above links to the SoTeRiA framework.

Figure 19. Schematic Representation of SoTeRiA (Mohaghegh, 2007)
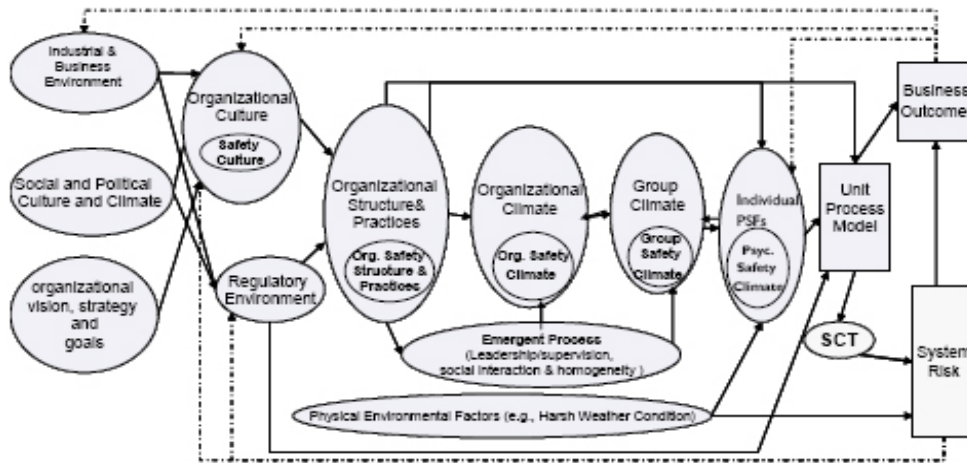
The strategic processes are linked to the SoTeRiA framework in multiple areas. Table 5 provides an overview of the links.

Table 5. Links Between SoTeRiA and Process Taxonomy

SoTeRiA	PROCESS TAXONOMY
Organizational Vision, Strategy and Goals	Strategic Process – Foundation
Organizational Culture	Strategic Process - Foundation
Organizational Structure & Practices	Strategic Process – Organizational Management & Resource Management
Organizational Climate	Strategic Process – Organizational Management – Customer Satisfaction – Internal Customer
Group Climate	Strategic Process – Organizational Management – Customer Satisfaction – Internal Customer
Emergent Process	Strategic Process – Organizational Management – Communication/Information & Customer Satisfaction – Internal Customer Strategic Process – Resource Management – Procurement – Human Resources
Unit Process Model	Core Processes - All

The organizational vision, strategy, and goals shown in Figure 19 are not defined by Mohaghegh. Rather, they seem to be an input into the overall organizational culture. The process taxonomy clearly shows that an organization's policy (vision), planning (strategy) and

objectives (goals) are an integral part of the processes of an organization as they form the basis

for the completion of the organization's output. Organizational culture is characterized by

Mohaghegh (2007) as shaping managerial decisions regarding practices and structural features.

Within the process taxonomy, this would be the foundation processes, those processes that

determine the fundamental framework from which the goals of the organization are attained.

Mohaghegh (2007) states that organizational structure and practices include all

organizational practices and activities that support the resources/tools/equipment and human

actions within the unit process model (the direct activities that affect the output of the

organization). This directly links to both the organizational and resource management portions

of the process taxonomy. Within the process taxonomy, the foundation processes are those

which will define the objectives of the organization and how these objectives will be attained.

The communication/information processes inform the members of the organization how the

objectives are to be attained. The customer satisfaction processes (specifically internal customer

satisfaction) defines how the employees will be regarded within the organization, and how their

reactions or concerns to issues within the organization will be handled. The ultimate objective of

the procurement processes is to have the correct equipment, tools, materials, individuals, in an

area conducive to the work required, when required. The calibration/preventive maintenance

processes ensure that the equipment, tools, and materials are maintained in a manner to keep

them available and reliable for use when required. Training and certification for the individuals

within the organization ensures that the individuals have the knowledge and skills necessary to

complete their required tasks. The allocation processes distribute all resources to meet the

objectives of the organization. Therefore, all of the processes within the strategic process area

support the actions in the unit process model.

Organizational climate is defined by Mohaghegh (2007) as being a temporary attitude of an organization. This links directly to the internal customer satisfaction category within the strategic processes, organizational management processes. Likewise, the group climate also directly relates to the internal customer satisfaction area within the strategic processes.

Emergent processes consist of supervision/leadership, homogeneity, and social interactions. Supervision/leadership refers to the filtering aspect performed by a supervisor or leader within an organization for the employees' perceptions. Homogeneity exists due to individuals being attracted to an organization that has or reflects similar attributes. Social interactions tend to affect the attitudes of individuals within the organization (either positively or negatively). Thus, the supervision/leadership portion of the emergent processes can be directly linked to the communication/information processes within the organizational management portion of the strategic processes. Information provided to a supervisor may be filtered prior to the supervisor speaking with management. The homogeneity factor of the emergent processes can be associated with the procurement (human resources) processes within the resource management area of the strategic processes, as the recruiting, selection, and hiring of individuals typically result in the employment of individuals those attributes match that of the organization. Social interactions are not formal processes, but rather a factor in an organization. Social interactions, however, can, and do affect formal processes throughout the organization. They can be linked directly to the customer satisfaction (internal) link of the organizational management processes in the process taxonomy.

The final area of the SoTeRiA framework that can be associated with the process taxonomy is the unit process model. As stated previously, the unit process model consists of the direct activities that affect the unit output. In the process taxonomy, these are the core processes,

those processes that are the realization processes that provide the intended output of the organization. The core processes include the design/development, execution, and measuring/monitoring processes.

We have taken the theoretical SoTeRiA framework and now linked many of the elements to the process taxonomy. The next step will be to demonstrate how the processes presented in the process taxonomy can be modeled within the construct of an organization.

Chapter 5: Modeling of the Organization from a Process Perspective

Section 5.1 Introduction

There are currently numerous graphical representations utilized to model organizations. The most basic organization model is the classical bureaucracy model where the organization is divided into functional departments run by the chief executive officer through various structures, job descriptions, rules, regulations, and controls. Carley and Lin (1997) investigated the remote access structure which looks at an organization from the view of how unfiltered information is distributed to members of the organization. Simms, B.W. and Peterson, E.R. (1991) modeled a police organization based on the information processing that occurred. Although processes are a part of this model, the model itself was not based on the overall processes of the organization. To date, the organizational models look at the "who" aspect of an organization versus the "who, what, where, when, and how" aspect. What is needed when looking at the processes within an entity is an organizational model based on the processes within that entity. Figure 20 shows the organizational model developed for this purpose. The elements of the model will be described in detail in section 5.3.

Figure 20. Process-Based Organizational Model

Figure 20. Process-Based Organizational Model
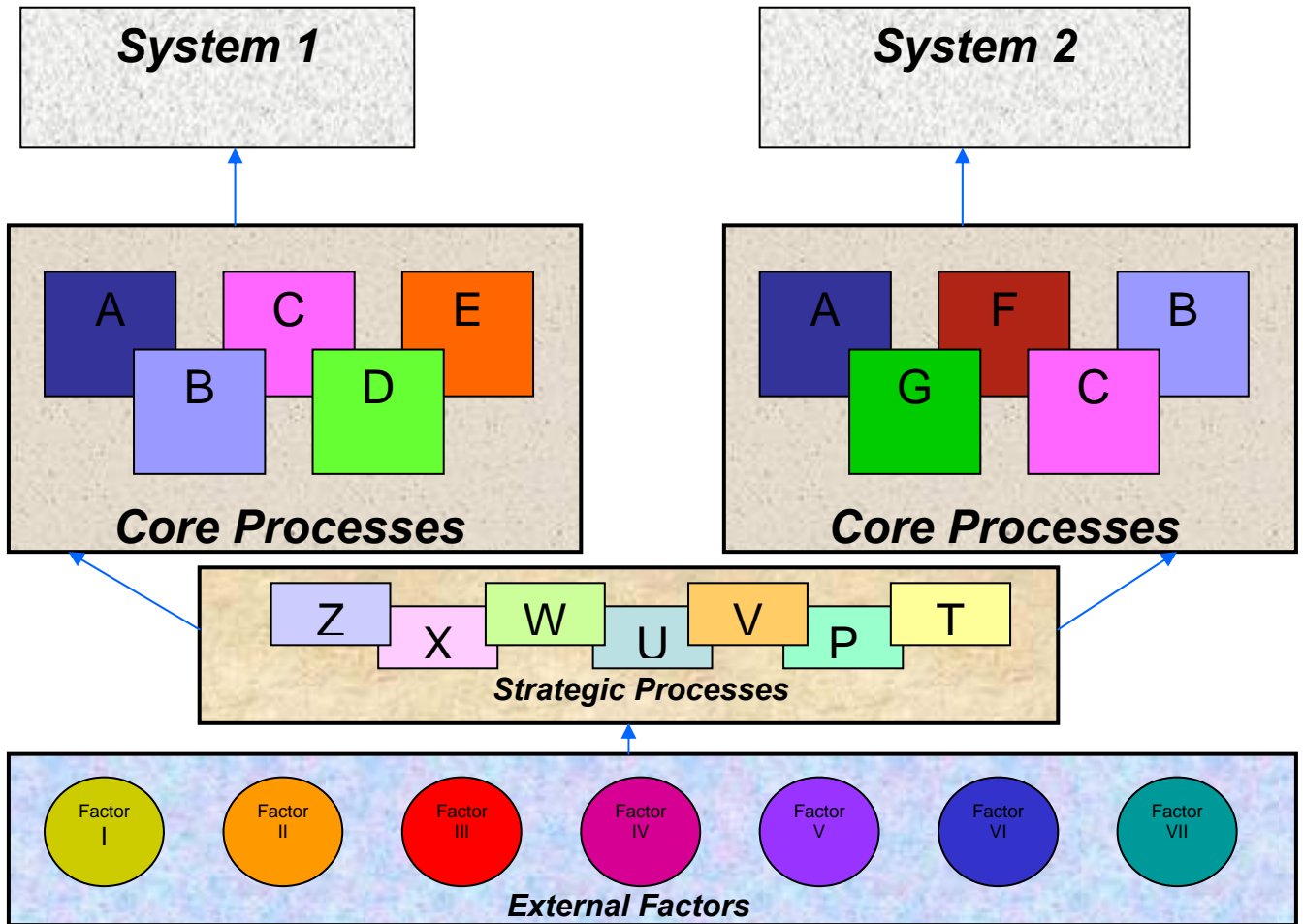
Section 5.2 Basis of the Process-Based Organizational Model

To understand this model, we return to the beginning of our journey with the definition of a process. A process is defined as a systematic sequence of activities which converts inputs into outputs utilizing resources and influenced by controls. Every process can be a formal process (an accepted collection of activities which converts inputs into outputs utilizing appropriate, consistent resources and directed by controls), or an informal process. The elements within a process have been schematically represented by the DROMĒ process model.

Our next step in the journey was to prepare a taxonomy of the processes within an organization. The strategic processes were identified as the organizational and resources management processes in an organization – the foundation for the organization. The core processes are the processes that directly affect the output of the organization. Thus, the strategic processes provide the support for the core processes. External factors play a role in any organization and must be part of an organizational model. Thus, the external factors affect the strategic processes of the organization.

Section 5.3 Elements of the Process-Based Organizational Model

Within this section we will examine the elements of the process-based organizational model; the external factors, strategic processes, core processes, and the system.

Subsection 5.3.1 External Factors

An external factor is defined to be any item that contributes logically or causally to a process or system, but that is not within the control of the organization. The rules and regulations of the Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA), and local fire regulations are examples of external factors for most organizations that produce products. The regulations, notices, advisory circulars, etc. of the Federal Aviation Administration (FAA) would be an external factor for airline carriers. Economic conditions, financial requirements, and market conditions would also be considered external factors. For the purposes of this research, the effect of external factors was considered, but the external factors themselves were not developed or identified within the context.

Subsection 5.3.2 Strategic Processes

External factors will affect how our organizational and resource management processes are defined and performed. Thus, the external factors influence the strategic processes as graphically shown in Figure 20. For example, the FAA has requirements regarding the training and certification of pilots of regulated airline carriers. These requirements must be identified by an airline carrier organization and be a requirement within their organization. Specifically, the training and certification requirements of the FAA would be acknowledged within the resource management, maintenance, training and certification portion of the strategic processes.

Subsection 5.3.3 Core Processes

The core processes (design/development, execution, and measuring/monitoring) are those processes that directly affect the output of the organization. These processes are supported by the strategic processes as shown in Figure 20. If we consider an organization that produces software, the core processes would be the design of the software code, the verification and validation of the software code, the actual coding itself, and all testing associated with the software code prior to being released to the customer.

For the software code to be completed (i.e. the core processes performed), the organization must first ensure that their strategic processes are in place. The policy of the organization, the objectives of the organization (what type of software will the organization produce), and the planning of how the objectives will be met must be determined. Specifications and documents (communication/information) must be in place, and a determination of how customer satisfaction will be achieved. Procurement processes need to have occurred – procuring any materials, equipment, personnel, and facilities that are required to meet the organization's objective (software). The procured items and personnel must be maintained

(calibrated or trained), and the items must be allocated so that the software may be produced on schedule.

Subsection 5.3.4 System

The system is defined as a group of independent yet interrelated processes comprising a unified whole which serves a common objective. Essentially, a system is an output of the organization. The system is produced directly by the core processes, which are supported by the strategic processes, which are influenced by the external factors.

Section 5.4 Relationship to SoTeRiA

Figure 21 presents both the technical schematic of SoTeRiA and the process-based organizational model with the associated links. Let us first examine the link between the "safety critical tasks" identified in the SoTeRiA schematic and the "system" from the process-based organizational model. As stated previously, within SoTeRiA, the safety critical tasks are the unit output; therefore, they are directly correlated to the system within the process-based organizational model. The unit process model within SoTeRiA leads to the unit output. The definition of the unit process model is the direct activities that affect the unit output – which corresponds to the core processes within the process-based organizational model. There is a difference however, between the SoTeRiA unit process model and the core processes within the process-based organizational model. The process-based organizational model considers a higher level of processes affecting the output than the SoTeRiA framework. As seen if Figure 16, the unit process model can be directly linked to the DROMĒ process model. Any of the core processes can be modeled using the DROMĒ process model.

As shown in Table 5, there are direct links between the group climate, emergent process, organizational structures and practices and organizational culture of SoTeRiA and the strategic processes of the process-based organizational model. And finally, the regulatory auditing system shown on the SoTeRiA framework is a type of external factor on the process-based organizational model.

SoTeRiA was developed for a specific purpose – that of providing an organizational safety framework based on organizational and behavioral theory. SoTeRiA contains information regarding the psychological aspect of an organization that is not addressed by the process-based organizational model, while the process-based organizational model is more specific in terms of the types of organizational structures and practices. The process-based organizational model can be utilized to enhance the areas within the SoTeRiA framework.

Figure 21. SoTeRiA Framework Compared with the Process-Based Organizational Model
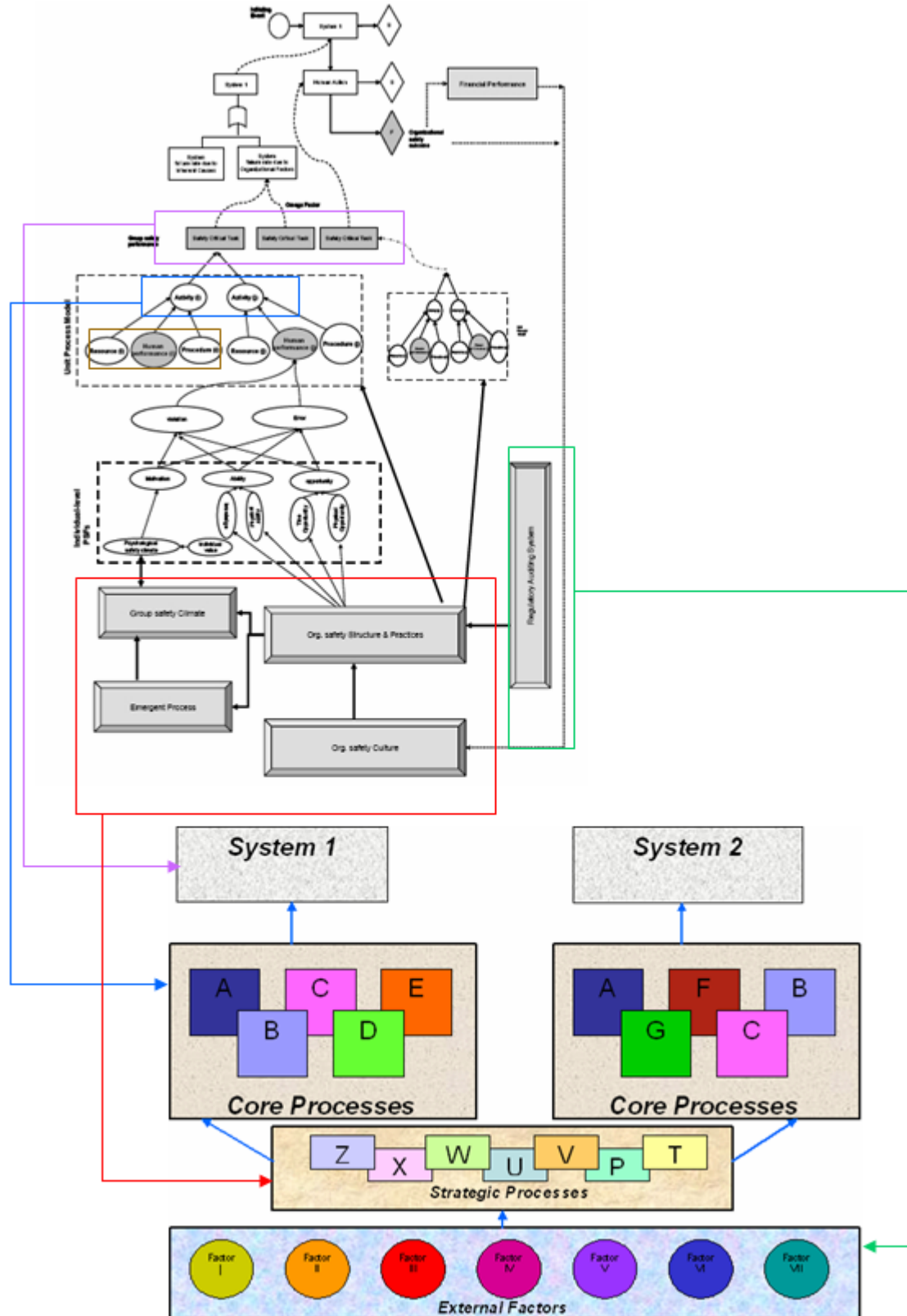
Chapter 6: Informal Processes

Section 6.1 Introduction

As discussed in earlier sections, informal processes may be found in all areas – economics, communication, organizational structure, and manufacturing operations to name a few. Likewise, informal processes can be found in all areas of any organization. In fact for every process, the process itself may contain both formal and informal components. Let us look at a procedure in a manufacturing facility. The formal process states that the operator is to use a torque wrench to tighten a bolt to 15 in-lb.   An informal process would occur if the operator could not locate the torque wrench, but had a wrench available, and decided that they had performed the operation often enough in the past that they could "guess" the torque, so just used the wrench to complete the operation. Some errors associated with human actions can be informal processes – but not all. Errors of omission, when one accidentally forgets a step in the process or performs a one time (not recurring) deviation are not informal processes. Conventional commission errors, however, when one purposefully deviates from the process are informal processes.

In this chapter, we will discuss the taxonomy of informal processes and look at the causes of informal processes. Additionally, we will examine where specific causes of informal processes can have an affect within the SoTeRiA framework.

Figure 22. Process Broken down into Formal and Informal Components
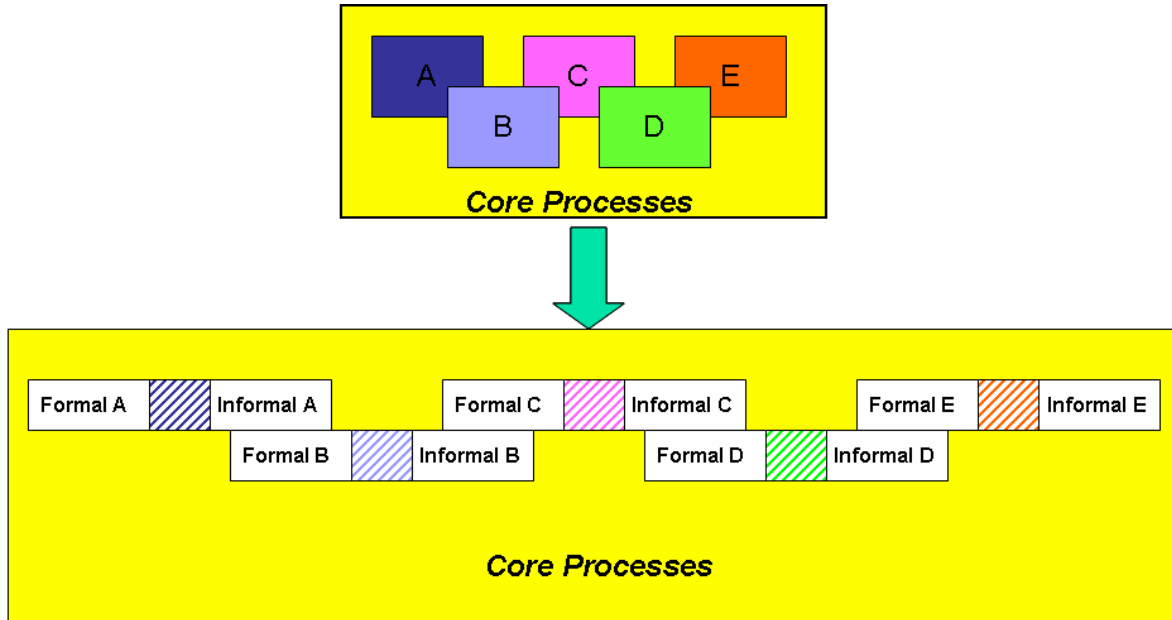
Section 6.2 Taxonomy of Informal Processes

As depicted in Figure 22, for every formal process that exists, there is the potential for an informal process to occur. We must have a means of categorizing the informal processes. There are three (3) basic areas of informal processes; functional informal processes, operational informal processes, and control/informational informal processes.

A *functional informal process* is one where there is no defined formal process by which to achieve an objective. Functional informal processes occur when a formal process does not exist. One of the best examples of a functional informal process is the Apollo 13 that was described in chapter 1. Let us look at another example of a functional informal process. A defense contractor manufactured two sections of an air-to-surface tactical missile – the guidance section and the control section. The two remaining sections – the warhead section and the rocket motor section were manufactured by other organizations. The four sections were shipped separately to the customer, where they were assembled and prepared for use. After assembly, the

missiles were designated as either trainer missiles (the warhead was a dummy warhead) and marked with a blue flag or armed missiles (ready to perform) that were marked with a red flag. Occasionally, there were issues with a section of the missile that required that section to be returned to the manufacturer. The customer would disassemble the missile and send the questionable section to the appropriate manufacturer.

One weekend, the quality assurance engineer (QA) on call received a call from an assembly supervisor that a full missile had been returned to the plant and they did not know how to handle the situation. The QA met the assembly supervisor and was shocked to see that not only had a complete missile been sent back, but the missile was armed. There were no procedures at the manufacturing location to instruct them on either disarming the missile or disassembling the missile. Functional informal processes were utilized to disarm and disassemble the missile.

An *operational informal process* is a process that deviates from the formal process in the areas of equipment, tools, materials, environment, humans, and/or inputs. If we examine the Titanic disaster, there are multiple informal processes at work. Let us consider the required use of a tool. The standard operating procedure of the Titanic required that binoculars be in the crow's nest. But, on the night of the disaster, there were not binoculars – the lookouts relied solely on their eyes. Thus, there was a deviation in the tools required by the formal process. Another deviation was in the environmental area. A notice in the chart room of the Titanic stated that one of the principles of the White Star Lines was "the vital importance of exercising the utmost caution in navigation; safety outweighing every other consideration". Titanic had received numerous ice warnings – several ships in the area had stopped due to the ice, yet Titanic continued to increase her speed through the ice.

Control/informational informal processes are those processes that supplement or deviate from the formal process in terms of the controls. An obvious example of a control/informational informal process was found in an elementary school in North Carolina. The procedures regarding a school secretary issuing a check require that the secretary has a valid receipt, invoice, and/or purchase order prior to issuing the check. The principal of the school routinely told the secretary to issue signed, blank checks without submitting any of the required documentation.

Another example of a control/informational informal process that is not as obvious occurred on the passenger vessel S/S Norway. The Norway was originally launched in 1960 as the S/S France. As the S/S France, the ship had eight (8) main steam boilers to power the vessel with high transoceanic operating speeds. In 1974, the S/S France made its final voyage and was idle until 1979 when Klosters Rederi A/S purchased her for a Caribbean cruise vessel, operated by a subsidiary, Norwegian Cruise Lines (NCL), and renamed the ship the S/S Norway. In 1979 four (4) of the boilers were removed in anticipation of Caribbean cruises which would not require the power of a transoceanic voyage. On May 25, 2003, the S/S Norway experienced a boiler rupture in which eight (8) crewmembers died. It signaled the end of the liner.

The original boiler manuals, provided by the vessel manufacturer, outlined detailed instructions for the operation and maintenance of the boilers. These instructions were designed to minimize thermal stresses and material degradation. Specifically, the manufacturer's manual stated that during start-up, one or more of a boiler's burners should be fired at intervals until the pressure reached 116 pounds per square inch (psi), after which continuous firing was allowed until the boiler reached a pressure of 870 psi. Additionally, the manual (Liner France, no date) states that reaching the recommended operating pressure requires approximately three (3) hours and that it is "advisable not to accelerate the procedure, and to allow the temperature to rise

gradually". In the case of shutting down a boiler, the manual states that the superheater should

not be filled with water until the boiler has cooled down – approximately forty-eight (48) hours

after the fires have been distinguished. NCL published procedures regarding the lighting and

shutting down of the boilers and posted these in the boiler room for the reference of the

engineering crew. These posted procedures did not specify a time period for raising the steam

pressure or for cooling down a boiler.

The National Transportation Safety Board investigated the accident and during interviews

with numerous engineers of the S/S Norway, found that many of the engineers did not follow the

manufacturer's instructions for lighting or shutting down the boilers. The stresses on the boilers

from incorrectly performing the lighting and shutting down procedures over the life of the

boilers, led to cracks and ruptures which caused the boiler to rupture and the liner to be scrapped

(see figure 23). The inconsistency between two controls (the manufacturer's manual and the

NCL procedures), is a control/informational informal process which led to loss of life, and the

scrapping of a forty-three (43) year old cruise ship that had been labeled the "Grand Dame".

Figure 23. S/S Norway Before and After

<u>Section 6.3 Causes of Informal Processes</u>

In the previous section we discussed the various types of informal processes; functional, operational, and informational. From the examples we see that informal processes may contribute positively to a situation (Apollo 13 and disarming of a missile), or negatively (preparing checks without cause, the Titanic disaster, and the S/S Norway demise). To continue on our journey, we must now ask the question "what causes informal processes"?

Subject Matter Experts (SME) were utilized in determining the causes of informal processes. The choice of individuals as SME is addresses in Section 8.2. A brainstorming session was held with eight (8) of the SME to identify the causes of informal processes. From the original identified causes, these were then categorized (see Table 6). In addition to the causes of informal processes listed in Table 6, there were three others identified: greed, sabotage, and terrorism. These three causes of informal processes will not be addressed in this research. At the completion of identifying the causes of the informal processes, the SME were asked to determine, based on their experience, the relationship of the informal causes to the areas within the strategic processes (Table 7), the core processes, and the DROMĒ process model. Relationships were marked if they were identified by four (4) or more SME.

Table 6. Causes of Informal Processes

PRIMARY CATEOGORY	CAUSE OF INFORMAL PROCESS
Facilities Related	Back-Up
	Capacity
	Loss of Power
	Upgrade
Environment Related	Catastrophic Event
	Contamination
	Environmental Conditions
Economics/Management	Costs
	Delays
	Demand
	Measureables
	Lack of Management Commitment
	Lack of Quality System
	Planning
	Quality of Requirements
	Resource Constraints
	Schedules
	Suppliers
Materials	No Material
	Wrong Material
	Quality of Material
Equipment	Faulty Equipment
	Lack of Equipment
Humans	Drugs
	Illness
	Mistakes
	Ethics
	Lack of Productivity
	Sleep Deprivation
	Lack of Responsibility
Training	Lack of Training
	Quality of Training
Communication/Information	Direct Order
	Improper Procedure
	Lack of Communication
	Regulations
	Communication Failure

The causes of informal processes as identified by the SME are briefly defined below. In many cases, the causes can be further categorized based on two (2) elements – availability and quality. For example, if we look at the causes of informal processes within the training category, we see that there are two (2) – lack of training and quality of training. Lack of training is an issue with the availability element, while quality of training is an issues with the quality element.

- Facilities Related

  o Back-Up: refers to the capabilities within the power and computer areas of the organization that would allow work to continue or an evacuation to occur without the loss of data or lives

  o Capacity: relates to the maximum production possible based on the capability of the facility

  o Loss of Power: see "back-up" above

  o Software Upgrades: becomes an issue when personnel are not aware of the upgrade and associated changes required in their work activity and/or if the upgrade is successful

- Environment Related

  o Catastrophic Event: refers to the damage or destruction associated with an act of nature or an event that is not anticipated

  o Contamination: any issues that are associated with pollution or adverse environmental conditions within the facility

  o Environmental Conditions: refers to the required conditions necessary to complete the objectives of the organization (temperature and humidity controls for example)

- Materials

  o No Material: required material is not available when needed to complete the process

  o Quality of Material: the material to be utilized within the process is not of sufficient quality

  o Wrong Material: the material provided for use in the process is incorrect

- Economics/Management

  o Costs: refers to the costs of all resources required to meet the objective of the organization. If costs are too high for the organization to be successful, management may determine that reduction in the quality of certain resources is acceptable

  o Delays: refers to delays both within and without the organization; i.e. waiting on materials furnished by suppliers, waiting on equipment to be calibrated or maintenance to be performed)

  o Demand: economic demand could drive the organization to produce product at a high speed without regard to the quality of the product, or conversely, the organization may lose materials that are time sensitive due to a downturn in the demand

  o Measurables: relate to the metrics utilized within the organization – are they the correct items to be measured, are the measurements being performed correctly, is the information obtained useful to the organization/

- Lack of Management Commitment: if management is not committed to the overall organizational goal, issues may be seen in the availability and quality of resources and training

- Lack of Quality System: the SME felt that every organization should have a quality system that addressed the needs of both the organization and the customers. Lack of a quality system could lead to issues with the quality of the product or service offered by the organization

- Planning: accomplishment of the organizational objectives require adequate planning by management including policy, goals, and objectives

- Quality of Requirements: relates to the quality of requirements as presented to the organization by the customer

- Resource Constraints: refers to the issues associated with the lack of resources required by an organization to meet their objectives

- Schedules: appropriate scheduling is mandatory for an organization to meet their objectives, including the scheduling of equipment, materials, and humans to complete the processes

- Suppliers: refers to the number of approved suppliers and their capacity of supplying the organization with the correct material when needed

- Humans

- Drugs: presence of drugs (either illegal or prescribed) can affect the performance of individuals

- Illness: if a person is ill or not feeling well, there is the potential for the quality of their work to be deficient

- o Mistakes: refers to repeated mistakes by an individual

- o Ethics: an individual's ethics and morals can effect the quality of the work performed

- o Lack of Productivity: refers to the cases where an individual's productivity is affected due to their lack of caring

- o Sleep Deprivation: if sleep deprived, an individual can make mistakes affecting the quality of their work

- o Lack of Responsibility: associated with the individual's mindset as to how their part of the process can affect others down the line, or the completed product or service

- Equipment

  - o Faulty Equipment: occurs when equipment does not function as intended or required in the completion of the process

  - o Lack of Equipment: occurs when the required equipment is not available, or not available in the quantity required to achieve the objectives of the organization

- Training

  - o Lack of Training: applicable when training is not present, or not available to personnel

  - o Quality of Training: refers to how well the training addresses the needs of the organization in relationship to the completion of the objectives

- Communication/Information

o Direct Order: associated with individuals being given oral information from a supervisor or manager in regards to a process that may or may not conflict with the established controls

o Improper Procedure: refers to a control that is not correct; or a control that is used improperly

o Lack of Communication: occurs when the personnel performing the activities within a process do not receive necessary communication for the completion if the process

o Regulations: refers to external regulations and guidelines required to be in compliance with federal, state, local, and/or industry requirements

o Understanding Communication: associated with the type of communication utilized by the organization and the ability of personnel to comprehend and understand the communication

As we have seen, informal processes can affect a process, and ultimately an organization either positively or negatively. It is imperative that we understand the causal relationship between the causes of informal processes and the process taxonomy presented in Chapter 4 and the DROMĒ process model presented in Chapter 3. Table 7 shows the relationship between the informal process causes and the strategic processes. Appendix A contains the relationship between the informal processes and the core processes, as well as the DROMĒ process model. With this information, there is still one final piece when discussing causes of informal processes – if an informal process is caused by one item, can that item also affect another cause of an informal process? The answer is "yes".

The subject matter experts (SME) that assisted in this research developed individual
mappings of the causes of informal processes and their relationship to one another. The
combination of all of the mappings from the SME are shown in Figure 24.

Figure 24. Relationship of Informal Process Causes
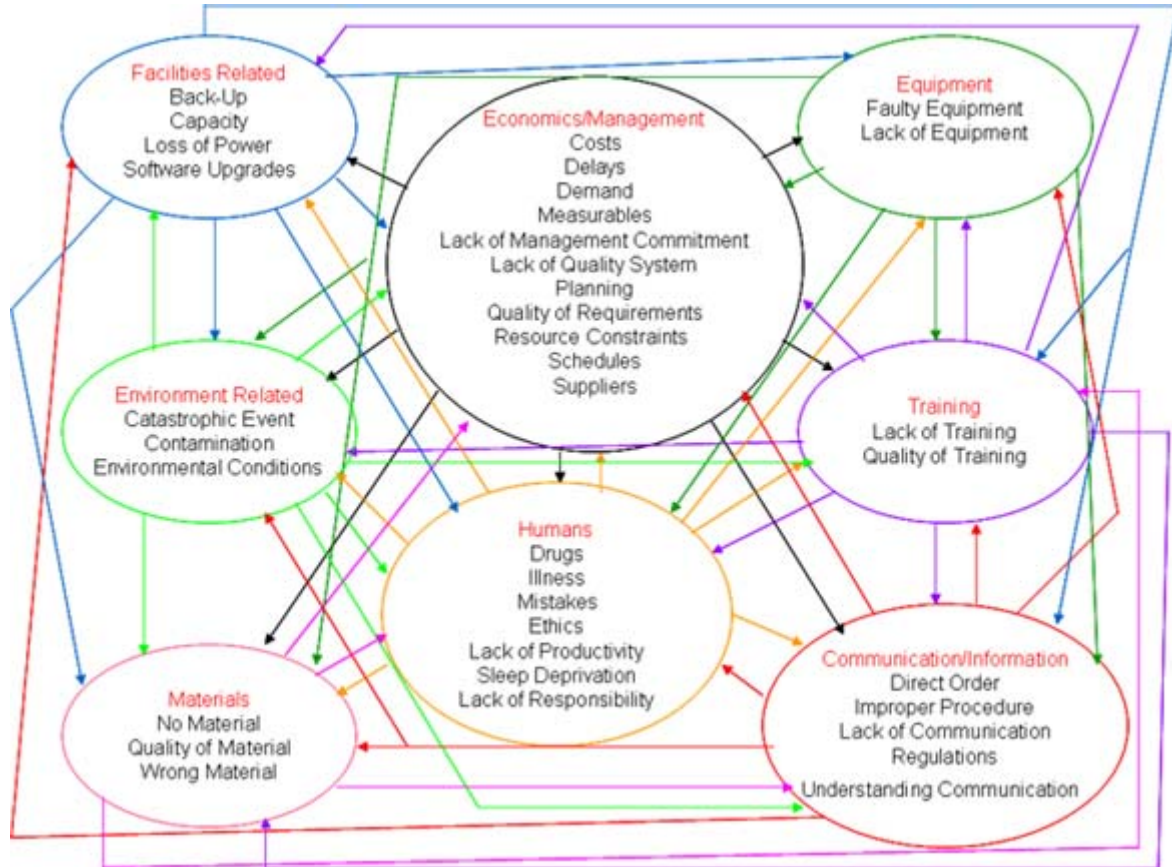
Table 7. Relationship between Causes of Informal Processes and the Strategic Processes

CAUSES OF INFORMAL PROCESSES	FOUNDATION	COMMUNICATION/INFORMATION	CUSTOMER SATISFACTION	PROCUREMENT	MAINTENANCE	ALLOCATION
Facilities Related						
Back Up	X	X			X	
Capacity	X		X			X
Loss of Power	X				X	X
Software Upgrades	X	X	X		X	
Environment Related						
Catastrophic Event	X					
Contamination	X	X	X	X	X	
Environmental Conditions	X				X	X
Materials						
No Material				X		
Quality of Material	X		X	X	X	
Wrong Material				X		
Economics/Management						
Costs	X	X	X	X	X	X
Delays	X		X		X	X
Demand	X		X			
Measurables	X					
Lack of Management Commitment	X					
Lack of Quality System	X		X			
Planning	X		X			X
Quality of Requirements	X		X			
Resource Constraints	X					X
Schedules	X					X
Suppliers				X		
Humans						
Drugs				X		
Illness		X		X		X
Mistakes	X	X	X	X	X	X
Ethics	X					
Lack of Productivity	X		X		X	
Lack of Responsibility	X		X			
Sleep Deprivation					X	X
Equipment						
Faulty Equipment			X		X	
Lack of Equipment	X			X	X	X
Training						
Lack of Training	X				X	
Quality of Training	X	X	X	X	X	X
Communication/Information						
Direct Order	X	X				
Improper Procedures	X	X				
Lack of Communication		X	X			
Regulation	X	X				
Understanding Communication		X	X			

We have seen in previous sections how the process taxonomies, organizational model from a process perspective, and the DROMĒ process model can be related to the SoTeRiA framework. Likewise, the causes of informal processes can be linked to the SoTeRiA framework. For this representation, we will assign a number to each of the primary categories associated with the informal processes as given below:

1. Facilities Related,

2. Environment Related,

3. Materials,

4. Economics/Management,

5. Humans,

6. Equipment,

7. Training, and

8. Communication/Information.

Figure 25 shows the areas in which the informal processes may have a primary affect. Due to the nature of the interrelationship of informal causes, there may be other informal process categories in the areas of the SoTeRiA framework that have a lesser influence. The relationship of informal process causes shown in Figure 24, as determined by the SME are consistent with those shown in the SoTeRiA framework (Figure 25). For example, as shown in Figure 25, within the SoTeRiA framework, we see that the organizational structures and practices are mapped to the individual PSF's (Performance Shaping Factors). The organizational structures and practices can be affected by causes of informal processes within all of the categories (facilities related, environment related, materials, economic/management, humans, equipment,

training, and communication/information). Likewise, the individual PSF's can be affected by the

"humans" category of the causes of informal processes. If we now compare these relationships

of informal process causes with Figure 24, we see that every category (facilities related,

environment related, materials, economics/management, equipment, training, and

communication/information) is related to the "humans" category of informal process causes.

Figure 25. Informal Process Categories Mapped to SoTeRiA Framework
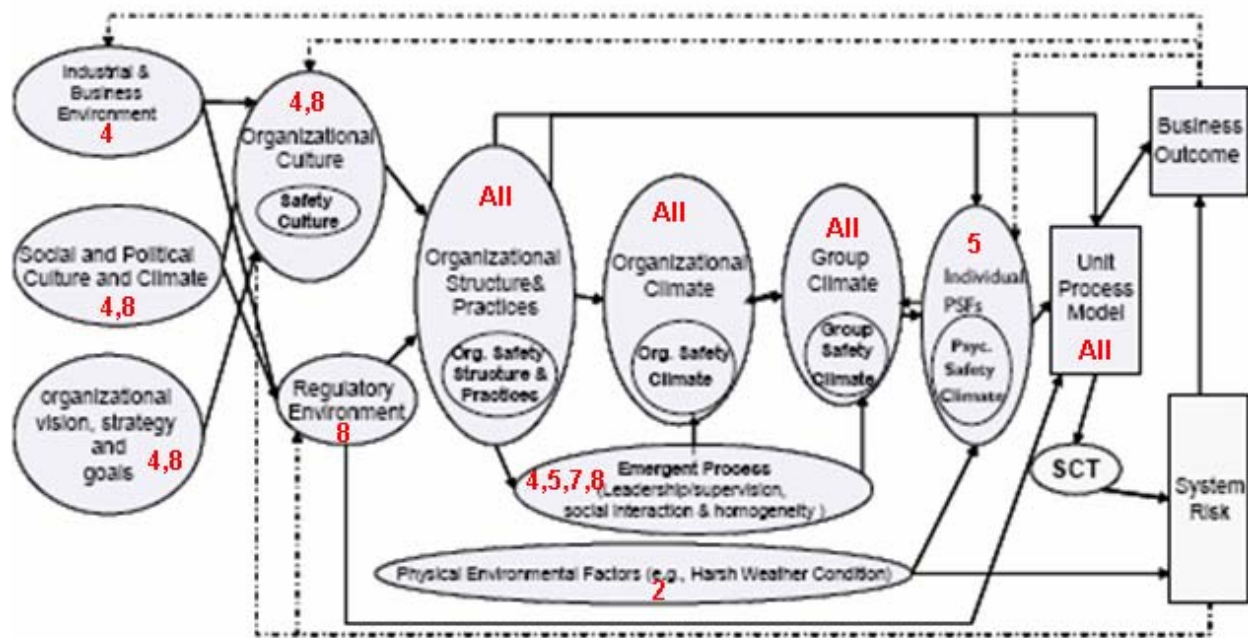
The key terminology and models have been presented at this point. We will now move

forward and utilize this information in the detection of informal processes within an

organization.

Chapter 7: Informal Process Detection

Section 7.1 Introduction

As stated previously, informal processes are an inherent part of any organization, can vary from day to day and can have both a positive and negative impact on the effectiveness and efficiency of the organization's processes in numerous areas. It is imperative that a methodology be available to detect informal processes within the organization. The detection methodology presented in this research is two-fold – an indirect detection method and a direct detection method.

The indirect method for detecting informal processes is a questionnaire that can be completed by a management representative. The advantages of the indirect method are the small amount of time required to complete the questionnaire and the minimal cost. The direct detection method of detecting informal processes is the performance of a process audit. Section 7.2 describes the indirect methodology including the development of the questionnaire, the justification of the questions, how the questions are linked to the process taxonomy presented in this research, and testing of the validity of the indirect method. The direct detection method is presented in Section 7.3, and includes the development methodology, how process elements are identified, process interactions, the usage of document trees, the methodology for conducting a process audit, validation of the direct method of detecting informal processes, and basic characteristics of process auditors.

Section 7.2 Indirect Method

The intent of the indirect method for the detection of informal processes is to provide an organization with a quick and inexpensive method of determining specific areas within the

organization that have a greater potential of containing informal processes. Once the areas of greater potential are identified, the direct method of detection can be utilized for the actual identification of the informal processes.

Subsection 7.2.1 Questionnaire Development

The goal of the questionnaire was to provide a quick method for determining the areas, as related to the process taxonomy, of an organization that have a greater likelihood of containing informal processes. Therefore, the questionnaire itself is brief, consisting of thirty-six (36) questions. The questionnaire is contained in Appendix B.

When developing the questions for the questionnaire, three (3) objectives were considered, two (2) from the view of analysis and validation, while one (1) was concerned with the individual that would complete the questionnaire. The first objective was that the questions must be indicative of the information discovered regarding informal processes in the literature review and the experience of subject matter experts, while the second objective was to ensure the questions covered all areas contained in the process taxonomy. For the individual completing the questionnaire, the objective was that the questions themselves would be straight-forward so that the questionnaire could be completed quickly and with little effort from the individual.

To aid in the completion of the questionnaire, a guidelines document was developed. The purpose of the guidelines is to provide the individual completing the questionnaire additional information definitions for selected items on the questionnaire. For example, question # 5 of the questionnaire asks "is the entity classified as traditional or lean/agile?" The guidelines developed for question #5 are as follows: *"Traditional refers to a process that is step-wise, where the completion of the product/service moves forward one phase at a time, with assurance that the prior phase is acceptable before the next phase begins. The traditional entity has the*

*ability to schedule personnel, equipment, and materials over time. Lean/agile refers to a process that solely focuses on the output. It does not consider what an individual will be working on the next week; individual assignments are subsumed by team efforts." (*Holweg, 2007) The guidelines document can be found in Appendix C.

Subsection 7.2.2 Justification of Questions

As stated previously, the questionnaire was designed to provide an efficient method for determining process areas that have a higher potential of containing informal processes. In the next section, we will look at how the questions relate to the process taxonomy presented in Chapter 4. Prior to this, it is important to provide a justification of the questions utilized on the questionnaire.

The questions were developed utilizing information discovered during the literature reviews, experience of subject matter experts, the researcher's personal experience, and from examples of informal processes in various industries couple with the determination of why the informal processes existed. It should be noted that there is a limited amount of information found in the current literature regarding informal processes and their causes. Therefore, the information discovered within the literature was utilized as the basis for the developed questions. If we consider question #1 (how long has the company been in business), there are four (4) responses: 0 – 1 year; 2 – 5 years; 6 – 10 years, or > 10 years. The potential for an organization to have informal processes is higher for those organizations that have been in business for either less than one (1) year or more than ten (10) years. Connaster (2005) states that tribal knowledge is knowledge that is not commonly known by others within a company. In the case of an organization that is young (0 – 1 year), there is a higher potential that formal processes would not exist for all areas/applications, or that the formal processes had not been verified for their

efficiency and effectiveness, thus leading to informal processes. For an organization that is more

seasoned (greater than ten (10) years), the experience level of the employees is more likely to be

high, and therefore, there will be more cases of tribal knowledge. The example presented in

Chapter 1 of the defense contractor and the spare parts where the drawing was wrong is a prime

example of tribal knowledge in an organization that is seasoned, and the resulting informal

process. Appendix D contains the justification for each of the questions contained within the

questionnaire.

Subsection 7.2.3 Linkage to Process Taxonomy

As stated in the previous subsections, the goal of the questionnaire was to provide a quick

method for determining the areas, as related to the process taxonomy, of an organization that

have a greater likelihood of containing informal processes. The purpose of this subsection is to

provide the link between the questions contained in the questionnaire and the process taxonomy

as presented in Chapter 4. Figures 26 and 27 show the portion of the process taxonomy (Figure

26 for the strategic process taxonomy and Figure 27 for the core process taxonomy) to which

each question of the indirect detection method is aligned. When coupled with the justifications

of the questions (Appendix D), one can determine the interrelationship between the information

to date.

Let us look at an example by considering questions 7 and 8 of the questionnaire.

Question #7 asks if there is a formal documentation system in place, while question #8 is a

follow-up to question #7. For those who respond that there is a formal documentation system in

place, then question 8 asks if the documents are reviewed on a periodic basis. The link to the

process taxonomy is obvious, as communication/information processes are defined to be the

transferring of information from a sender to a receiver with the use of a medium in which the

communicated information is understood by both the sender and the receiver. The next question would be are questions #7 and #8 appropriate for the communication/information area? Looking at the justification for these questions, we see that Connaster (2005) in his discussion of tribal knowledge (knowledge that is not commonly known by others within a company) states that tribal knowledge should be transformed into written instructions (formal documentation) for the benefits of having the best practices documented, distributed, and used by all workers; and decreasing the opportunity for worker turnover imperiling the continuous operation of the company, nor the quality of the products. This portion of Connaster's (2005) discussion illustrates the point that question #7 is legitimate for the area of communication/information within the process taxonomy. Moving on to question #8, for those entity's that have a formal documentation system, is the documentation reviewed on a periodic basis? In the same discussion, Connaster (2005) states that an added benefit of transforming tribal knowledge into written instructions is that during the documentation process itself, inconsistent or ineffective practices can be discovered and hopefully resolved. Whether the documentation process is occurring for the first time, or is being reviewed periodically, the opportunity to discover inconsistencies is available and vital for the organization. Thus, question #8 provides insight into the efficiency and effectiveness of the formal documentation, and is a vital part of the communication/information area of the process taxonomy.

A real world example is taken from a defense contractor in the mid-1980s. The formal documentation system was vital for the performance of the work, and the completion of the defense contracts. An audit was being conducted by the customer to determine if the documentation was accurate and adequate for the product being manufactured. During the audit, a single sentence was found in the assembly line procedures that all information entered on the

assembly work order was to be completed in blue or black ink. In reality, the assembly work

orders had ink from the entire spectrum of the rainbow (blue, green, red, purple, and shades

thereof). The defense contractor received an audit finding for this issue. In investigating where

the requirement initiated (was the requirement from the contract or was it an internal

requirement), it was found that the requirement had been originally written into the assembly line

procedures due to the fact that the copiers at the time would only copy blue or black ink.

Although the assembly line procedure had been revised numerous times since originally being

issued, the revisions were specific to a change, and no one had reviewed the entire procedure to

assess the efficiency and effectiveness of the procedure. If there had been a requirement within

the defense contractor for periodic review of the documents, chances are that the audit finding

would not have occurred.

Figure 26. Indirect Detection Method (Questionnaire) Linked to Process Taxonomy (Strategic)
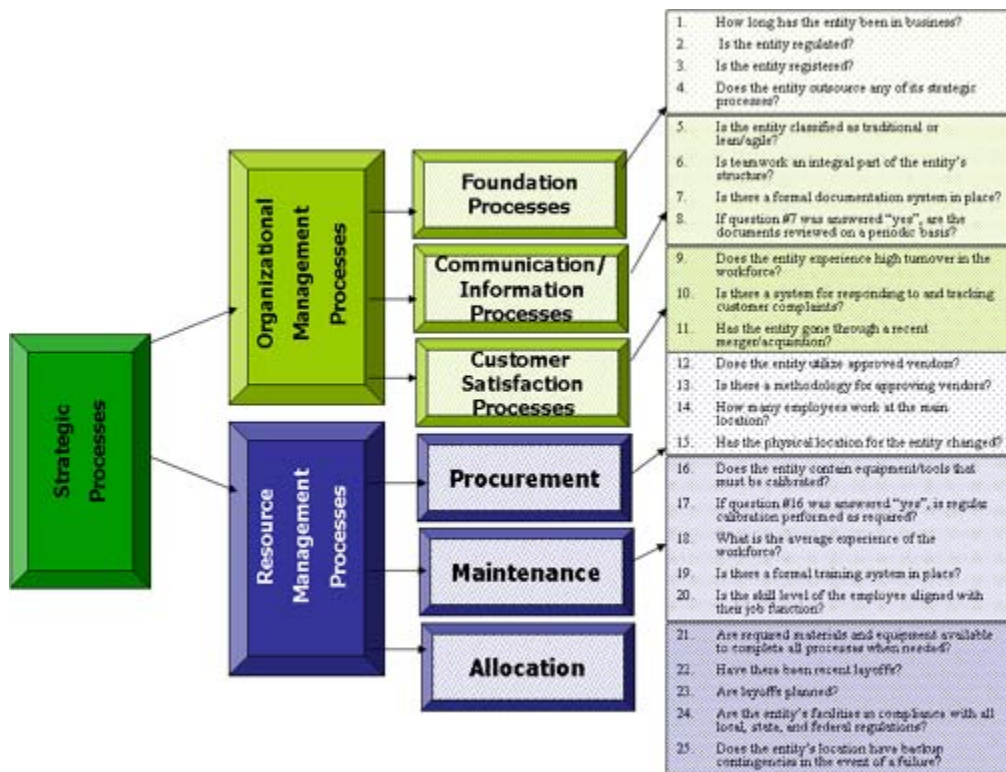
Figure 27. Indirect Detection Method (Questionnaire) Linked to Process Taxonomy (Core)
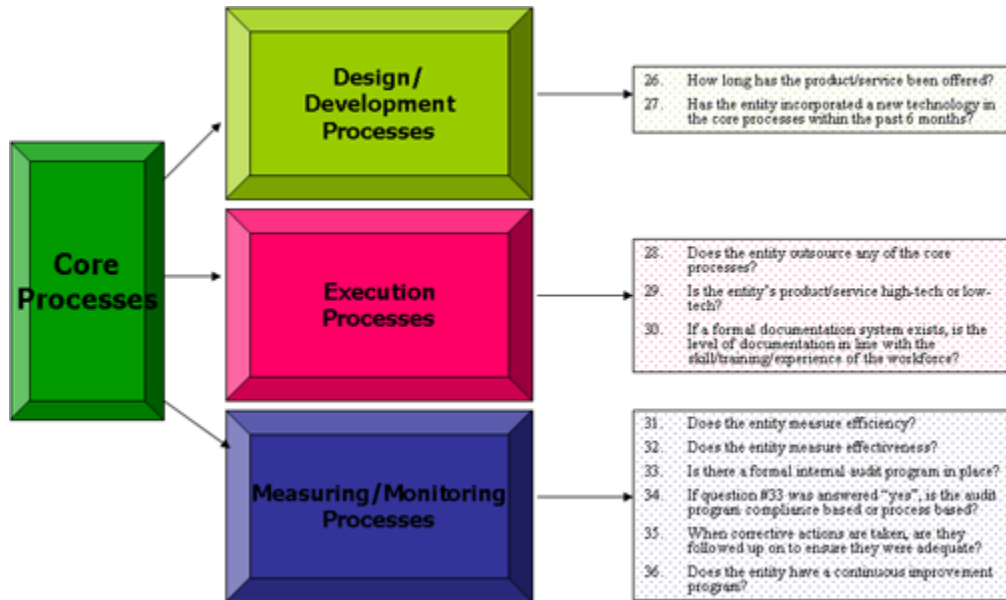
Subsection 7.2.4 Test of Validity of Indirect Method

The questionnaire was completed by thirty (30) organizations within the computer-related industry, semiconductor industry, defense industry, accounting (CPA) arena, educational institutions, laboratories - both private and government, the non-profit arena, banking institutions, oil and gas exploration, government (town and state attorney offices), medical device manufacturers, healthcare providers, various contractors for both commercial and residential areas, dating service providers, utility providers, multiple manufacturing firms, and retail. These organizations were also classified as large or small, high-tech or low-tech, manufacturing or service industries, and highly regulated organizations or those with little to no regulation. After completion, but prior to analysis, a separate individual from each organization was asked their opinion on the percentage of time that informal processes are used within the organization. The questionnaires were then scored with a "1" being assigned to a question if the

answer reflected a potential for informal processes, or a "0" if the potential for informal processes was nonexistent or lower, based on the information from the literature review and this researcher's experience (twenty-eight (28) years in auditing and consulting for organizations in various industries). The scoring is shown in Appendix B following each question. Justification for the scoring follows that of the justification for the questions shown in Appendix D. The potential for the existence of informal processes was then calculated using an average for the overall organization, the strategic processes, the core processes, or any area within the strategic and core processes. Table 8 shows the results of the scoring for the thirty (30) questionnaires.

As seen in Table 8, the normalized score for informal processes occurring in the strategic processes ranges from 0.2 to 0.6, in the core processes from 0.2 to 1.0, and overall from 0.2 to 0.7. If we examine the normalized score of informal processes occurring from the view of the size of an organization (small or large), the type of organization (manufacturing or service), whether the organization is high-tech or low-tech, and whether the organization is highly regulated or has little to no regulation, we find the range of results, and the average (shown in parentheses) in Table 9. Additionally, the data was reviewed from the standpoint of the combining of two of the classifications for a more refined observation. The range of the data is based on the data obtained from Table 8. The averages (in parentheses) are the average of the data for the given organizations within the classification, not the average of the range. This is also shown in Table 9. As an example, if we are interested in the core process area for organizations that participated in this research that are classified as "small", from Table 8, we find there are thirteen (13). The normalized scores for informal processes in the core area, from the results of the questionnaire are 0.6, 0.4, 0.4, 0.5, 0.3, 0.9, 1.0, 0.9, 0.6, 0.5, 0.8, 0.3, and 0.9. The range of this data is 0.3 – 1.0, and the average is 0.6.

104

Table 8. Indirect Detection Method Results

	CO #1	CO #2	CO #3	CO #4	CO #5	CO #6	CO #7	CO #8	CO #9	CO #10	CO #11	CO #12	CO #13	CO #14	CO #15	CO #16	CO #17	CO #18	CO #19	CO #20	CO #21	CO #22	CO #23	CO #24	CO #25	CO #26	CO #27	CO #28	CO #29	CO #30
SCORES																														
S/L	S	S	L	L	L	S	S	S	L	L	L	L	L	L	L	L	L	S	L	S	S	S	L	S	S	L	S	L	S	S
MFG/SRV	MFG	SRV	MFG	MFG	SRV	SRV	SRV	SRV	MFG	MFG	SRV	SRV	SRV	SRV	SRV	SRV	SRV	MFG	SRV	SRV	SRV	SRV	SRV	MFG	MFG	MFG	MFG	SRV	SRV	SRV
HT/LT	LT	HT	HT	LT	LT	LT	LT	HT	HT	HT	HT	LT	LT	LT	HT	LT	LT	HT	LT	LT	HT	HT	HT	LT	LT	HT	LT	HT	HT	HT
HR/NR	NR	NR	NR	NR	NR	NR	NR	NR	HR	HR	HR	NR	HR	NR	NR	NR	HR	NR	NR	HR	NR	NR	NR	NR	NR	HR	HR	HR	HR	NR
QUESTION #																														
1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	1	1	0	1	1	1	1	0	1	1
2	1	1	1	0	1	1	1	1	0	0	0	0	0	0	1	1	0	0	1	1	1	1	0	1	1	0	0	1	0	1
3	0	1	0	0	1	0	1	1	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	1	1	1
4	0	0	1	1	1	1	0	1	1	0	1	1	1	0	1	0	0	1	0	1	1	1	1	1	1	1	1	1
Foundation	0.5	0.8	0.8	0.5	1.0	0.8	0.8	1.0	0.5	0.3	0.5	0.5	0.3	0.5	1.0	0.8	0.5	0.8	0.5	1.0	1.0	1.0	0.8	0.8	0.8	0.5	0.5	1.0	0.8	1.0
5	0	1	0	1	1	0	0	1	0	0	0	0	1	0	1	0	0	0	1	0	0	1	1	1	0	0	0	1	0	1
6	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	0	1	1	1
7	0	1	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1	0	0	0	0	1	0	0
8	1	N/A	0	N/A	N/A	0	0	0	0	0	0	0	0	0	N/A	0	0	N/A	0	N/A	N/A	1	0	0	0	0	N/A	0	N/A
Communication/Information	0.5	1.0	0.3	1.0	1.0	0.3	0.3	0.5	0.3	0.3	0.3	0.3	0.5	0.3	0.5	0.3	0.3	0.3	1.0	0.3	0.3	0.7	0.8	0.3	0.0	0.0	0.3	1.0	0.3	1.0
9	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	1	1	0	1	0	1	0	1	1	0	1	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
11	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Customer Satisfaction	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.3	0.0	0.7	0.3	0.3	0.0	0.0	0.7	0.3	0.0	0.7	0.0	0.3	0.0	0.3	0.3	0.0	0.3	0.0	0.0
12	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	1	0	0	1
13	0	1	0	0	1	1	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	1	1
14	1	1	1	1	1	1	0	1	1	1	1	0	1	1	1	1	0	1	1	0	1	0	1	1	0	1	0	0
15	0	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Procurement	0.3	0.5	0.3	0.3	0.5	1.0	0.0	0.3	0.3	0.3	0.3	0.0	0.5	1.0	0.3	0.3	0.3	0.3	0.8	0.3	0.0	0.8	0.3	0.5	0.3	0.0	0.3	0.5	0.3	0.5
16	1	1	0	1	1	0	1	0	1	1	0	1	0	1	1	1	0	1	0	1	1	1	1	1	1	0	1	0
17	0	N/A	0	0	N/A	0	N/A	0	0	0	1	0	N/A	0	1	1	1	N/A	1	N/A	N/A	0	1	1	1	1	0	0	N/A	0	N/A
18	1	0	0	0	0	1	0	1	1	1	0	0	0	0	1	0	1	1	1	1	0	0	0	0	1	0	1	0
19	1	1	0	1	1	0	1	0	0	0	1	0	1	0	1	1	0	1	0	1	0	0	1	1	0	1	1	0
20	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0
Maintenance	0.4	0.5	0.4	0.6	0.5	0.3	0.4	0.3	0.4	0.4	0.4	0.2	0.4	0.3	0.4	0.6	0.4	0.4	0.5	0.4	0.5	0.5	0.4	0.4	0.6	0.0	0.4	0.3	0.4	0.3
21	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	1	0	1	1	0	0	0
22	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0	1	1	0	0	1	0	0	1	0	1	0	0	0
23	0	1	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	1	0	1	1	0	1	1	0	0	0	1
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	1	0	0	1	0	0	1	0
Allocation	0.2	0.0	0.4	0.0	0.2	0.2	0.0	0.4	0.0	0.2	0.0	0.2	0.0	0.4	0.4	0.0	0.4	0.4	0.0	0.8	0.2	0.0	0.8	0.4	0.8	0.4	0.4	0.0
Strategic	0.3	0.4	0.4	0.4	0.6	0.4	0.2	0.4	0.3	0.2	0.4	0.2	0.4	0.4	0.4	0.5	0.4	0.4	0.6	0.3	0.5	0.5	0.4	0.5	0.4	0.4	0.3	0.6	0.3	0.4
26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
27	0	1	1	0	0	0	1	1	0	0	1	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	1	1	1
Design/Development	0.5	1.0	1.0	0.5	0.5	0.5	1.0	1.0	0.5	0.5	1.0	0.5	0.5	0.5	0.5	0.5	1.0	1.0	0.5	0.5	1.0	0.5	0.5	0.5	0.5	0.5	0.5	1.0	1.0
28	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	1	1	0
29	1	0	0	0	0	1	0	0	0	1	1	1	0	1	0	1	0	0	0	1	0	1	0	0	1	0	0	0
30	0	N/A	0	N/A	N/A	0	0	0	1	0	0	0	1	0	1	0	0	N/A	0	1	N/A	0	0	0	0	0	N/A	0	N/A
Execution	0.3	0.5	0.0	0.5	0.5	0.0	0.3	0.0	0.7	0.0	0.3	0.3	0.3	0.7	0.0	0.7	0.3	0.3	1.0	0.0	1.0	1.0	0.3	0.0	0.3	0.3	0.3	1.0	0.0	0.5
31	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	1	1	1	1	0	0	1	0	0
32	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	1	1	0	1	0	1
33	0	1	0	1	1	0	1	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	1	1	0
34	1	0	0	1	N/A	N/A	0	N/A	1	1	1	1	1	0	N/A	1	1	N/A	N/A	0	N/A	N/A	1	1	1	1	1	N/A	N/A	N/A
35	1	0	0	0	1	1	1	0	0	0	0	0	0	1	0	0	1	0	1	1	1	1	0	1	1	0
36	1	0	0	0	1	1	0	1	0	0	0	0	1	0	0	1	0	0	1	0	1	1	1	0	1	0	0	1	0	1
Measuring/Monitoring	0.8	0.2	0.0	0.2	0.6	0.6	0.3	0.2	0.5	0.2	0.2	0.2	0.7	0.0	0.2	0.8	0.2	0.2	1.0	0.3	1.0	1.0	0.7	0.5	0.8	0.5	0.2	0.8	0.2	1.0
Core	0.6	0.4	0.2	0.3	0.6	0.4	0.5	0.3	0.5	0.2	0.4	0.3	0.5	0.3	0.2	0.7	0.4	0.4	0.9	0.3	1.0	0.9	0.6	0.5	0.6	0.5	0.3	0.8	0.3	0.9
OVERALL	0.4	0.4	0.3	0.4	0.6	0.4	0.3	0.4	0.4	0.2	0.4	0.2	0.4	0.3	0.3	0.6	0.4	0.4	0.7	0.3	0.7	0.6	0.5	0.5	0.5	0.4	0.3	0.6	0.3	0.6

S/L	Small or Large Organization
MFG/SRV	Manufacturing or Service Organization
HT/LT	High-Tech or Low-Tech Organization
HR/NR	Highly Regulated or No to Little Regulation

105

Table 9. Ranges and Averages of Indirect Detection Results Based on Classification

CLASSIFICATION	STRATEGIC	CORE	OVERALL
S	0.2 – 0.6 (0.4)	0.3 – 1.0 (0.6)	0.3 – 0.7 (0.5)
L	0.2 – 0.6 (0.4)	0.2 – 0.7 (0.4)	0.2 – 0.6 (0.4)
MFG	0.2 – 0.5 (0.4)	0.2 – 0.6 (0.4)	0.2 – 0.5 (0.4)
SRV	0.2 – 0.6 (0.4)	0.2 – 1.0 (0.5)	0.2 – 0.7 (0.5)
HT	0.2 – 0.5 (0.4)	0.2 – 0.9 (0.4)	0.2 – 0.6 (0.4)
LT	0.2 – 0.6 (0.4)	0.3 – 1.0 (0.6)	0.2 – 0.7 (0.5)
HR	0.2 – 0.4 (0.3)	0.2 – 0.6 (0.4)	0.2 – 0.5 (0.3)
NR	0.2 – 0.6 (0.4)	0.2 – 1.0 (0.6)	0.3 – 0.7 (0.5)
S and MFG	0.3 – 0.4 (.4)	0.5 – 0.6 (0.6)	0.4 – 0.5 (0.4)
S and SRV	0.2 – 0.6 (0.4)	0.3 – 1.0 (0.6)	0.3 – 0.7 (0.5)
S and HT	0.3 – 0.4 (0.4)	0.3 – 0.9 (0.5)	0.3 – 0.6 (0.4)
S and LT	0.2 – 0.6 (0.4)	0.4 – 1.0 (0.7)	0.3 – 0.7 (0.5)
S and HR	0.3 – 0.4 (0.4)	0.3 – 0.5 (0.4)	0.3 – 0.4 (0.4)
S and NR	0.2 – 0.6 (0.4)	0.3 – 1.0 (0.7)	0.3 – 0.7 (0.5)
L and MFG	0.2 – 0.5 (0.4)	0.2 – 0.5 (0.3)	0.2 – 0.5 (0.3)
L and SRV	0.2 – 0.6 (0.4)	0.2 – 0.7 (0.4)	0.2 – 0.6 (0.4)
L and HT	0.2 – 0.5 (0.4)	0.2 – 0.6 (0.4)	0.2 – 0.5 (0.4)
L and LT	0.2 – 0.6 (0.4)	0.3 – 0.7 (0.4)	0.2 – 0.6 (0.4)
L and HR	0.2 – 0.4 (0.3)	0.2 – 0.6 (0.4)	0.2 – 0.5 (0.3)
L and NR	0.4 – 0.6 (0.5)	0.2 – 0.7 (0.4)	0.3 – 0.6 (0.4)
MFG and HT	02 – 0.5 (0.4)	0.2 – 0.5 (0.4)	0.2 – 0.5 (0.4)
MFG and LT	0.3 – 0.4 (0.4)	0.3 – 0.6 (0.5)	0.4 – 0.5 (0.4)
MFG and HR	0.2 – 0.4 (0.3)	0.2 – 0.5 (0.4)	0.2 – 0.4 (0.3)
MFG and NR	0.3 – 0.5 (0.4)	0.2 – 0.6 (0.4)	0.3 – 0.5 (0.4)
SRV and HT	0.3 – 0.4 (0.4)	0.2 – 0.9 (0.4)	0.3 – 0.6 (0.4)
SRV and LT	0.2 – 0.6 (0.4)	0.3 – 1.0 (0.6)	0.2 – 0.7 (0.5)
SRV and HR	0.2 – 0.4 (0.3)	0.3 – 0.9 (0.4)	0.2 – 0.6 (0.4)
SRV and NR	0.2 – 0.6 (0.5)	0.2 – 1.0 (0.6)	0.3 – 0.7 (0.5)
HT and HR	0.2 – 0.4 (0.3)	0.2 – 0.6 (0.4)	0.2 – 0.5 (0.4)
HT and NR	0.4 – 0.5 (0.4)	0.2 – 0.9 (0.4)	0.3 – 0.6 (0.4)
LT and HR	0.2 – 0.4 (0.3)	0.3 – 0.5 (0.4)	0.2 – 0.4 (0.3)
LT and NR	0.2 – 0.6 (0.4)	0.3 – 1.0 (0.6)	0.3 – 0.7 (0.5)

The data shown above in Table 8 will be utilized in Chapters 8 during the discussion of the subject matter experts' opinions and results, and in Chapter 10 with the application of this technique to actual organizations.

At this stage, we must validate the indirect detection methodology. Two (2) methods of validation will be utilized – the Chi-Square (χ^2) Test of Model Validity and triangulation. We will discuss the triangulation validation method in Chapter 10 after the evidence from the direct methodology is presented. The Chi-Square (χ^2) Test of Model Validity (Juran, 1974) allows us to determine if there is a significant difference between expected and observed values. The null hypothesis will be that there is no significant difference between the observed values and the expected values, H_0: O = E. For the Chi-Square (χ^2) Test of Model Validity, we utilized the analyzed results of the questionnaires (shown in Table 8) as the "expected" values, while the "observed" values are those provided by an individual within the organizations that participated in the indirect methodology survey, but not the individual that completed the questionnaire. The "observed" values are shown in Table 10. The formula for the χ^2 test is as follows:

$$\chi^2 = \sum_{i=1}^{r} \sum_{j=1}^{c} \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

where:

O_{ij} = observed values (those provided by experts within the organizations surveyed),

E_{ij} = expected values (those obtained from the survey results),

r = number of rows, and

c = number of columns.

Calculating χ^2 for the indirect detection methodology, we find that $\chi^2 = 1.29$. Using a χ^2 table, for a p value of .99 (that is, the probability that the null hypothesis is true), and degress of freedom equal to 29 ((r – 1)(c - 1) = (30 – 1)(2 – 1)), we find a value of 14.26. Our calculated

value (1.29) is less than the table value of 14.26; therefore, we accept the null hypothesis that there is no significant difference between the observed and expected values.

Table 10. Observed Values for Indirect Detection Methodology

COMPANY #	"OBSERVED VALUE" *	COMPANY #	"OBSERVED VALUE" *
1	0.4	16	0.6
2	0.45	17	0.33
3	0.25	18	0.48
4	0.6	19	0.65
5	0.85	20	0.15
6	0.25	21	0.8
7	0.3	22	0.75
8	0.2	23	0.4
9	0.5	24	0.6
10	0.15	25	0.85
11	0.1	26	0.35
12	0.15	27	0.25
13	0.4	28	0.75
14	0.33	29	0.1
15	0.25	30	0.6

* "Observed" Values are those provided by an individual within the organizations that participated in the indirect methodology survey, but not the individual that completed the questionnaire

Subsection 7.2.5 Results and Conclusions

In this section, we have provided a means for indirectly detecting informal processes. The questionnaire was developed to provide an organization with a quick and inexpensive method of determining specific areas within the organization that have a greater potential of containing informal processes. Questions present on the questionnaire were developed utilizing information discovered during the literature review and through the experience of the researcher. Justification of the questions was provided in Subsection 7.2.2 with a direct link from each question to information found during the literature review. In addition, each question can be linked to the process taxonomy developed during this research.

Thirty organizations, representing various industries completed the questionnaires for this research. At the completion of the questionnaire, but prior to analysis, a separate individual from each organization with knowledge of the entire organization, was asked their opinion regarding the percentage of informal processes that were utilized throughout the organization. These responses were then used as the observed values during the χ^2 test. The results from the analysis of the questionnaires were used as the expected values for the χ^2 test. The χ^2 test determined that there was no significant difference between the observed and expected values, thereby validating the indirect detection methodology developed for this research.

Section 7.3 Direct Method

The purpose of the direct method for the detection of informal processes is to allow an organization to identify the actual informal processes and where they are occurring. This research provides an organization with comprehensive guidelines for the identification of the actual informal processes and where they occur. Once the informal processes are known, they can be analyzed to determine if they are beneficial or detrimental to the organization. Those

processes that are beneficial should be adopted into the formal system, while the formal system should be amended to preclude the use of detrimental informal processes.

Subsection 7.3.1 Development Methodology

The direct method of detecting informal processes presented in this research may be performed on all processes within an organization, or a portion of the processes, depending on the overall goal of the organization, the time allowed, and resources available. When developing the direct detection method, the goal was to utilize all prior information related to the indirect detection results, the process taxonomy as applied to an individual organization, the process models and their interactions. An efficient and effective means of identifying informal processes are those related to auditing.

Currently there are numerous types of audits used throughout various industries. The audit type most frequently used is a *compliance audit*, where an auditor is verifying that an organization is performing their tasks and processes as documented. This audit methodology is viable for determining if an organization is in compliance with external and internal regulations, policies, and procedures. However, the compliance audit does not consider if a process is being performed efficiently and effectively. Many compliance audits are performed behind a desk, verifying information provided to the auditor, versus actual auditor observations of the processes as they occur. Although this is not the best technique to use for auditing, it does occur. There are guidelines available throughout industries outlining how a compliance audit should be performed.

From a process audit stand-point, the automobile industry is a leader at this time. Specific guidelines exist for the automobile industry in the area of conducting process audits. Outside of the automobile industry, true process audits are not being performed, nor are there

currently any guidelines to aid in the performance of such audits. It is difficult for many auditors to perform process audit, as there should be no standard checklists. A process audit is one that focuses on one particular process (the process may be comprised of numerous "sub-processes"). The auditor must look at the process overall, dissect each element of the process, and be willing to follow any interesting discovery through to its end. This research provides a guideline for the performance of a process audit within any industry, for any organization. The guideline is based on the use of the DROMĒ model presented in Chapter 3. The DROMĒ model is used for the identification and modeling of the process elements to be audited as well as for describing the interactions between processes. To ensure that the process is performed in accordance with all written polices, procedures, and regulations, and that there is no conflict between these documents that could render a process inefficient of ineffective, a document tree is utilized. The items above are generally performed prior to the start of an audit. This will give the auditor a basis for the performance of the audit. During the audit, it is imperative that leading questions be asked. The guideline provides a methodology for generating leading questions for the auditor to use during the process audit.

Subsection 7.3.2 Identification of Process Elements

For any process audit, the first step is to identify the process elements associated with the process to be audited. The DROMĒ process model developed for this research is the tool that will be utilized for this effort. The elements of any process include the input (the catalyst for the process being initiated, whether is be a new order or the output from a prior process), the controls (the written or oral information that establishes the methods required to achieve the output), the equipment/tools utilized during the process, the environment in which the process is to be performed (clean room, surgical suite, vent hood, etc.), materials to be used during the

process, and the humans that will be performing the process. In addition, an important piece of every process is the metrics associated with the elements. The DROMĒ model has the capability for each of the metrics to be identified.

Let us consider a generic document control process to see how the DROMĒ process model would be developed. For our example, let's imagine that our customer has sent a revised procedure for the test specifications of their product. We must review our current internal procedure to determine if revisions are required, and if so, change our internal procedures to be compliant with the customer's requirements. Our input will be the receipt of the revised customer procedure, and our output will be the release of the revised internal procedure. We will break the process down into five (5) basic activities: the initial review of the external document to identify what effect it has on the internal procedures; document control verification of the current status of the internal procedure; revision, validation, and verification of the internal procedure; approval cycle; and finally the internal document release process. Figure 28 shows the overall document control process for the revision of internal documents based on changes to external documents.

Figure 28. Overall Document Control Process Modeled Utilizing the DROMĒ Technique
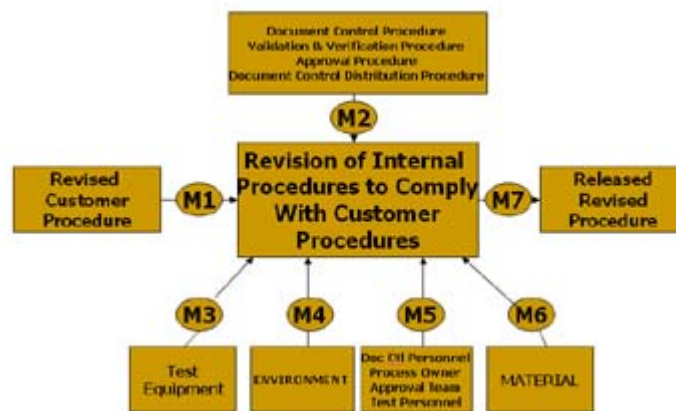
All of the elements that are essential to the overall document control process related to the revision of internal procedures based on an amended customer specification have been identified in Figure 28. Notice there are no items shown for the environment or materials elements within the process model, although there are spaces available for these elements.   The reason for this is that the example process does not require any of these elements beyond the typical office machines. It would be up to the auditor to include these elements if they desired, but from a practical perspective, they are not required. Additionally, initial metrics have been placed for each element. As the process is expanded into the five (5) basic activities, we will see how these metrics relate to both the sub-processes and each other.

Subsection 7.3.3 Process Interactions

Figure 29 shows the DROMĒ model expanded with the five (5) sub-processes identified in Subsection 7.3.2.   The input for the initial sub-process is identical to the input for the overall process model shown in Figure 28. Each sub-process thereafter has the input as the output from the prior sub-process, with the final output being identical to that of Figure 28. Figure 29 allows us to see the various interactions of the processes involved in the revision of an internal document based on an amended customer specification.

It is imperative that we have an understanding of the metrics shown in Figure 29. For each element within a process, there is the potential for a metric to be taken. For example, if we look at the input to the first sub-process (internal review of external document), noted as M1A on Figure 30, there could be a metric with regards to the number of revised customer specifications received that would tie to the overall contract. For the control element on the sub-processes, the metrics are identified as M2A, M2B, M2C, M2D, and M2E. Looking at the controls section of

113

Figure 29. Expansion of Document Control Process Model

114
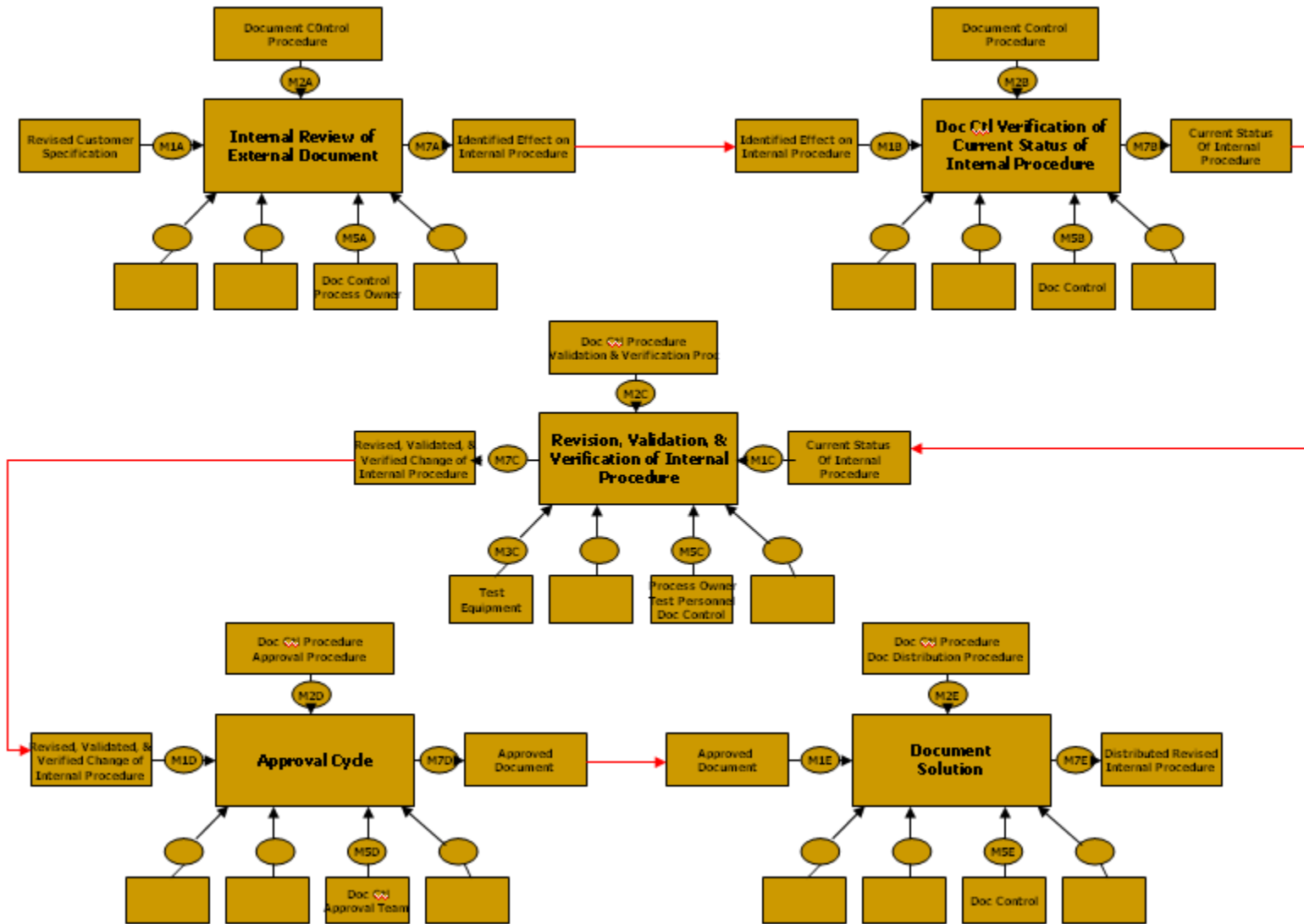
each of the sub-processes, we see that the document control procedure is a part of every control element within the expanded model. The metrics, M2A and M2B are identical, as the document control procedure is the only control for these two sub-processes.. For metrics, M2C, M2D, and M2E, the metric M2A will be a part of the overall metric. Let's look at metric M2C. This metric is associated with both the document control procedure (which we have previously identified as having the metric M2A), and the validation and verification procedure, which will have a separate metric. We could say that M2C = M2A + Metric for the validation and verification procedure. The advantage of having the elements and metrics identified is that during the audit process, there should be no duplication of audit for various elements and metrics, thus allowing the audit to be more efficient. Additionally, any concerns associated with a specific element or metric can be traced to other processes to determine the effect.

Subsection 7.3.4 Usage of Document Trees

A document tree is a diagram of all documents related to a process. The purpose of a document tree is two-fold: (1) to ensure the process is performed in accordance with all written policies, procedures, and regulations, and (2) to ensure there is no conflict between these documents that could render a process inefficient or ineffective. In the late 1980s a defense contractor testified before a committee within the Department of Defense (DoD) regarding the cost of a specific item being manufactured. One of the line items within the contract appeared to the committee to be inflated. The line item dealt with the engineers on staff whose sole job function was to review the standards and regulations required by the contract to determine what items must be followed by the defense contractor. To illustrate the defense contractor's point, a copy of every standard and regulation that was referenced by the DoD in the contract was taken to Washington, D.C. and stacked in a pile – the pile was over nine (9) feet tall. In addition to the

115

sheer volume of regulations, there was a separate pile (smaller, only three (3) feet tall), that

represented the documents referenced within the contract that conflicted with other referenced

documents. A document tree was used to aide in the discovery of this issue.

The above example illustrates the importance of a document tree. It is a simple, but

useful tool for an auditor. An example of a document tree is shown in Figure 30. This specific

document tree is an actual diagram for a process that was audited for this research and will be

discussed in Chapter 10. A document tree can start at any point within the documentation

system. For this specific example, the organization that was being audited was an ISO 9000

registered company, and the quality manual was the upper level document. As seen in Figure 30,

the quality manual appears at the top of the tree. Within the purchasing section of the quality

manual, five (5) documents are referenced (production process, quality records master list,

purchasing, approved vendor list, and vendor selection). The document tree also shows the

interrelationships between documents – the vendor selection procedure and purchasing are

directly referenced by the quality manual; and the purchasing procedure references the vendor

selection procedure. It is not required to utilize different colors when preparing a document tree,

Figure 30. Example of Document Tree for Purchasing Process

but it is useful, especially when the document trees are large and there are numerous interrelationships between documents.

Subsection 7.3.5 Methodology for Conducting a Process Audit

The majority of audits performed are for the sole purpose of ensuring if an entity is in compliance with applicable rules and regulations.   While this is an important and critical factor, it does not provide the entity with information on the effectiveness and efficiency of their processes. In today's economic times, it is critical for an entity to understand their processes and know how effective and efficient the processes are in order to compete. A methodology has been developed for conducting process audits to ensure that the processes within an organization are not only compliant, but also efficient and effective. Guidelines for performing process audits are found in Appendix E. The proposed process audit and the current audit used today are contrasted in Table 11.

Table 11. Contrast Between Current Audit System and Process Audit System

CURRENT AUDIT SYSTEM	PROCESS AUDIT SYSTEM
Audit focused	Objective focused
Element/area based	Process based
Compliance objective	Risk identification/process improvement
Policies and procedures focus	Process and risk focus
Policy adherence	Change facilitator
Methodology: focuses on policies, work performance, and compliance	Methodology: focuses on objectives, effectiveness, efficiency, and risk management

The objective of any audit is to provide information regarding the status of an entity's processes and compliance to all required laws and regulations. Compliance audits will provide a portion of this objective. It is essential that an entity audit all of their processes and determine the state of the process, the state of the process elements and the interaction of the elements. This audit will allow the entity to assess and measure the effectiveness of their processes as well as the process efficiency.

Achieving an organization's goals is a critical factor in the world today. The continuation of an entity at times depends on the entity becoming more efficient. Improvements to an entity's processes will only be advantageous when the status of that process' effectiveness and efficiency are known. The results of a process audit can provide this information to the organization. The first step in preparing for a process audit is to determine the process that will be the subject of the audit. A process may be large (i.e. an audit of the entire document control process from the development of a procedure to the distribution of the procedure), or small (i.e. distribution of new or revised documents). It is critical that the boundaries of the process be defined and agreed upon with the individual's affected by the audit prior to starting the audit.

Upon agreement, the auditor will model the process using the DROMĒ process model which provides the auditor with a tool that can identify all elements of the process and their associated metrics. Additionally, numerous DROMĒ models can be linked together to show the interrelationships of various activities associated with a process, or to show the interrelationship of numerous processes. During the modeling process, the information for the "control" element within the DROMĒ model should be obtained utilizing a document tree discussed in subsection 7.3.4.

When the DROMĒ model(s) is (are) complete, the auditor should review the models, associated documents from the control section, and metrics to ensure an understanding of the process prior to performing the audit, and note any areas of concern (conflict between documents, delivery of material in an efficient manner, etc).

Prior to beginning the audit, the process auditor should perform a review to include any contractual or legislative requirements; codes, standards, and regulations, management practices; past audit results (both internal and external audits), corrective and preventive actions and the associated conclusions, customer satisfaction and complaint information, and prior metrics for the elements within the process being audited. The performance of this background information will provide the auditor with requirements of the process and a history of the process audited as well as suggesting strengths and weaknesses of the process and its elements.

Process audits do not require a checklist, and in fact, should not have a checklist. Checklists do not allow an auditor the leeway to examine items of interest that occur during the progression of the audit. Additionally, checklists tend to confine an audit to yes or no responses, which do not allow efficiency and effectiveness to be adequately considered. From the information collected and completed (history, DROMĒ process model, document tree), the process auditor can begin the audit.

There are three (3) basic components of an audit; (1) interview of personnel, (2) observation of the process being performed and (3) document review. Each of these components combines to form an audit that achieves its intended purpose. For a process audit, the above components should be applied to every element within the process model, the interaction of the elements, as well as the interactions with the processes immediately before the subject process

and after the subject process. The information below provides a basic guide for the three (3) components.

When interviewing personnel, it is important that the auditor establish a rapport with the individual being interviewed and make that individual feel important. The auditor should have a goal of gaining the trust of the interviewee. The auditor should be aware of the surroundings during the interview process – are they in an area where they can be overheard, is the interviewee's supervisor/manager looking over their shoulder? The interview should take place in a neutral area that is private. Gaining the interviewee's trust can also be achieved by the attitude of the auditor (being prepared and being open). When speaking with the interviewee, pay attention to not only their words but their actions and body language. If an interviewee appears to be under stress or nervous, tell them a little about yourself, and paraphrase their words in other follow-up questions. Open-ended questions and leading questions are preferable to those that require a yes or no response from the interviewee. The ultimate goal of the interview process is to gather information. During the interview portion of the process audit, there are three (3) areas that should be explored. These areas are the process itself; the identification of any non-conformances, inefficiencies, and ineffective activities; and an exploration of the non-conformances, inefficiencies and ineffective activities.

One of the first areas visited during the interview will be the process itself. The questions during this stage should be well defined, process targeted, and simple. These types of questions typically begin with the words how, what, and why. As the interview continues, it is important to be aware of questions that would make the interviewee uncomfortable. For these types of questions, the auditor should split the uncomfortable question into smaller questions that allow them to gather information while maintaining the trust of the interviewee. For example, an

auditor could ask the question, "this procedure has changed. When were you trained in the new procedure?" This question can appear to an interviewee as one that is targeting them specifically. An alternative to this question would be to divide the question into smaller, less threatening questions, such as: "About how long ago was this procedure changed?", "How were the workers notified of the change?", "Are there records of the change that you are aware of?", "Would there be records of training on the procedure changes?" Some of these questions will require follow-up questions and a chance to verify specific records associated with the change. At this stage, the process auditor should share the DROMĒ process model with the interviewee and obtain their opinion in regards to the elements and their interfaces.

When identifying nonconformities, inefficiencies, or ineffective actions, the auditor should phrase their questions about the circumstances of the process. If, for example, the auditor determined that there was a conflict between a customer specification and the organization's internal specifications, an appropriate question would be "How do customers provide you with requirements", versus "Why do you not follow the specifications that the customer has provided?" The first question is non-threatening, allows an auditor to learn more about the actual process of how customer requirements are brought into the organization's internal procedures, and could highlight potential ineffectiveness and inefficiencies within the process. The second question is threatening and tends to just a compliance issue. During this portion of the audit, the auditor must be careful to remember that everything has a minimum of two sides. More information can be gathered from an interviewee if the auditor starts with a positive statement about the process and moves to the problem.

When inefficiencies, ineffective situations, or nonconformities are identified, and further exploration is needed, it is helpful if the auditor takes the side of the interviewee. Instead of

asking a question such as "Why do you not keep track of the metrics like the procedure requires?", the auditor could say, "I think that the requirements in this procedure for keeping track of these metrics would make it difficult for anyone. Tell me about this."

Upon completion of the interview the auditor will have additional information to aide in the observation and document review portion of the process audit. The DROMĒ model will be the roadmap for the auditor during the observation portion and should be referenced throughout the observation. During the observation phase of the audit, the auditor must verify that all elements shown on the DROMĒ model are utilized, that they meet the requirements set forth in the documentation, and that all elements of the DROMĒ model are effective and efficient in the activity being performed. The auditor should follow the path of the elements both forward and backward though their progression. It is imperative that the auditor note any areas of risks or concerns during the observation phase. These risks may be from various perspectives including safety, efficiency, effectiveness, or not adhering to the documented procedures. It is reasonable for the process auditor to question an employee as they are performing an activity as long as the interruption does not have an impact on the safety of the employee or others, or have a detrimental impact on the activity of the employee.

The observation phase leads to the question of sampling during the process audit. Any size sample is adequate for audit purposes since an audit is not intended for product acceptance nor process control. A sampling plan may be used if it is required by management or if the auditor prefers. If a sampling plan is to be used, it must be adhered to. It is unacceptable for an auditor to add to the sample size if no issues were found with the original sample.

The last phase of performing a process audit is document review. Throughout the audit preparation and actual audit process, the auditor has gathered information that will lead them to specific document types to be reviewed. To obtain an unbiased view of the documents, the auditor should not request typical documents. If allowed, the auditor should pull their own samples from the files, or be present when requested samples are pulled. For an overview, the auditor should pull or request documents from each of the process elements and metrics identified on the DROMĒ model.

The phases of the process audit identified here are used during compliance audits today. The difference lies in how the interviews are conducted (yes or no responses during a compliance audit with no follow-up questions, or open-ended questions during a process audit), and how observations are made (compliance audits look only at whether the activity is being performed in accordance with the procedures, where process audits will examine not only the compliance aspect, but also whether the activity is efficient and effective). Document review techniques are identical. The leeway gained in conducting a process audit by following the elements of the process in the direction that they lead allows an auditor to examine an activity for efficiency and effectiveness which could lead to an organization remaining viable in the market of today.

Subsection 7.3.6 Basic Characteristics of Process Auditors

The characteristics of an auditor play a crucial role in the effectiveness of any audit. At a minimum, an auditor should receive audit training, either internally or from an external source. For a process audit, it is not required that the auditor be an expert in the process they are auditing. In fact, it is best that they not be for the reason that the auditor can approach the audit without preconceived notions of how the process should be performed. Conversely, it is desired

that the auditor have sufficient general knowledge regarding the general type of process. For example, if the process to be audited was a manufacturing process that converted metals into solder, it would be advantageous to have an auditor with a manufacturing or engineering background – you would not want a financial auditor to perform this audit. Likewise, you would not want an auditor with a specific manufacturing background performing an audit on financial processes.

Auditor traits that are desirable for process auditors include:

- Good judgment

- Open minded

- Resilient

- Diplomatic

- Self-disciplined

- Honest

- Unbiased

- Good listener

- Patient

- Articulate

- Professional

- Interested

- Analytical, and

- Self confident

In addition, the auditor should be able to organize their thoughts and notes in a manner that aides in the performance of the audit. In many of today's organizations, the technical background of the auditor is the most important aspect. However, if the human side of the auditing process (open-minded, listener) is swept aside, the audit results will not be sufficient to determine the actual state of the process.

Subsection 7.3.7 Validation of Direct Method

In the previous subsections of Section 7.3, we have presented a methodology for the performance of process audits – that is, we developed a direct method for the identification of informal processes. The question now becomes, can we show that the proposed method is more effective than the compliance method of auditing? To address this question, an independent SME arranged audit scenarios in which they were aware of the number of informal processes. A randomized block design experiment was performed in which there were three (3) treatments:

1. Process audit conducted by an experienced auditor with more than ten (10) years of auditing experience,

2. Process audit conducted by an individual trained in process audits, but without audit experience, and

3. Compliance audit conducted by an experienced auditor with more than ten (10) years of audit experience.

A total of fifteen (15) blocks were utilized in this experiment. Each of the fifteen (15)

blocks can be linked to the process taxonomy as defined in Chapter 4. Table 12 summarizes the

process type that was audited (showing the process taxonomy to which it is linked), the number

of arranged informal processes within the audit scenario, the number of informal processes

identified by the experienced process auditor, the number of informal processes identified by the

trained process auditor with no prior experience, and the number of informal processes identified

by the experienced auditor performing a compliance audit. Within the first audit (foundation,

objectives, planning) the audit consisted of interviewing personnel involved in planning of the

product lines for the next two (2) quarters, observing the planning meeting, and reviewing the

documentation. The planning included the product lines, quantity, and quality objectives. The

audit for the document revision within the communication/information process taxonomy area

followed the revision process of three (3) documents from the requirement of the needed revision

(one was a customer change, one was a engineering revision, and one was as a result of a

corrective action request). During this audit, personnel from document control, engineering, and

logistics (the individual that received the customer request) were interviewed. The process was

observed from the request for a document change to the distribution of the completed document.

Training records were reviewed and a training session attended for the audit in the maintenance –

training area of the process taxonomy. Interviews were conducted with the trainer and

individuals attending the training and training records were reviewed for accuracy. The first

process audited in the execution area was a soldering process. Interviews were held with the

assembly worker and inspector, with the operations of solder and inspection being observed.

Records were reviewed related to the soldering process. Corrective action requests were

reviewed for the measuring/monitoring audit. Samples of corrective action reports were pulled

and the initiator and responder for each were interviewed regarding their roles and methods in completing the requests. Metrics from the prior six (6) months were reviewed for accuracy. Internal surveys of the organization's employees were distributed once a year. Interviews were held with personnel representing the department responsible for the survey and various responders to the survey. Records of the survey results and actions taken on items of concern were reviewed. A request for purchase provided the input for the audit within the area of procurement – purchasing. The purchasing process was observed from the receipt of the purchase request through the order confirmation. Personnel were interviewed from the requesting department for the purchase and within the purchasing group. Within the allocation area, the audit observed the process of scheduling personnel to comply with the plans resulting from the first audit (foundation – objectives – planning). Change notices are a form of quick turn-around changes within the organization that allow critical changes to assembly work procedures to get to the floor prior to a full document revision and release. Personnel responsible for generating the change notices, informing personnel, and following up to ensure the changes are incorporated into the formal documents were interviewed. Personnel from the assembly area were also interviewed to determine if they received adequate information and training on change notices. Documents were reviewed for three (3) months prior to ensure change notices were incorporated into the formal system. An audit of the calibration process was performed for the process taxonomy area of maintenance – calibration. Personnel were interviewed from the area where the equipment to be calibrated was located, calibration technicians were interviewed regarding their process, the actual calibration was observed, and records were reviewed for the piece of equipment being calibrated. The second and third audits within the execution process taxonomy were conducted identically, and the same personnel were

interviewed for both, as they were performed in the same area. The second process audited in the execution area was a paint process, the final assembly step in the production line. A paint process was observed and careful attention was made to the environmental requirements for the process. The third process was a stenciling process where the serial number and part information was placed on the product. The process was observed and records reviewed for four (4) months prior. The organization audited was a three-shift, seven-day operation. Shift pass off is a vital part of communication within the organization on the production floor. Therefore, the next audit for the communication/information process taxonomy was shift pass-off. Shift pass-off is verbal. A shift pass-off was observer and interviews were conducted with supervisors and personnel from both shifts present to ascertain if they receive the correct information in a manner that is useful for them. Within the design/development area of the process taxonomy, the next process audited was the technical change process. This process occurs when the engineers make a technical change to an item that is still in design. Interviews were conducted with engineering, quality assurance, and document control in regards to this process. Records were reviewed for three (3) prior design efforts. The final process audited in the audit scenarios for the validation of the process-based audit was the internal audit process (measuring/monitoring area of the process taxonomy). An audit was observer and interviews were conducted with the auditor and auditee of the organization. Records for the past four audits of the specific area being audited were reviewed. From the data collected from the fifteen (15) audits, we can see that the experienced process auditor identified the informal processes 99% of the time, the trained process auditor identified the informal processes 83% of time, and the experienced compliance auditor identified the informal processes 58% of the time. It should be noted that during the April 3, 2009 audit of the execution – process 1 scenario, the experienced process

auditor identified an additional informal process within the controls section that was unknown by the corporation. This informal process identification was deleted from the numbers when calculating the above percentages for the experienced process auditor.

In a randomized block design (Juran, 1974), we apply each of the treatments (the experienced process auditor, the trained process auditor, and the experienced compliance auditor) to each of the blocks (the fifteen (15) audit scenarios). Our null hypothesis will be that there is no difference in the treatments, i.e. the results should be the same whether using a compliance audit technique, the process audit technique with an experienced auditor, or the process audit technique with an auditor trained in the technique but with no experience. There are six (6) calculations involved in a randomized block design experiment. At the completion of the calculations, if the calculated F value is greater than the F value from the respective table, we will reject the null hypothesis.

Table 12. Summary of Randomized Block Design Experiment for the Direct Method

PROCESS TYPE AUDITED	DATE	ARRANGED INFORMAL PROCESSES	PROCESS AUDIT/ EXPERIENCED AUDITOR	PROCESS AUDIT/ TRAINED AUDITOR	COMPLIANCE AUDIT/ EXPERIENCED AUDITOR
Foundation - Objectives Planning	3/20/09	4	4	3	3
Communication/ Information – Document Rev.	3/20/09	10	10	8	5
Maintenance – Training	4/3/09	9	9	9	7
Execution – Process 1	4/3/09	6	7	5	3
Measuring/ Monitoring – Corrective Act.	4/17/09	8	7	6	5
Customer Satisfaction – Internal Surveys	5/29/09	3	3	2	2
Procurement – Purchasing	5/29/09	7	7	5	4
Allocation – Scheduling	5/29/09	2	2	2	2
Communication/ Information – Change Notices	6/26/09	6	6	5	3
Maintenance – Calibration	6/26/09	5	5	4	2
Execution – Process 2	6/26/09	7	7	5	4
Execution – Process 3	7/10/09	8	8	7	5
Communication/ Information – Shift Pass Off	7/24/09	3	3	3	0
Design/ Development – Tech Change	7/24/09	4	4	4	2
Measuring/ Monitoring – Internal Audit	7/24/09	8	8	7	5

We will begin by defining the nomenclature.

- $i = 1, 2, \ldots, k$ (number of treatments)

- $j = 1, 2, \ldots, b$ (number of blocks)

- B_j = row total (the total off all of the treatments for a given block)

- $b_j = \dfrac{B_j}{k}$ (row average – the average of the treatments for a given block)

- T_i = (column totals – the average of a specific treatment for all blocks)

- G (grand total) $= \displaystyle\sum_i T_i$

- TSS (corrected sum of squares) $= \displaystyle\sum_i \sum_j y^2{}_{ij} - (G^2 / kb)$

- SSB (sum of squares of the blocks) $= \dfrac{B_1{}^2 + B_2{}^2 + \ldots + B_b{}^2}{k} - (G^2 / kb)$

- SST (sum of square of the treatments) $= \dfrac{T_1{}^2 + T_2{}^2 + \ldots + T_k{}^2}{b} - (G^2 / kb)$

- s^2 (estimate of the variance) $= \dfrac{TSS - SSB - SST}{(b-1)(k-1)}$

- γ (degrees of freedom) $= (b-1)(k-1)$

- α (level of significance)

- $F_{\text{calculated}}$ (ratio) $= \dfrac{(SST / (k-1))}{s^2}$

When performing a randomized block design experiment, the six (6) calculation steps are as follows:

1. Compute the corrected sum of squares, TSS,

2. Compute the sum of squares for the blocks (SSB)

3. Compute the sum of squares of the treatments (SST)

4. Compute the estimate of the variance (s^2)

5. Select α for the test, and

6. Calculate the F ratio.

Table 13 presents the data and calculations for the randomized block design experiment. As seen in Table 13, the calculated F value is 31.49, and the F value from the tables is 3.34. Since the calculated F value is greater than the table F value, we reject the null hypothesis, i.e. all treatments are not the same.

Subsection 7.3.8 Results and Summary

Section 7.3 presented the direct method for identification of informal processes utilizing a process audit. The DROMĒ model, introduced in Chapter 3 provides a roadmap for the process auditor. Combining the DROMĒ model with the document tree and background information (regulations, standards, history of the process) provides the auditor with the tools required to begin the audit. During the audit, three (3) phases were reviewed – the interview phase, observation phase, and document review phase. Guidelines for conducting a process audit were developed and appear in Appendix E.

The process audit technique developed and discussed was validated through a randomized block design experiment where audit scenarios were arranged by an SME and three (3) auditors conducted an audit. The results were analyzed and the null hypothesis that all of the treatments (types of audit/experience of the auditor) were the same was rejected. Further validation of the direct detection methodology will be seen in Chapter 10 when this methodology is applied to actual organizations.

Table 13. Randomized Block Design Calculations

BLOCKS	TREATMENTS			Row Total (B)	Row Average (b)
	1	2	3		
Foundation - Objectives Planning	4	3	3	10	3.33
Communciation/Information - Document Revision	10	8	5	23	7.67
Maintenance - Training	9	9	7	25	8.33
Execution - Manufacturing Process 1	7	5	3	15	5.00
Measuring/Monitoring - Corrective Action	7	6	5	18	6.00
Customer Satisfaction - Internal Surveys	3	2	2	7	2.33
Procurement - Purchasing	7	5	4	16	5.33
Allocation - Scheduling	2	2	2	6	2.00
Communication/Information - Change Notices	6	5	3	14	4.67
Maintenance - Calibration	5	4	2	11	3.67
Execution - Manufacturing Process 2	7	5	4	16	5.33
Execution - Manufacturing Process 3	8	7	5	20	6.67
Communication/Information - Shift Pass Off	3	3	0	6	2.00
Design/Development - Technology Change	4	4	2	10	3.33
Measuring/Monitoring - Internal Audit	8	7	5	20	6.67
COLUMN TOTALS (T)	90	75	52		

GRAND TOTAL (G)	217				
COMPUTED SUM OF SQUARES (TSS)	234.58				
SUM OF SQUARES OF BLOCKS (SSB)	171.24				
SUM OF SQUARES OF TREATMENTS (SST)	48.84				
ESTIMATE OF THE VARIANCE (s²)	0.52				
s	0.72				
DEGREE OF FREEDOM FOR VARIANCE	28				
α	0.05				
CRITICAL F VALUE (2,28) with α above	3.34				
CALCULATED F RATIO	31.49				

Chapter 8: Quantitative Assessment of the Effect of Informal Processes

Section 8.1 Introduction

Thus far, we have followed our path through process modeling, including the introduction of a new process model, DROMĒ; we have presented a process taxonomy; developed an organizational process-based model; identified causes of informal processes; and linked al of the above to the SoTeRiA framework. In Chapter 7 we presented two methods for the identification of informal processes within an organization – the indirect detection methodology (a questionnaire that will allow an organization to determine the types of processes with the highest probability of containing informal processes), and the direct detection methodology (a process based audit with the objective of not only determining the compliance of a process but also the its effectiveness and efficiency). Upon identifying informal processes, we must have a method to quantify them to determine the impact of the informal processes on an organization. When an informal process is identified that is beneficial to the organization, the informal process must be brought into the formal system. The adoption of beneficial informal processes in the formal system can increase the overall efficiency and effectiveness of the organization. If an informal process is identified that is detrimental to the organization, the formal system should be revised in a manner that will preclude the use of the informal process. In this chapter, we will apply Bayesian Belief Networks and the Stiber methodology to SME inputs and correlate this information with our research to date. Utilizing this information, we will present a quantitative methodology that can be used to determine the probability of an output being deficient.

Section 8.2 Assessment Methodology

Three (3) methods were utilized in the development of the quantitative methodology; (1) Bayesian Belief Networks (BBN), (2) Subject Matter Experts (SME), and (3) the Stiber Methodology. This section will provide a background on each of these methods and discuss how the methods were utilized in this research.

Subsection 8.2.1 Bayesian Belief Networks (BBN)

Bayes' theorem was developed by Thomas Bayes and published posthumously in 1763. Bayes' theorem states that if you have a prior probability (Pr(A)), and receive new information (Pr B|A), then the knowledge regarding the occurrence of an event (Pr A|B) is:

$$\Pr\langle A|B\rangle = \frac{\Pr\langle B|A\rangle \Pr(A)}{\Pr(B)}$$

"Bayesian networks" was a term established by Judea Pearl in 1985 to emphasize three (3) aspects of Bayes' theorem. The first aspect being the often subjective nature of the input information, the second being the reliance on Bayes' conditioning as the basis for updating information, and the third aspect regarding the distinction between causal and evidential modes of reasoning.

Bayesian Belief Networks (BBNs) are also known as Belief Networks, Causal Nets, Graphical Probability Networks, Causal Probabilistic Networks, Probability Nets, and Probabilistic Cause-Effect Models. BBNs are unique in that they provide a model as well as the equations for calculating the probability of a specific occurrence. BBNs are effective for modeling situations where the evidence about the past and/or current situation is incomplete, conflicting, uncertain, and/or vague. BBNs model causes and effects utilizing nodes (representing variables) and arcs (representing the causal relationships between the variables).

From Figure 22, we see that any process may contain both formal and informal components. Utilizing this information, we can see that a BBN in its most basic form, can be modeled as shown in Figure 31.

Figure 31. Diagram of a Basic Output with an Informal and Formal Process
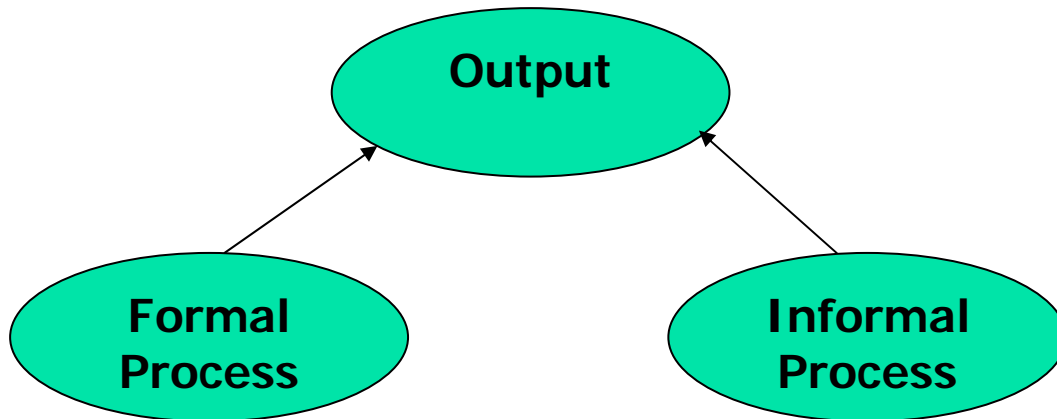
For the BBN shown in Figure 31, the probability of the output (O) being defective, is the probability of the formal process (F) being defective or the informal process (I) being defective. If we assume that the formal process and the informal process are independent, and also assume that the output will fail if the formal process, the informal process, or both fail, and let:

$\overline{O}$ = output defective,

F = formal process is good,

$\overline{F}$ = formal process failing,

I = informal process is good,

$\overline{I}$ = informal process failing, and

$P(*)$ = probability of * occurring, then

$$P(\overline{O}) = P\langle \overline{O}|F,I\rangle P(F)P(I) + P\langle \overline{O}|\overline{F},I\rangle P(\overline{F})P(I) + P\langle \overline{O}|F,\overline{I}\rangle P(F)P(\overline{I}) + P\langle \overline{O}|\overline{F,I}\rangle P(\overline{F})P(\overline{I})$$

The first term in the above equation can be set to zero (0), from our assumption that the output is bad if the formal process fails, or the informal process fails, or both the informal and formal processes fail. From this, we will have:

$$P(\overline{O}) = P\langle \overline{O}|\overline{F},I\rangle P(\overline{F})P(I) + P\langle \overline{O}|F,\overline{I}\rangle P(F)P(\overline{I}) + P\langle \overline{O}|\overline{F,I}\rangle P(\overline{F})P(\overline{I})$$

BBNs were the chosen model utilized by the subject matter experts to determine the influence between the various process taxonomies for the strategic processes, the core processes, and the output of the organization. The results of the SME contribution will be discussed in Section 8.4.

Subsection 8.2.2 Subject Matter Experts (SME)

To date, there is no definitive standard or criteria for the selection of subject matter experts. However, we know that the SME need to have a proven expertise within their field and have the capability to understand the area of interest of the research for which they will be providing their opinion. Requirements for an SME to participate in the study include their willingness to devote the necessary time and effort, a willingness to be impartial and participate in discussions, and have strong communication and interpersonal skills (Mosleh 2002).

The number of SME required for a given study varies through the literature. Ashton (1986) suggests three (3) to six (6) experts, while Shirazi and Mosleh (2009) conclude that six (6) to seven (7) experts will produce a high accuracy. Mosleh (2002) suggests that the number of SME can be determined on a case-by-case basis taking into consideration the availability of resources and the criticality of the issue. For this research, nine (9) SME were utilized.

Originally, eight (8) SME were chosen based on their fields of expertise, as the goal was to have a broad sample for the research. The eight (8) SME had a total of 256 years of experience (with the average being thirty-two (32) years), with experience in twenty-six (26) industries, and twenty-three (23) fields as shown below:

- Industries
  - Nuclear
  - Medical Device
  - Semiconductor
  - Defense
  - Manufacturing
  - Health Insurance
  - Credit Card
  - Airline
  - Heating-Ventilation-Air Conditioning
  - Automotive
  - Power Tools
  - Furniture Design and Manufacturing
  - Information Technology
  - Telecommunications
  - Space (NASA)
  - Appliance
  - Packaging
  - Electronics

- o Office Supplies

- o Paper

- o Converting

- o Drug Testing

- o Environmental Protection

- o US Congress

- o Petroleum

- o University Professor

- Fields

  - o Manufacturing Engineering

  - o Quality Engineering

  - o Reliability Engineering

  - o Environmental Engineering

  - o Mechanical Engineering

  - o Compliance

  - o Safety

  - o Audit

  - o Training

  - o Management

  - o Business Owner

  - o Consulting

  - o Software Programming

  - o Airline Crew

- o Facilities

- o Electrical Engineering

- o Design

- o Heat Transfer

- o Seismic

- o Computer Networking

- o Analytical Chemistry

- o Analytical Biology

- o Forensic Examination

The initial meeting of the SME was held February 28, 2009 with eight (8) SME present. A short presentation was given relative to the research being performed, that included definitions, structures, work to date, and the objectives for the SME. Causes of informal processes were generated using brainstorming techniques (refer to Section 6.3), and then the causes were mapped to the process taxonomy. The SME received a brief overview and training of BBNs with the objective of providing those SME without an understanding of BBNs the basic principles required. The SME concurred to utilize the areas of the process taxonomy as the nodes for the BBNs. At the conclusion of the initial meeting, each SME had constructed their BBN based on their experience for the strategic portion of the organizational model and completed the associated conditional probability tables. The results are shown in Subsection 8.4.1. Based on these results, the SME were divided into two groups – those from an industry that is highly-regulated, and those from industries that have little to no regulation. At this time, it was decided to add an additional SME from the nuclear field to ascertain if their responses would

agree with those from the highly-regulated industry. Also, at this time, one of the SME (also

from a highly regulated industry) had to leave the group due to time constraints.

In the months following, the SME completed BBNs for the core area, abbreviated

organization processes output, and an expanded organizational processes output individually. At

the completion of the individual BBNs, the two groups met separately to reach an agreement on

one structure for the strategic, core, abbreviated organizational processes output, and expanded

organizational processes output BBNs. The associated conditional probability tables were then

completed. The results can be found in Section 8.4. Analysis of the results was performed

utilizing the Stiber methodology.

Subsection 8.2.3 Stiber Methodology

The utilization of multiple SME presents a challenge in regards to how the various

outcomes will be used as a whole. Stiber, Small, and Pantazidou (2004) developed a method for

combining multiple experts' opinions (Stiber Methodolgy). The Stiber methodology is an

aggregate method in which the individual SME judgment is weighted by a posterior probability,

with observed evidence, rendering the model correct for a given problem.   The SME that are

more consistent with the observed evidence are given a larger posterior probability weight.

For J SME utilized in a study, where M_j is the SME model, the probability weighted

aggregate probability for an event P(E) is:

$$P(E) = \sum_{j=1}^{j} P\langle E | M_j \rangle P(M_j)$$

Where $P(E | M_j)$ is the probability of the event, E, occurring given that SME j model is correct.

$P(M_j)$ represents the probability that SME j model is correct.   When observed evidence (x) is

available, the $P(E | M_j)$ can be determined and will modify the probability of each SME model is

correct. To update the probability of the correctness for each of the SME model is correct per the evidence,

$P(M_j \mid x)$, we have:

$$P\langle M_j \mid x \rangle = \frac{P\langle x \mid M_j \rangle P^0(M_j)}{\displaystyle\sum_{h=1}^{J} P\langle x \mid M_h \rangle P^0(M_h)}$$

where $P(x \mid M_j)$ is the likelihood function for the probability that x could have occurred given model j.

For the purposes of our research, the Stiber method was utilized following the initial model development of the individual SME and after the consensus model development. The results are shown in Section 8.4. The Stiber method provides us with the probability that a given model, combined with the conditional probability tables completed by a specific SME is the most correct. This method has two variables that must be taken into account with this research. The first variable is the model itself. The steps taken in this research allow a total of eleven (11) total models in some cases (nine (9) individual models, and two (2) group models). The second variable is the inputs to the conditional probability tables as defined by each SME. One of the goals of this research is to define a model that can be utilized within any industry. To obtain the model that provided the least variance among the SME conditional probabilities, a variance calculation was performed on the probabilities that the SME were correct, where:

$$\sigma^2 = \frac{\displaystyle\sum_{i=1}^{N}(X_i - \mu)^2}{N}$$

letting N = number in the population,

X = P(M_j), and

μ = mean of P(M_j).

Section 8.3 Correlation of Concepts

In this section, we will correlate all of the concepts presented thus far, utilizing the BBN approach. Specifically, the process taxonomy and the process-based organizational model will be shown in a BBN format that was used by the SME in determining the causal arcs and the associated conditional probability tables. The basis of the following figures lies within Figure 32, showing that for every output there is the potential for both a formal and an informal process.

Looking at the strategic portion of the process taxonomy, we have six (6) major areas of processes; foundation, communication/information, customer satisfaction, procurement, maintenance, and allocation. Each of these six areas can be considered an output in themselves, and leading to an overall output of the strategic processes as seen in Figure 32. For the purposes of this figure, the arcs of the BBN are added for completion purposes only. They are not representative of the work performed by the SME.

Figure 32. Strategic Process Taxonomy Modeled as BBN

Adding the knowledge from Figure 31, Figure 33 shows the strategic process taxonomy modeled as a BBN with the informal processes and formal processes that affect each of the strategic process taxonomy areas.

Continuing this with the core portion of the process taxonomy, we have three (3) major areas of processes; design/development, execution, and measuring/monitoring. Each of these three areas can be considered an output in themselves, and leading to an overall output of the core processes as seen in Figure 34. Again, for the purposes of this figure, the arcs of the BBN are added for completion purposes only. They are not representative of the work performed by the SME. Likewise, Figure 35 shows the core process taxonomy modeled as a BBN with the informal and formal processes that affect each of the core process taxonomy areas.

Figure 33. Strategic Process Taxonomy BBN Including Informal and Formal Processes
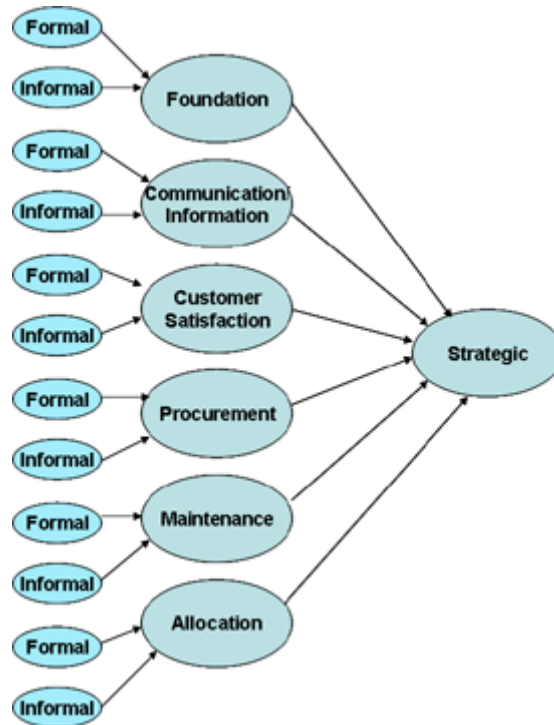
Figure 34. Core Process Taxonomy Modeled as BBN
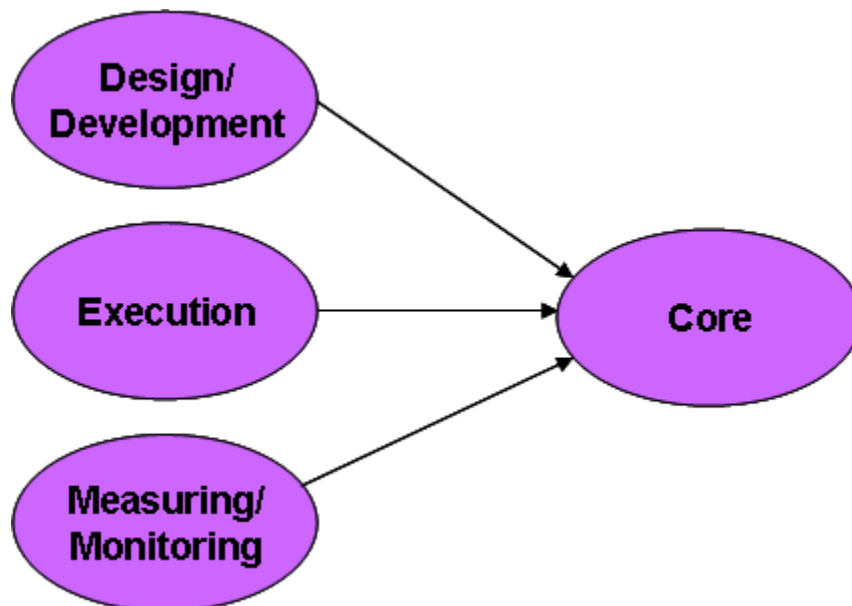
Figure 35. Core Process Taxonomy BBN Including Informal and Formal Processes
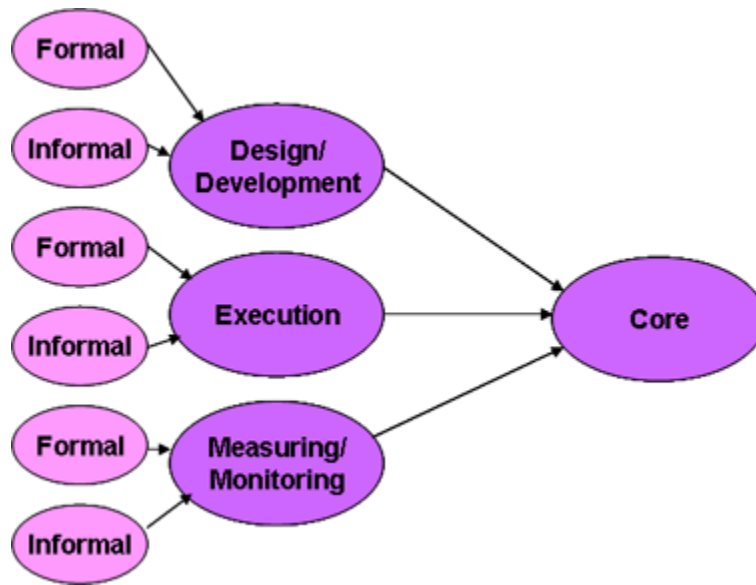
The process-based organizational model shown in Figure 20 depicts the strategic

processes supporting the core processes which produce the system (output). With this

information, a BBN was generated for the abbreviated organizational output (Figure 36). Figure

37 shows the abbreviated organizational output BBN with the addition of the formal and

informal processes as they relate to the strategic and core portions of the mode.

Figure 36. Abbreviated Organizational Process Output BBN
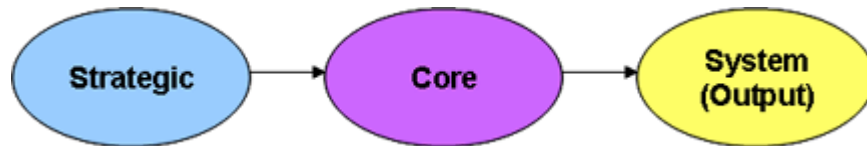
Figure 37. Abbreviated Org. Process Output BBN Including Informal and Formal Processes
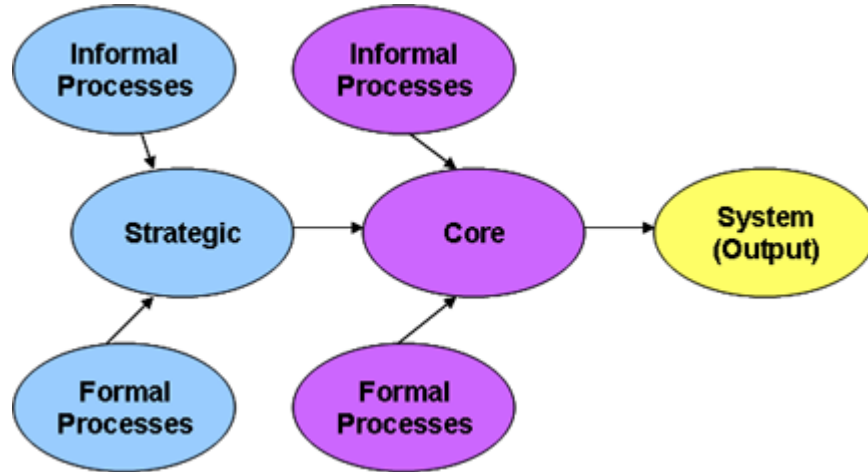
During this research, the SME utilized Figures 32, 34, and 36 (without the arcs) as a basis for development of their individual BBNs. The SME determined the causal relationship of the areas of process taxonomies based on their expertise for the first round of research. Figure 36 is the most basic BBN model of an organization. It does not consider the relationships of the areas within either the strategic or core processes. Therefore, a more comprehensive model was developed for this purpose (expanded organizational processes output). The SME then determined the causal relationship of the areas of the process taxonomies based on their expertise. The expanded organizational processes output is shown in Figure 38 without the arcs.

The probability of the output of any of the above figures can be calculated using the formula from subsection 8.2.1:

$$P(\overline{O}) = P\langle \overline{O} \mid \overline{F}, I \rangle P(\overline{F}) P(I) + P\langle \overline{O} \mid F, \overline{I} \rangle P(F) P(\overline{I}) + P\langle \overline{O} \mid \overline{F}, \overline{I} \rangle P(\overline{F}) P(\overline{I})$$

For the purposes of this research, the calculations were not performed by hand, but rather the Microsoft Research's Bayesian network authoring and evaluation tool (MSBNx) was utilized.

Figure 38. Expanded Organizational Output BBN
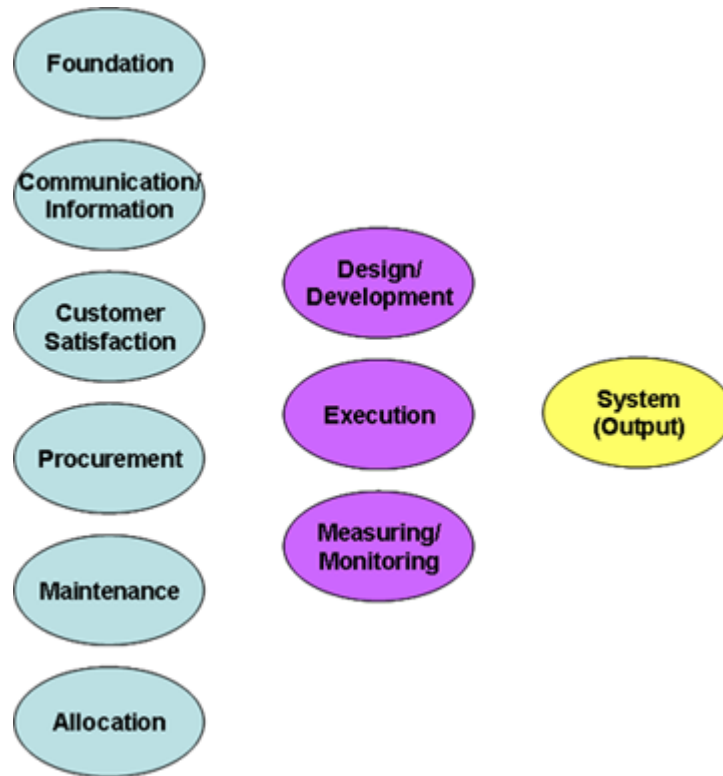
Section 8.4 Results

In this section, we will review the results from the SME BBNs that were generated, both

the individual BBNs and the consensus BBN. The Stiber methodology will be applied to both

using observed evidence from the example to be discussed in Chapter 10. Additionally, the BBN

results will be compared with those of the indirect method for detection of informal processes.

Subsection 8.4.1 reviews the information for the strategic processes portion of the process

taxonomy, subsection 8.4.2 contains the results for the core processes portion of the process

taxonomy, the abbreviated organizational processes output is discussed in subsection 8.4.3, and

finally the expanded organizational processes output is discussed in subsection 8.4.4. This

section concludes with the formulation for the quantitative assessment of the impact of informal

processes on an organization.

Subsection 8.4.1 Strategic Processes

The strategic processes portion of the process taxonomy includes the processes related to the foundation, communication/information, customer satisfaction, procurement, maintenance, and allocation of an organization. Individual BBNs (noted as M-1) were completed for nine (9) of the SME. Examples from two (2) of the SME BBNs are shown in Figures 39 (a and b) and 40 (a and b). The remaining seven (7) BBNs can be found in Appendix F.

Figure 39a. SME #5 Strategic BBN
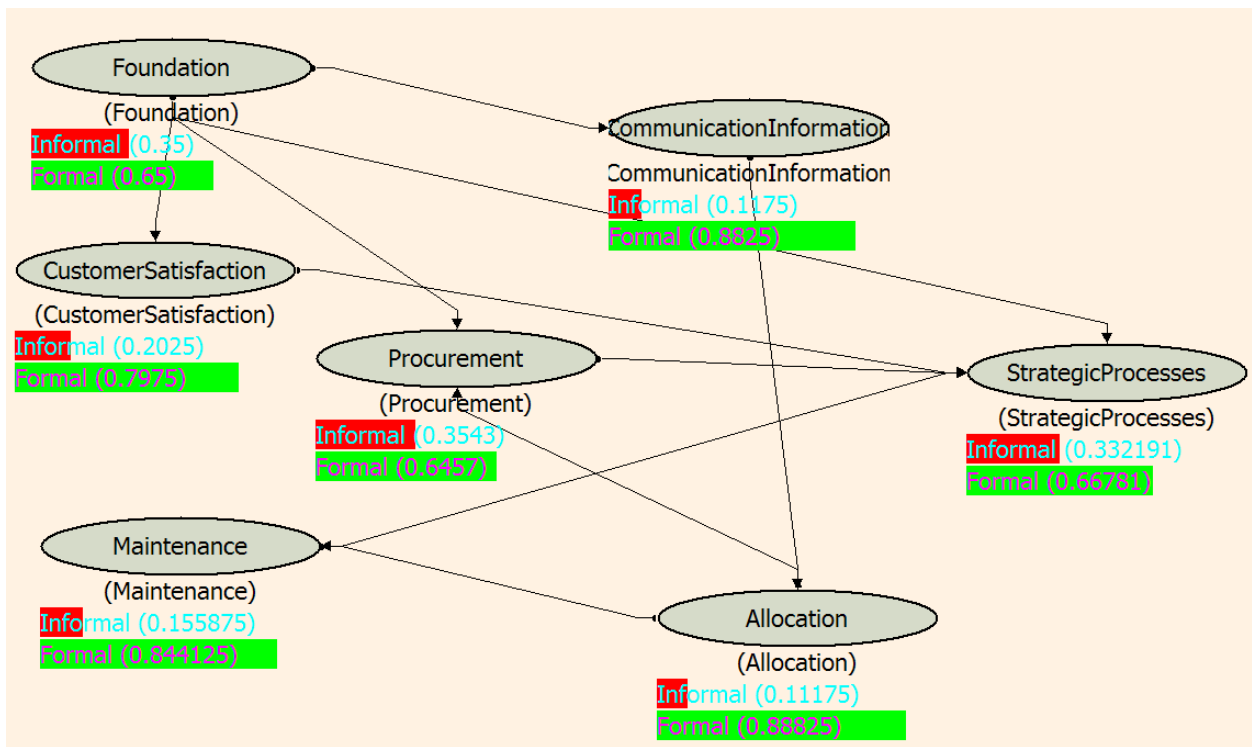
Figure 39b. Conditional Probability Tables for SME #5 Strategic BBN

Foundation		
Informal	Formal	bar charts
0.35	0.65	

Parent Node(s)	CustomerSatisfaction		
Foundation	Informal	Formal	bar charts
Informal	0.3	0.7	
Formal	0.15	0.85	

Parent Node(s)	Maintenance		
Allocation	Informal	Formal	bar charts
Informal	0.6	0.4	
Formal	0.1	0.9	

Parent Node(s)		Procurement		
Foundation	Allocation	Informal	Formal	bar charts
Informal	Informal	0.6	0.4	
Informal	Formal	0.6	0.4	
Formal	Informal	0.4	0.6	
Formal	Formal	0.2	0.8	

Parent Node(s)	CommunicationInformation		
Foundation	Informal	Formal	bar charts
Informal	0.15	0.85	
Formal	0.1	0.9	

Parent Node(s)	Allocation		
CommunicationInformation	Informal	Formal	bar charts
Informal	0.2	0.8	
Formal	0.1	0.9	

Parent Node(s)				StrategicProcesses		
Foundation	CustomerSatisfaction	Procurement	Maintenance	Informal	Formal	bar charts
Informal	Informal	Informal	Informal	0.9	0.1	
Informal	Informal	Informal	Formal	0.85	0.15	
Informal	Informal	Formal	Informal	0.85	0.15	
Informal	Informal	Formal	Formal	0.5	0.5	
Informal	Formal	Informal	Informal	0.85	0.15	
Informal	Formal	Informal	Formal	0.5	0.5	
Informal	Formal	Formal	Informal	0.6	0.4	
Informal	Formal	Formal	Formal	0.8	0.2	
Formal	Informal	Informal	Informal	0.75	0.25	
Formal	Informal	Informal	Formal	0.4	0.6	
Formal	Informal	Formal	Informal	0.6	0.4	
Formal	Informal	Formal	Formal	0.25	0.75	
Formal	Formal	Informal	Informal	0.4	0.6	
Formal	Formal	Informal	Formal	0.25	0.75	
Formal	Formal	Formal	Informal	0.2	0.8	
Formal	Formal	Formal	Formal	0.05	0.95	

Figure 40a. SME #7 Strategic BBN
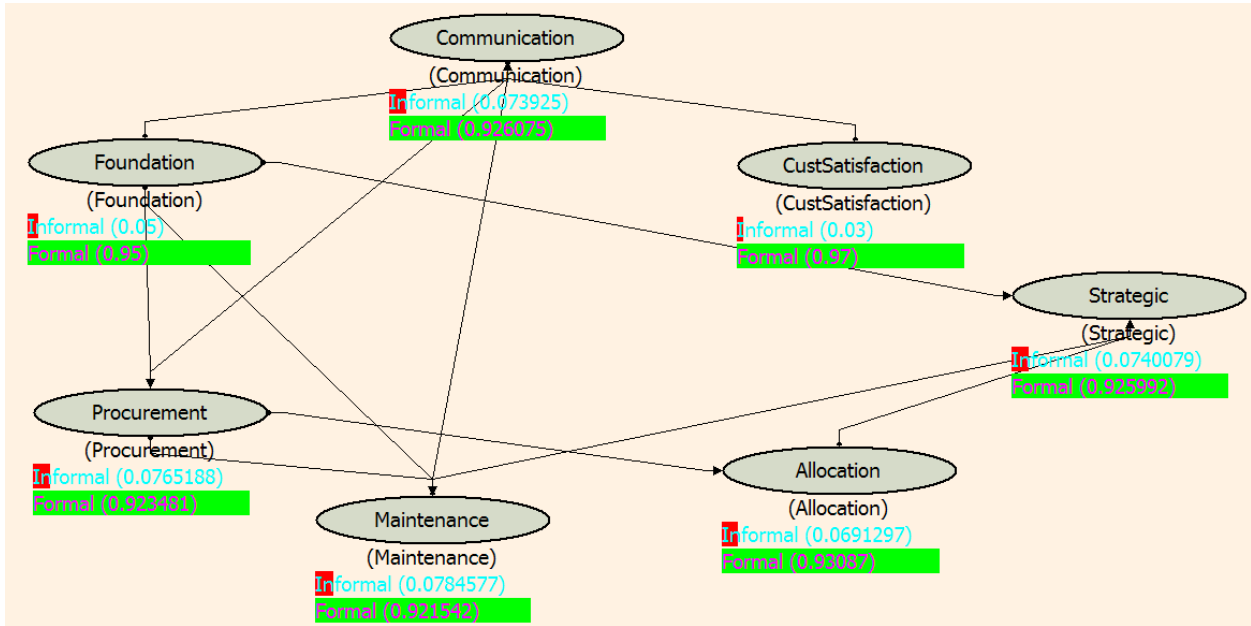
Table 14 provides a summary of the probabilities for the presence of formal and informal

processes for each SME for the strategic processes. We notice that there are two (2) distinct

groupings of the results as shown in Figure 41. At the completion of the first phase of the SME

process, it was noticed that the group with the highest probability for formal processes within the

strategic area consists of SME from highly regulated industries. From the results shown in Table

8, the indirect detection method, for the strategic processes, the highly regulated industries have

a probability of 0.3 for informal processes to be present (0.7 that formal processes are utilized),

compared with a 0.4 probability of informal processes for those industries with little to no

regulation.

The results of the M-1 models are shown in Table 15.   The upper portion of the table

shows the prior, determined from the M-1 BBN for each SME, with each SME receiving an

Figure 40b. Conditional Probability Tables for SME #7 Strategic BBN

Foundation

Informal	Formal	bar charts
0.05	0.95	

Procurement

Parent Node(s)		Procurement		
Foundation	Communication	Informal	Formal	bar charts
Informal	Informal	0.5	0.5	
Informal	Formal	0.2	0.8	
Formal	Informal	0.3	0.7	
Formal	Formal	0.05	0.95	

Communication

Parent Node(s)		Communication		
Foundation	CustSatisfaction	Informal	Formal	bar charts
Informal	Informal	0.7	0.3	
Informal	Formal	0.2	0.8	
Formal	Informal	0.6	0.4	
Formal	Formal	0.05	0.95	

Maintenance

Parent Node(s)			Maintenance		
Foundation	Communication	Procurement	Informal	Formal	bar charts
Informal	Informal	Informal	0.5	0.5	
Informal	Informal	Formal	0.3	0.7	
Informal	Formal	Informal	0.3	0.7	
Informal	Formal	Formal	0.2	0.8	
Formal	Informal	Informal	0.3	0.7	
Formal	Informal	Formal	0.2	0.8	
Formal	Formal	Informal	0.2	0.8	
Formal	Formal	Formal	0.05	0.95	

CustSatisfaction

Informal	Formal	bar charts
0.03	0.97	

Allocation

Parent Node(s)	Allocation		
Procurement	Informal	Formal	bar charts
Informal	0.3	0.7	
Formal	0.05	0.95	

Strategic

Parent Node(s)			Strategic		
Allocation	Maintenance	Foundation	Informal	Formal	bar charts
Informal	Informal	Informal	0.5	0.5	
Informal	Informal	Formal	0.3	0.7	
Informal	Formal	Informal	0.3	0.7	
Informal	Formal	Formal	0.1	0.9	
Formal	Informal	Informal	0.4	0.6	
Formal	Informal	Formal	0.2	0.8	
Formal	Formal	Informal	0.2	0.8	
Formal	Formal	Formal	0.05	0.95	

Table 14. Summary of SME Probabilities for Formal/Informal Strategic Processes

SME	FORMAL (F) INFORMAL (I)	FOUNDATION	COMMUNICATION/ INFORMATION	CUSTOMER SATISFACTION	PROCUREMENT	MAINTENANCE	ALLOCATION	OVERALL STRATEGIIC
1	F	.85	.84	.80	.81	.79	.74	.66
	I	.15	.16	.20	.19	.21	.26	.34
2	F	.80	.74	.70	.59	.60	.57	.58
	I	.20	.26	.30	.41	.40	.43	.42
3	F	.70	.59	.57	.60	.64	.70	.62
	I	.30	.41	.43	.40	.36	.30	.38
4	F	.50	.77	.50	.72	.77	.60	.59
	I	.50	.23	.50	.28	.23	.40	.41
5	F	.65	.88	.80	.65	.84	.89	.67
	I	.35	.12	.20	.35	.16	.11	.33
6	F	.70	.71	.74	.75	.81	.84	.82
	I	.30	.29	.26	.25	.19	.16	.18
7	F	.95	.93	.97	.92	.92	.93	.93
	I	.05	.07	.03	.08	.08	.07	.07
8	F	.99	.95	.94	.91	.91	.90	.94
	I	.01	.05	.06	.09	.09	.10	.06
9	F	.99	.30	.90	.74	.57	.52	.85
	I	.01	,70	.10	.26	.43	.48	.15

equal weight in the prior. The observed evidence is seen in the bottom portion of the table

(posterior). The observed evidence is the actual results from the application that is discussed in

Chapter 10, where a one (1) signifies that no informal processes were identified, and a zero (0)

signifies the presence of informal processes. With this information, each SME judgment

received a new weight depending on how close their prior model represents the actual state based

on the new evidence. From Table 15, we see that SME #3 is closer to reality.
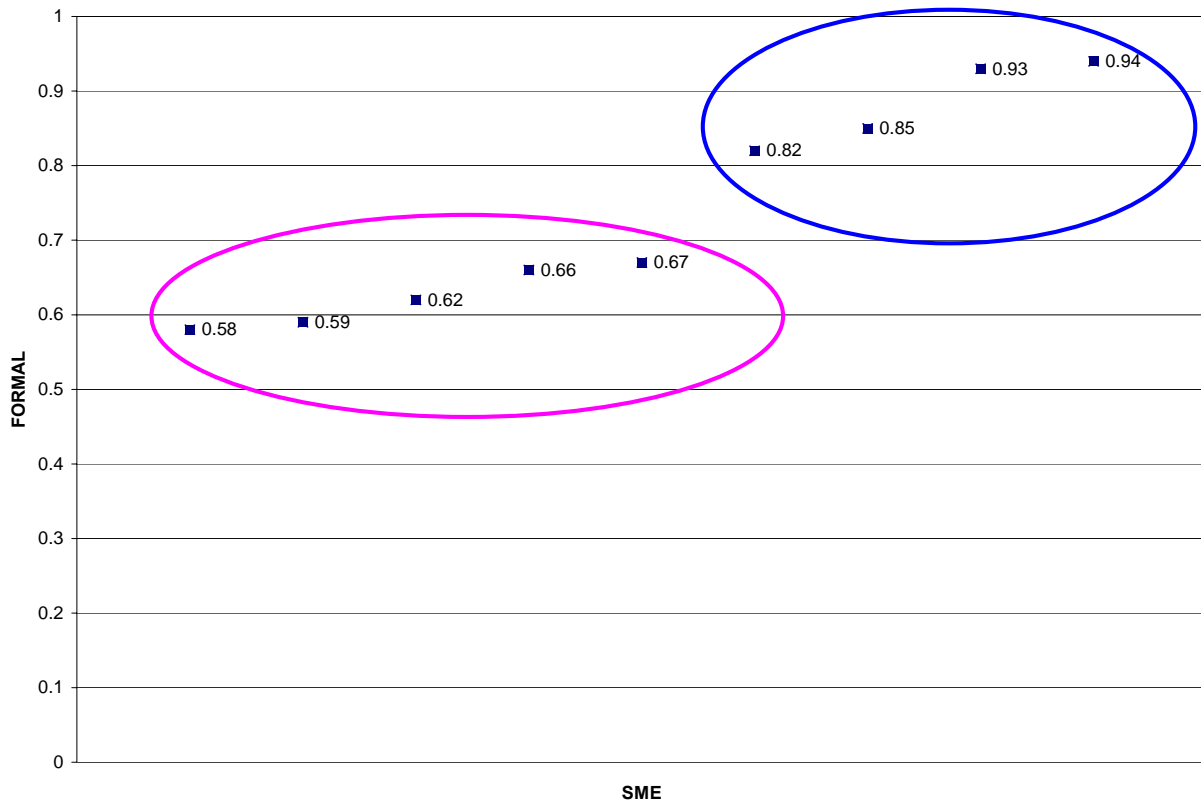
Figure 41. Strategic BBN SME Results

Table 15. M-1 BBN – Strategic Process Results

Method: M-1 Expert Aggregate Structure BBN Model - Strategic Processes

Node Variable	Prior									Aggregate	Mean	Std Dev
	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Expert 9			
Foundation	0.85	0.80	0.70	0.50	0.65	0.70	0.95	0.99	0.99	0.79	0.79	0.17
Communication/Information	0.84	0.74	0.59	0.77	0.88	0.71	0.93	0.95	0.30	0.75	0.75	0.20
Customer Satisfaction	0.80	0.70	0.58	0.50	0.80	0.74	0.97	0.94	0.90	0.77	0.77	0.16
Procurement	0.81	0.60	0.60	0.73	0.65	0.75	0.92	0.91	0.74	0.75	0.75	0.12
Maintenance	0.79	0.60	0.64	0.78	0.84	0.81	0.92	0.91	0.57	0.76	0.76	0.13
Allocation	0.74	0.57	0.70	0.60	0.89	0.84	0.93	0.90	0.52	0.74	0.74	0.16
Strategic	0.66	0.58	0.62	0.59	0.67	0.82	0.93	0.94	0.85	0.74	0.74	0.15
Likelihood	-	-	-	-	-	-	-	-	-			
Prob (Mj)	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11			

Node Variable	Posterior									Aggregate		
	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Expert 9			
Foundation	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		
Communication/Information	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Customer Satisfaction	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		
Procurement	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Maintenance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Allocation	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		
Strategic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Likelihood	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01			
Prob (Mj)	0.05	0.26	0.30	0.04	0.05	0.05	0.00	0.00	0.25			

154

Due to the fact that there appeared to be a division among the group of those that were in highly regulated industries versus those in industries with little to no regulation, a decision was mode to divide the group into two smaller groups. The group that contained the SME in the industries with little to no regulation was denoted as Group 1, and contained five (5) SME. The second group, Group 2, consisted of the SME representing industries that are highly regulated. There were three (4) SME in this group at the beginning of the process, but one (1) was lost due to a time commitment, leaving three (3) in Group 2. The next step in our process was to have the SME in their respective groups reach a consensus on the model structure for the strategic process. Figure 42 provides the starting point of this process with each of the SME arcs shown in accordance with their individual M-1 BBN for the strategic processes.

Figure 42. Summary of SME Group 1 M-1 BBNs
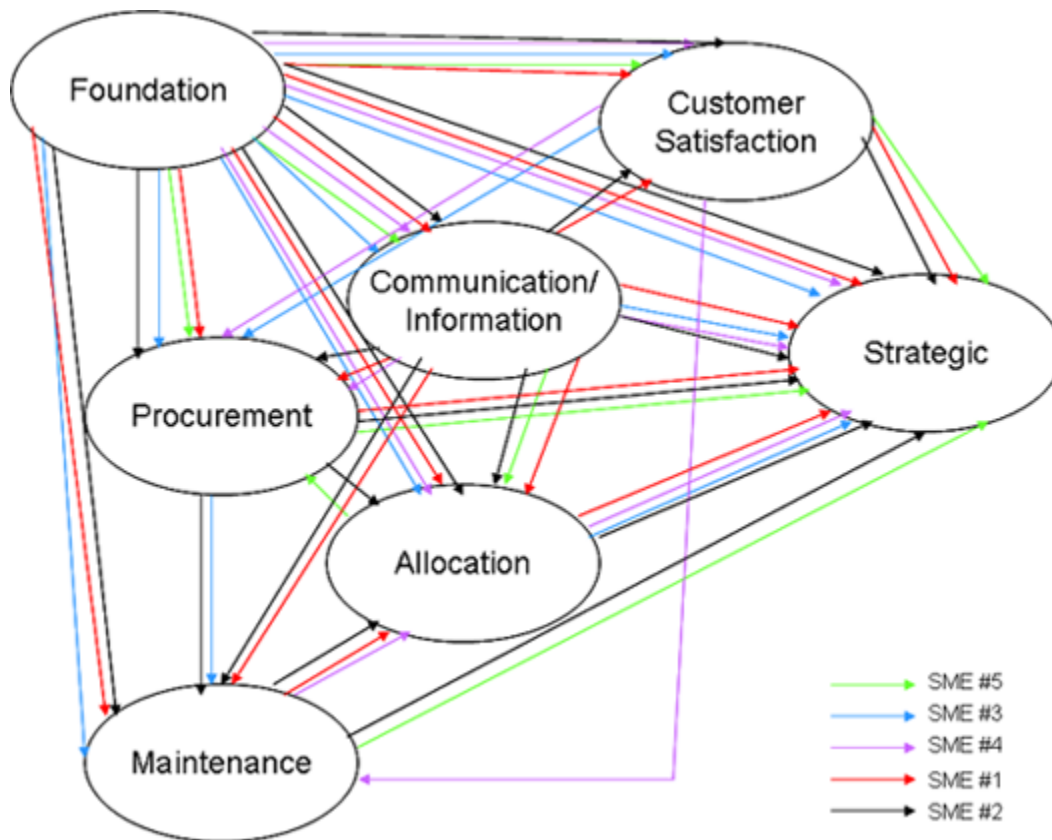
On August 25, 2009 the five (5) Group 1 SME met to reach a consensus on the structure for the BBN related to the strategic processes. Figure 43 shows the consensus BBN (denoted from this point forward as M-2).

Figure 43. Group 1 M-2 BBN for Strategic Processes
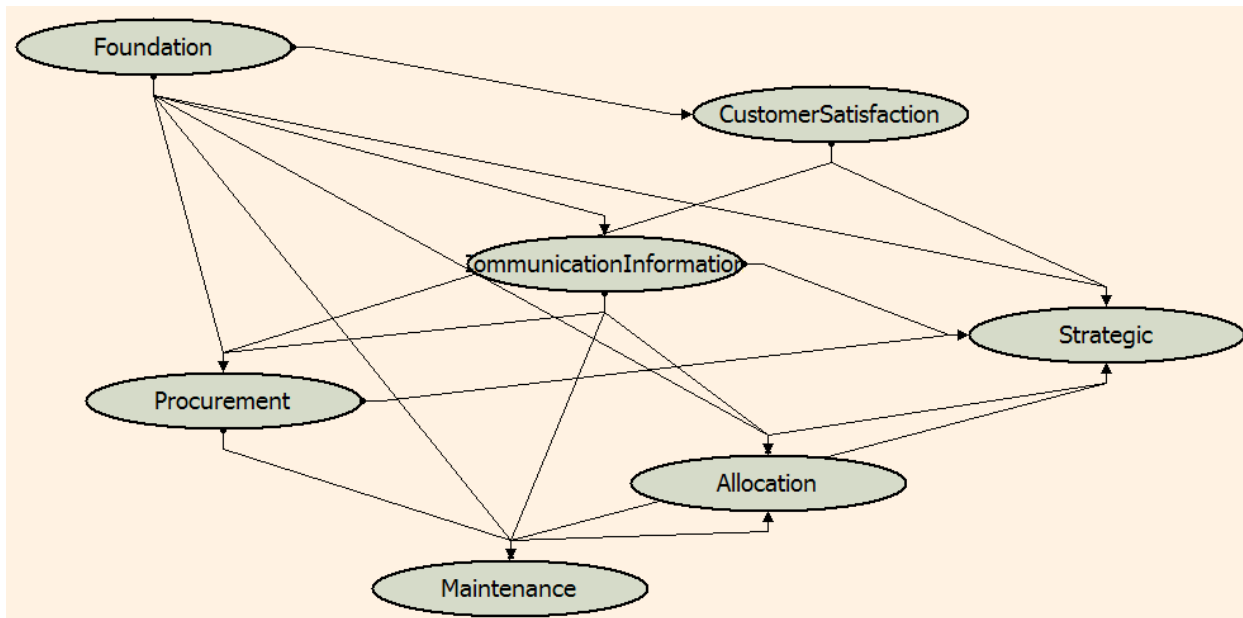
After completing the consensus model, each Group 1 SME generated conditional probability tables for the above BBN. The conditional probability tables for SME #5 are shown in Figures 44a and 44b, the remaining Group 1 SME BBNs with the bar charts are located in Appendix G. The next step in our process was to again apply the Stiber methodology to the priors for the M-2 models. The results of the M-2 models are shown in Table 16. The upper portion of the table shows the prior, determined from the M-2 BBN for each SME, with each SME receiving an equal weight in the prior. The observed evidence is seen in the bottom portion of the table (posterior). The observed evidence is the actual results from the application that is discussed in Chapter 10, where a one (1) signifies that no informal processes were identified, and a zero (0) signifies the presence of

Figure 44a. Conditional Probability Tables for SME #5 Strategic BBN M-2

Foundation		
Informal	Formal	bar charts
0.01	0.99	

Parent Node(s)			Procurement		
Foundation	CommunicationInformation	CustomerSatisfaction	Informal	Formal	bar charts
Informal	Informal	Informal	0.9	0.1	
		Formal	0.9	0.1	
	Formal	Informal	0.9	0.1	
		Formal	0.8	0.2	
Formal	Informal	Informal	0.6	0.4	
		Formal	0.6	0.4	
	Formal	Informal	0.2	0.8	
		Formal	0.1	0.9	

Parent Node(s)			Maintenance		
Foundation	Procurement	CommunicationInformation	Informal	Formal	bar charts
Informal	Informal	Informal	0.7	0.3	
		Formal	0.65	0.35	
	Formal	Informal	0.7	0.3	
		Formal	0.6	0.4	
Formal	Informal	Informal	0.5	0.5	
		Formal	0.3	0.7	
	Formal	Informal	0.3	0.7	
		Formal	0.1	0.9	

Parent Node(s)	CommunicationInformation		
Foundation	Informal	Formal	bar charts
Informal	0.3	0.7	
Formal	0.05	0.95	

Parent Node(s)			Allocation		
Foundation	CommunicationInformation	Maintenance	Informal	Formal	bar charts
Informal	Informal	Informal	0.9	0.1	
		Formal	0.9	0.1	
	Formal	Informal	0.85	0.15	
		Formal	0.75	0.25	
Formal	Informal	Informal	0.5	0.5	
		Formal	0.3	0.7	
	Formal	Informal	0.2	0.8	
		Formal	0.1	0.9	

Parent Node(s)	CustomerSatisfaction		
Foundation	Informal	Formal	bar charts
Informal	0.75	0.25	
Formal	0.05	0.95	

informal processes. With this information, each SME judgment received a new weight

depending on how close their prior model represents the actual state based on the new evidence.

From Table 16, we see that now SME #4 is closer to reality, whereas SME #2 was closer to

reality when considering the M-1 BBNs.

On September 16, 2009 the three (3) Group 2 SME met to reach a consensus on the

structure for the BBN related to the strategic processes. Figure 45 provides the starting point of

this process with each of the SME arcs shown in accordance with their individual M-1 BBN for

the strategic processes Figure 46 shows the consensus BBN (denoted from this point forward as

Figure 44b. Conditional Probability Tables for SME #5 Strategic BBN M-2

Parent Node(s)						Strategic		
Foundation	CommunicationInformation	Allocation	CustomerSatisfaction	Procurement	Maintenance	Informal	Formal	bar charts
Informal	Informal	Informal	Informal	Informal	Informal	0.95	0.05	
					Formal	0.95	0.05	
				Formal	Informal	0.95	0.05	
					Formal	0.95	0.05	
			Formal	Informal	Informal	0.95	0.05	
					Formal	0.95	0.05	
				Formal	Informal	0.95	0.05	
					Formal	0.95	0.05	
		Formal	Informal	Informal	Informal	0.95	0.05	
					Formal	0.95	0.05	
				Formal	Informal	0.95	0.05	
					Formal	0.95	0.05	
			Formal	Informal	Informal	0.95	0.05	
					Formal	0.95	0.05	
				Formal	Informal	0.95	0.05	
					Formal	0.95	0.05	
	Formal	Informal	Informal	Informal	Informal	0.95	0.05	
					Formal	0.95	0.05	
				Formal	Informal	0.95	0.05	
					Formal	0.95	0.05	
			Formal	Informal	Informal	0.95	0.05	
					Formal	0.95	0.05	
				Formal	Informal	0.95	0.05	
					Formal	0.95	0.05	
		Formal	Informal	Informal	Informal	0.95	0.05	
					Formal	0.95	0.05	
				Formal	Informal	0.95	0.05	
					Formal	0.95	0.05	
			Formal	Informal	Informal	0.95	0.05	
					Formal	0.95	0.05	
				Formal	Informal	0.95	0.05	
					Formal	0.95	0.05	
Formal	Informal	Informal	Informal	Informal	Informal	0.95	0.05	
					Formal	0.95	0.05	
				Formal	Informal	0.95	0.05	
					Formal	0.95	0.05	
			Formal	Informal	Informal	0.95	0.05	
					Formal	0.95	0.05	
				Formal	Informal	0.95	0.05	
					Formal	0.95	0.05	
		Formal	Informal	Informal	Informal	0.95	0.05	
					Formal	0.95	0.05	
				Formal	Informal	0.95	0.05	
					Formal	0.95	0.05	
			Formal	Informal	Informal	0.95	0.05	
					Formal	0.95	0.05	
				Formal	Informal	0.95	0.05	
					Formal	0.95	0.05	
	Formal	Informal	Informal	Informal	Informal	0.95	0.05	
					Formal	0.95	0.05	
				Formal	Informal	0.95	0.05	
					Formal	0.95	0.05	
			Formal	Informal	Informal	0.95	0.05	
					Formal	0.95	0.05	
				Formal	Informal	0.95	0.05	
					Formal	0.95	0.05	
		Formal	Informal	Informal	Informal	0.95	0.05	
					Formal	0.95	0.05	
				Formal	Informal	0.95	0.05	
					Formal	0.95	0.05	
			Formal	Informal	Informal	0.95	0.05	
					Formal	0.95	0.05	
				Formal	Informal	0.95	0.05	
					Formal	0.1	0.9	

Table 16. Group 1 M-2 BBN – Strategic Process Results

M-2 Group 1 Expert Aggregate Structure BBN Model - Strategic Processes

Node Variable	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Aggregate	Mean	Std Dev
			Prior			Aggregate		
Foundation	0.60	0.80	0.95	0.90	0.99	0.85	0.85	0.16
Communication/Information	0.56	0.74	0.91	0.74	0.95	0.78	0.78	0.16
Customer Satisfaction	0.58	0.71	0.91	0.69	0.94	0.77	0.77	0.15
Procurement	0.57	0.72	0.88	0.64	0.86	0.73	0.73	0.14
Maintenance	0.57	0.72	0.73	0.71	0.86	0.72	0.72	0.10
Allocation	0.58	0.67	0.80	0.73	0.87	0.73	0.73	0.11
Strategic	0.58	0.72	0.90	0.37	0.60	0.63	0.63	0.19
Likelihood	-	-	-	-	-			
Prob (Mj)	0.20	0.20	0.20	0.20	0.20			

Node Variable	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Aggregate
			Posterior			Aggregate
Foundation	1.00	1.00	1.00	1.00	1.00	1.00
Communication/Information	0.00	0.00	0.00	0.00	0.00	0.00
Customer Satisfaction	1.00	1.00	1.00	1.00	1.00	1.00
Procurement	0.00	0.00	0.00	0.00	0.00	0.00
Maintenance	0.00	0.00	0.00	0.00	0.00	0.00
Allocation	1.00	1.00	1.00	1.00	1.00	1.00
Strategic	0.00	0.00	0.00	0.00	0.00	0.00
Likelihood	0.01	0.00	0.00	0.01	0.00	
Prob (Mj)	0.40	0.13	0.01	0.45	0.02	

M-2). After completing the consensus model, each Group 2 SME generated conditional probability tables for the BBN shown in Figure 46. The conditional probability tables for SME #7 are shown in Figure 47, the remaining Group 2 SME BBNs with associated bar charts are located in Appendix H. As before, we applied the Stiber methodology to the priors for the M-2 models. The results of the M-2 models are shown in Table 17.   The upper portion of the table shows the prior, determined from the M-2 BBN for each SME, with each SME receiving an equal weight in the prior. The observed evidence is seen in the bottom portion of the table (posterior). The observed evidence is the actual results from the application that is discussed in Chapter 10, where a one (1) signifies that no informal processes were identified, and a zero (0) signifies the presence of informal processes. With this information, each SME judgment

received a new weight depending on how close their prior model represents the actual state based on the new evidence. From Table 17, we see that now SME #9 is closer to reality, whereas SME #2 was closer to reality when considering the M-1 BBNs. All of the M-1 models were reviewed to ascertain if any two were alike, and there were not any. Variance calculations were performed on both the M-2 Group 1 results, and the M-2 Group 2 results to determine which of the models had less of a dispersion in light of the various conditional probability tables.

Figure 45. Summary of SME Group 2 M-1 BBNs
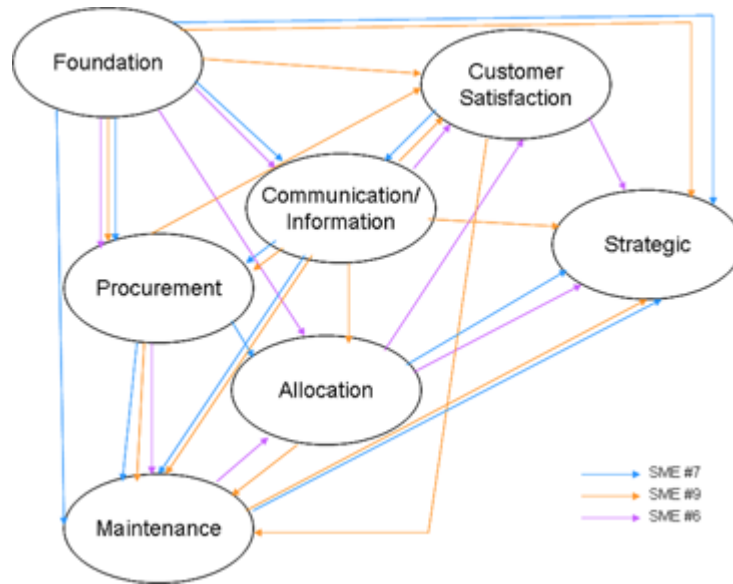
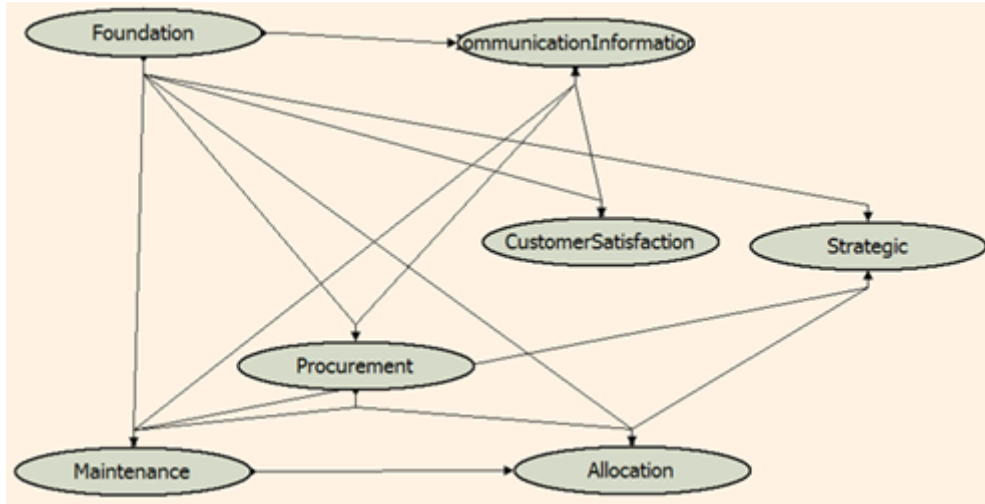*Figure 46. Group 2 M-2 BBN for Strategic Processes*

Table 17. Group 2 M-2 BBN – Strategic Process Results

M-2 Group 2 Expert Aggregate Structure BBN Model - Strategic Processes						
	Prior			Aggregate		
Node Variable	Expert 6	Expert 7	Expert 9		Mean	Std Dev
Foundation	0.70	0.95	0.90	0.85	0.85	0.13
Communication/Information	0.56	0.93	0.48	0.66	0.66	0.24
Customer Satisfaction	0.78	0.95	0.45	0.73	0.73	0.25
Procurement	0.54	0.92	0.47	0.64	0.64	0.24
Maintenance	0.49	0.92	0.59	0.67	0.67	0.23
Allocation	0.45	0.92	0.67	0.68	0.68	0.24
Strategic	0.41	0.92	0.69	0.67	0.67	0.26
Likelihood	-	-	-			
Prob (Mj)	0.33	0.33	0.33			
				Posterior	Aggregate	
Node Variable	Expert 6	Expert 7	Expert 9			
Foundation	1.00	1.00	1.00	1.00		
Communication/Information	0.00	0.00	0.00	0.00		
Customer Satisfaction	1.00	1.00	1.00	1.00		
Procurement	0.00	0.00	0.00	0.00		
Maintenance	0.00	0.00	0.00	0.00		
Allocation	1.00	1.00	1.00	1.00		
Strategic	0.00	0.00	0.00	0.00		
Likelihood	0.01	0.00	0.01			
Prob (Mj)	0.61	0.00	0.39			

Figure 47. Conditional Probability Tables for SME #7 Strategic BBN M-2

Foundation

Bad	Good	bar charts
0.05	0.95	

Maintenance

Parent Node(s)			Bad	Good	bar charts
Foundation	CommunicationInformation	Procurement			
Bad	Bad	Bad	0.5	0.5	
Bad	Bad	Good	0.3	0.7	
Bad	Good	Bad	0.3	0.7	
Bad	Good	Good	0.2	0.8	
Good	Bad	Bad	0.3	0.7	
Good	Bad	Good	0.2	0.8	
Good	Good	Bad	0.2	0.8	
Good	Good	Good	0.05	0.95	

Procurement

Parent Node(s)		Bad	Good	bar charts
Foundation	CommunicationInformation			
Bad	Bad	0.5	0.5	
Bad	Good	0.2	0.8	
Good	Bad	0.3	0.7	
Good	Good	0.05	0.95	

CommunicationInformation

Parent Node(s)		Bad	Good	bar charts
Foundation	CustomerSatisfaction			
Bad	Bad	0.7	0.3	
Bad	Good	0.2	0.8	
Good	Bad	0.6	0.4	
Good	Good	0.03	0.97	

CustomerSatisfaction

Parent Node(s)	Bad	Good	bar charts
Foundation			
Bad	0.5	0.5	
Good	0.03	0.97	

Allocation

Parent Node(s)			Bad	Good	bar charts
Foundation	Procurement	Maintenance			
Bad	Bad	Bad	0.5	0.5	
Bad	Bad	Good	0.4	0.6	
Bad	Good	Bad	0.25	0.75	
Bad	Good	Good	0.4	0.6	
Good	Bad	Bad	0.2	0.8	
Good	Bad	Good	0.15	0.85	
Good	Good	Bad	0.15	0.85	
Good	Good	Good	0.05	0.95	

Strategic

Parent Node(s)			Bad	Good	bar charts
Foundation	Allocation	Maintenance			
Bad	Bad	Bad	0.5	0.5	
Bad	Bad	Good	0.3	0.7	
Bad	Good	Bad	0.4	0.6	
Bad	Good	Good	0.25	0.75	
Good	Bad	Bad	0.3	0.7	
Good	Bad	Good	0.2	0.8	
Good	Good	Bad	0.2	0.8	
Good	Good	Good	0.05	0.95	

Within this subsection related to the strategic processes portion of the taxonomy, a total of eleven (11) BBNs were generated along with their respective conditional probability tables. The Stiber methodology was utilized to determine the probability that any given model was more correct based on observed evidence. There were no identical M-1 models between any of the SME. The variance for the Group 1 M-2 strategic model was 0.125, where the variance for the Group 2 M-2 strategic model was 0.091. The model chosen to provide the greatest information relating to an organization's strategic processes is the Group 2 M-2 model shown in Figure 46.

The results for the model for the individual SME show that the probability of the strategic processes being formal are 0.41 (SME #6), 0.92 (SME #7), and 0.69 (SME #9), an average of 0.67, which corresponds to the probability of the strategic processes being informal of 1 - 0.67 = 0.33. The result of the scoring of the indirect detection method for strategic processes shows the probability of informal processes as 0.4.

Subsection 8.4.2 Core Processes

The core processes portion of the process taxonomy includes the processes related to the design/development, execution, and measuring/monitoring, of an organization. The steps that were completed for the strategic processes will be utilized here as well. Individual BBNs (noted as M-1) were completed for eight (8) of the SME. Examples from two (2) of the SME BBNs are shown in Figures 48 (a and b) and 49 (a and b). The remaining six (6) BBNs can be found in Appendix I.

Figure 48a. SME #5 M-1 BBN for Core Processes
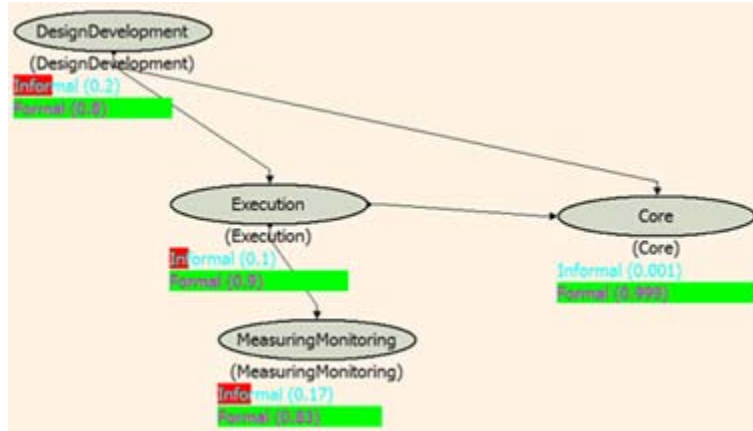
Figure 48b. Conditional Probability Tables for SME #5 M-1 BBN for Core Processes

Figure 49a. SME #7 M-1 BBN for Core Processes
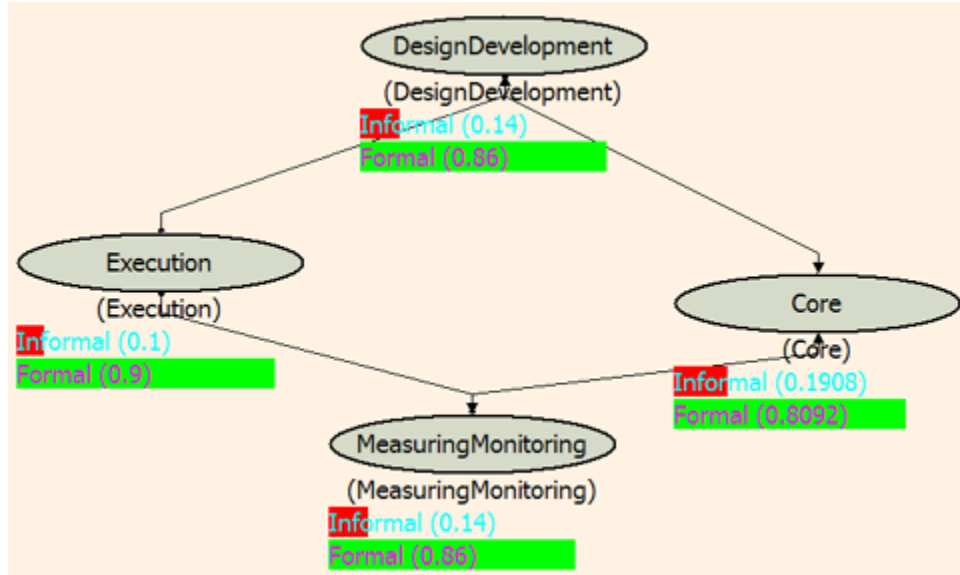
Figure 49b. Conditional Probability Tables for SME #7 M-1 BBN for Core Processes

	Execution		
	Informal	Formal	bar charts
	0.1	0.9	

Parent Node(s)	DesignDevelopment		
Execution	Informal	Formal	bar charts
Informal	0.5	0.5	
Formal	0.1	0.9	

Parent Node(s)	MeasuringMonitoring		
Execution	Informal	Formal	bar charts
Informal	0.5	0.5	
Formal	0.1	0.9	

Parent Node(s)		Core		
DesignDevelopment	MeasuringMonitoring	Informal	Formal	bar charts
Informal	Informal	0.9	0.1	
Informal	Formal	0.4	0.6	
Formal	Informal	0.4	0.6	
Formal	Formal	0.1	0.9	

At this stage, the probabilities for the presence of informal processes were reviewed to determine if there was still a separation between the organizations that were highly regulated versus those that were not. At the core process level, there is no distinction. Next, the data was

reviewed to see if there was a difference between large or small organizations, high-tech or low-tech organizations, or manufacturing versus service industries. There was a slight distinction between the service and manufacturing organizations as shown in Figure 50. The Stiber methodology was applied to the M-1 BBNs for the core processes for all SME. Results are shown in Table 18, and we can see that the model generated by SME #3 is the most correct based on the observed evidence. It should be noted that four (4) of the BBNs developed by the SME were identical in structure. Within Group 1, SME #1 and SME #4 BBNs was identical in structure, and also had the same structure as SME #6, and SME #9 from Group 2.

The Group 1 and Group 2 SME met separately to develop an M-2 core process model. Group 1 began with the starting point shown in Figure 51. Group 2 began with the starting point shown in Figure 52. The final M-2 structure for both groups is identical and is given in Figure 53.

Figure 50. Comparison of M-1 Results of SME BBN (Core) By Category

166
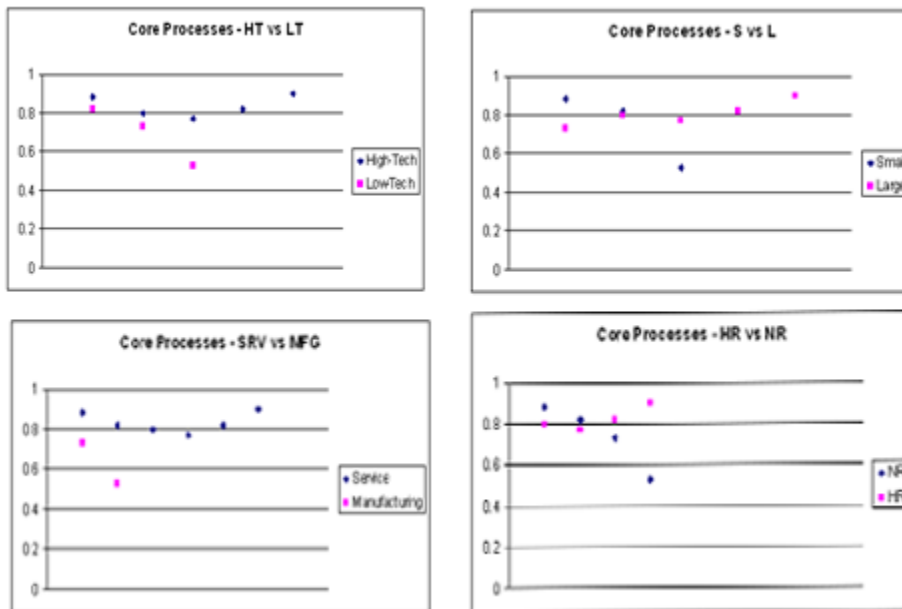
Table 18. Stiber Method Results for M-1 BBN for Core Processes

Method: M-1 Expert Aggregate Structure BBN Model - Core Processes									Aggregate		
Prior											
Node Variable	**Expert 1**	**Expert 2**	**Expert 3**	**Expert 4**	**Expert 5**	**Expert 6**	**Expert 7**	**Expert 9**		**Mean**	**Std Dev**
Design/Development	0.90	0.60	0.50	0.30	0.80	0.70	0.86	0.99	0.71	0.71	0.23
Execution	0.90	0.59	0.85	0.50	0.90	0.87	0.90	0.99	0.81	0.81	0.17
Measuring/Monitoring	0.88	0.65	0.60	0.80	0.83	0.89	0.86	0.90	0.80	0.80	0.11
Core	0.89	0.56	0.60	0.34	0.99	0.77	0.81	0.90	0.73	0.73	0.22
Likelihood	-	-	-	-	-	-	-	-			
Prob (Mj)	**0.13**	**0.13**	**0.13**	**0.13**	**0.13**	**0.13**	**0.13**	**0.13**			
Posterior									Aggregate		
Node Variable	**Expert 1**	**Expert 2**	**Expert 3**	**Expert 4**	**Expert 5**	**Expert 6**	**Expert 7**	**Expert 9**			
Desing/Development	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Execution	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00		
Measuring/Monitoring	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Core	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
Likelihood	0.00	0.04	0.07	0.05	0.00	0.01	0.00	0.00			
Prob (Mj)	**0.01**	**0.22**	**0.42**	**0.29**	**0.00**	**0.04**	**0.02**	**0.00**			

Figure 51. Group 1 Starting Point for M-2 BBN

167
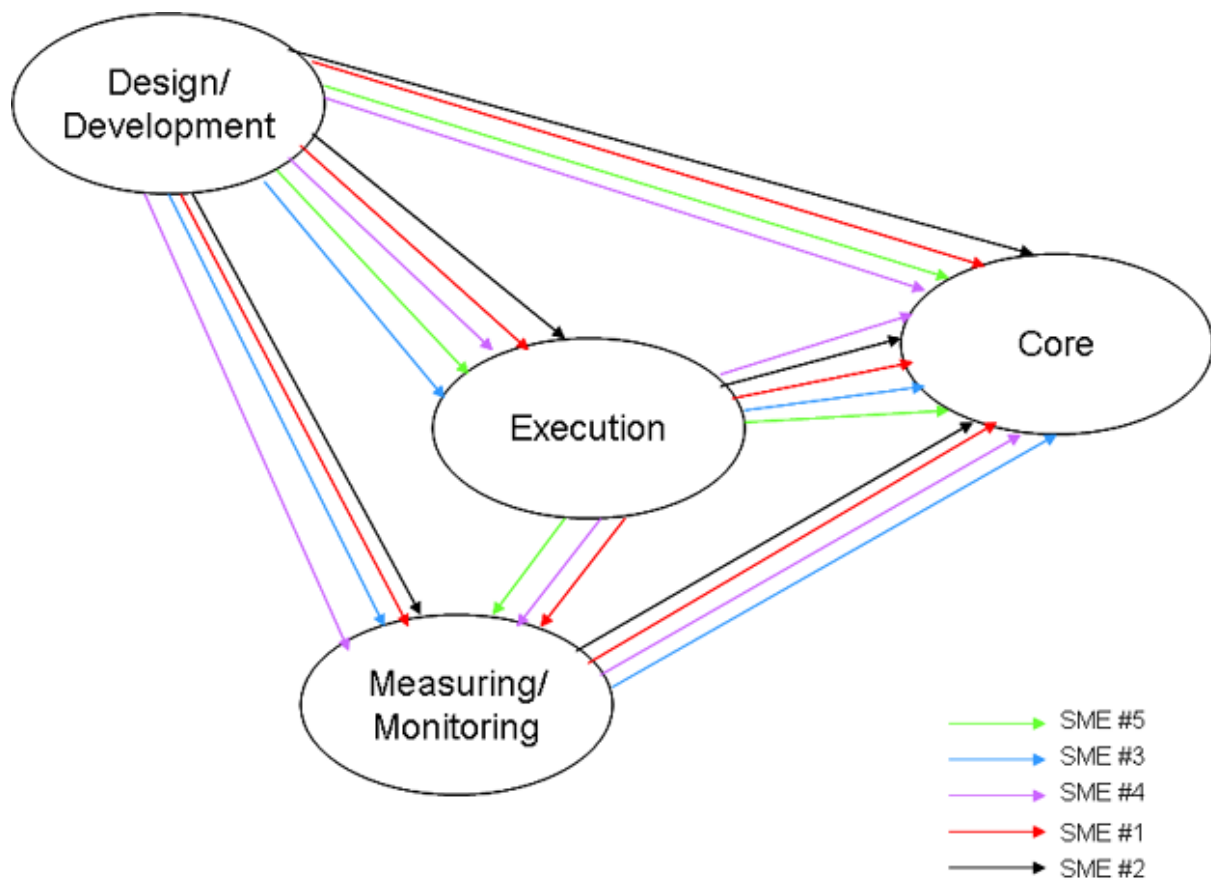
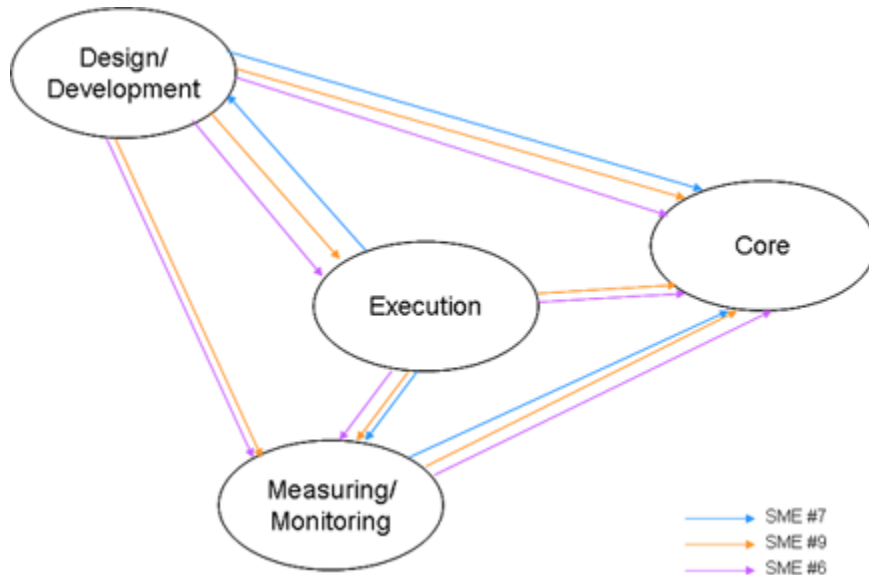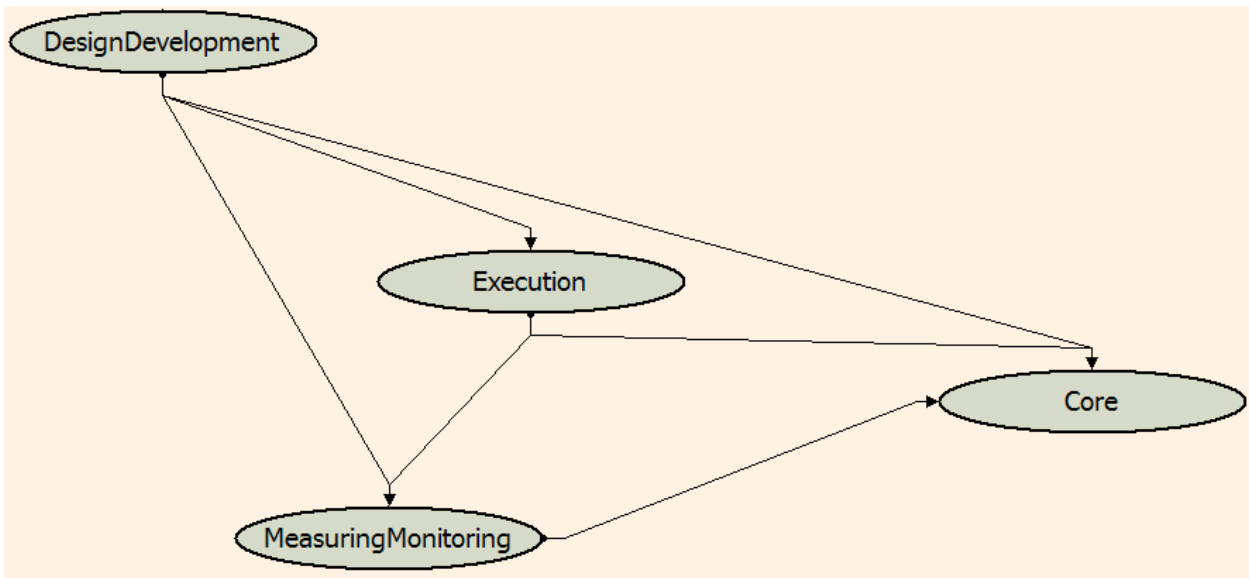*Figure 52. Group 2 Starting Point for M-2 BBN*

Figure 53. M-2 Core Process Structure for Groups 1 and 2

The completed BBN structure with related probabilities for the M-2 core processes are

shown in Appendix J. The Stiber method was completed for all SME for the M-2 model as seen

in Table 19. Since there was no difference for the M-2 models between the two groups, the

model generated by the SME will be the model chosen for the core processes. The variance for

the model is calculated as 0.17.

Comparing the results of the BBN model chosen to the indirect detection method, we find

that the average probability of formal processes within the core area is 0.78 (see "Aggregate" on

upper portion of Table 19, for "core"). From the indirect detection method, the average

probability for informal processes in the core area is 0.5.

Table 19. Stiber Results for M-2 BBN for Core Processes

Method: M-2 Expert Aggregate Structure BBN Model - Core Processes											
	Prior								Aggregate		
Node Variable	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 9		Mean	Std Dev
Design/Development	0.90	0.85	0.95	0.50	0.90	0.70	0.85	0.99	0.83	0.83	0.16
Execution	0.86	0.75	0.83	0.45	0.86	0.87	0.94	0.99	0.82	0.82	0.17
Measuring/Monitoring	0.89	0.84	0.73	0.75	0.85	0.89	0.86	0.90	0.84	0.84	0.06
Core	0.88	0.82	0.73	0.53	0.80	0.77	0.82	0.90	0.78	0.78	0.12
Likelihood	-	-	-	-	-	-	-	-			
Prob (Mj)	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13			

	Posterior								Aggregate	
Node Variable	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 9		
Desing/Development	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Execution	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	
Measuring/Monitoring	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Core	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Likelihood	0.00	0.00	0.00	0.03	0.00	0.01	0.00	0.00		
Prob (Mj)	0.02	0.07	0.06	0.57	0.06	0.14	0.08	0.00		

Subsection 8.4.3 Abbreviated Organizational Processes

Following the process-based organizational model shown in Figure 20, we define the

abbreviated organizational processes model as a model with three (3) nodes; strategic, core, and

system (output) shown in Figure 36. The M-1 models and their associated conditional

probability tables were developed by the SME. Initially, five (5) of the SME developed the

identical structure – three (3) from Group 2, and two (2) from Group 1.   The remaining three (3)

SME had the identical structure for their abbreviated organizational processes BBN. Figure 54

shows the BBN structure developed by the five (5) SME, while Figure 55 shows the structure of

the abbreviated organizational processes BBN generated by the remaining three (3) SME.

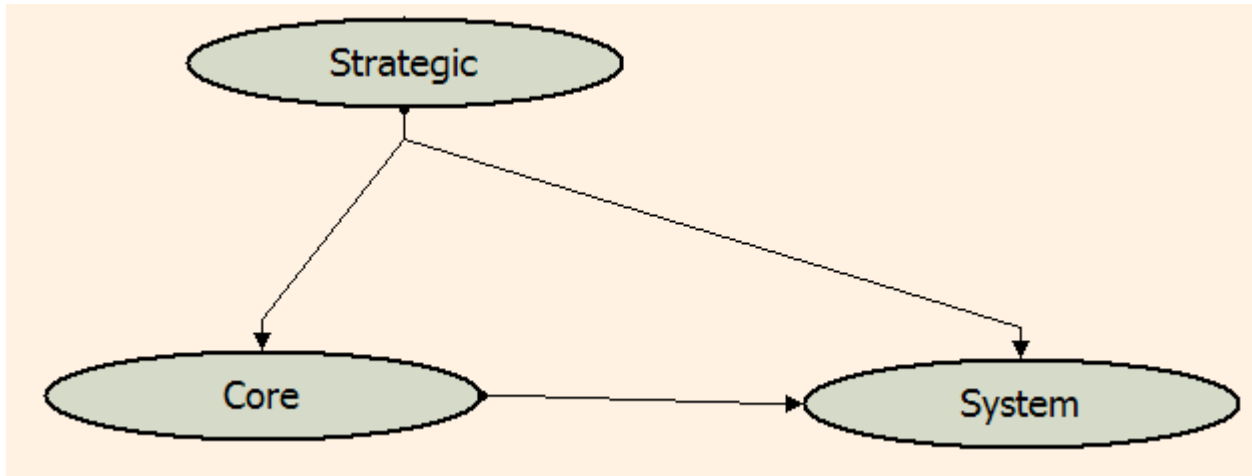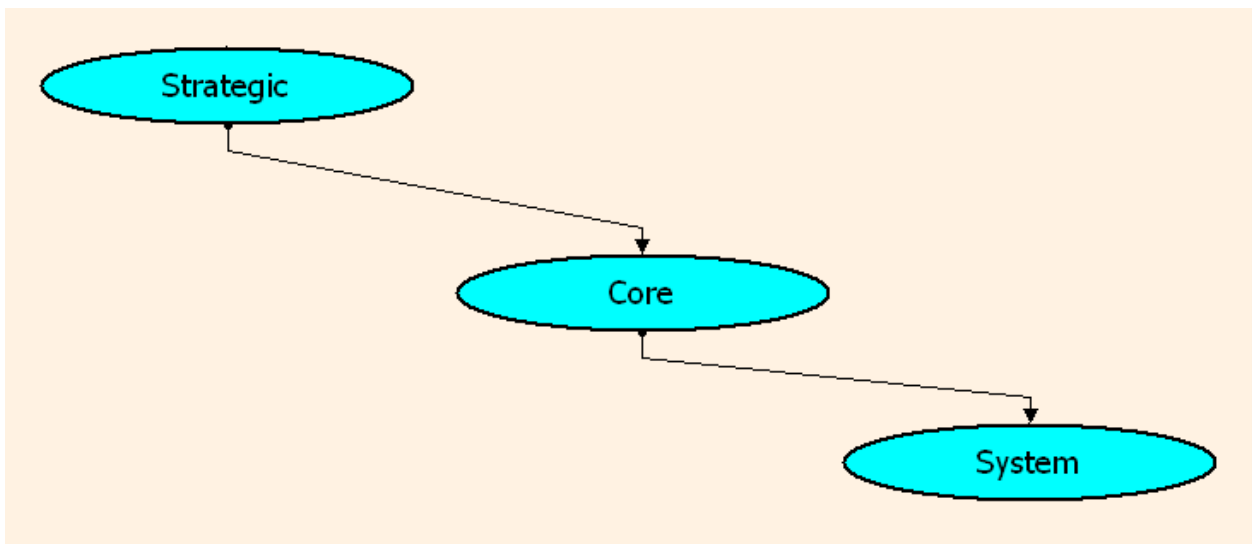*Figure 54. Abbreviated Organizational Processes BBN (Five (5) SME)*

Figure 55. Abbreviated Organizational Processes BBN (Three (3) SME)

The BBNs with associated bar charts for all SME for the abbreviated organization

processes are found in Appendix K. The Stiber method was applied to the M-1 BBNs with the

results shown in Table 20. The variance is 0.17.

Method: M-1 Expert Aggregate Structure BBN Model - Abbreviated

Node Variable	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 9	Aggregate	Mean	Std Dev
				Prior					Aggregate		
Strategic	0.66	0.58	0.62	0.59	0.67	0.82	0.93	0.85	0.72	0.72	0.13
Core	0.66	0.41	0.56	0.24	0.99	0.65	0.79	0.90	0.65	0.65	0.25
Output	0.62	0.43	0.47	0.27	0.95	0.64	0.85	0.90	0.64	0.64	0.24
Likelihood	-	-	-	-	-	-	-	-			
Prob (Mj)	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13			

Node Variable	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 9	Aggregate
				Posterior					Aggregate
Strategic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Core	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Output	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Likelihood	0.04	0.14	0.09	0.23	0.00	0.02	0.00	0.00	
Prob (Mj)	0.08	0.27	0.17	0.43	0.00	0.04	0.00	0.00	

At the meetings for the Group 1 and Group 2 SME, the SME reached a consensus on the M-2 BBN for the abbreviated organizational processes. The resulting M-2 from both of the groups was the same as that shown in Figure 54. An example of the conditional probability tables (SME #5) for this structure is shown in Figure 56. The remaining BBNs with associated bar charts for the M-2 structure are provided in Appendix L.

Figure 56. SME #5 Conditional Probability Tables for M-2 Abbreviated Org. Processes BBN

	Strategic		
	Informal	Formal	bar charts
	0.4	0.6	

Parent Node(s)	Core		
Strategic	Informal	Formal	bar charts
Informal	0.9	0.1	
Formal	0.19	0.81	

Parent Node(s)		Output		
Core	Strategic	Informal	Formal	bar charts
Informal	Informal	0.9	0.1	
Informal	Formal	0.5	0.5	
Formal	Informal	0.5	0.5	
Formal	Formal	0.05	0.95	

The Stiber method was applied to the results of all SME for the M-2 BBN for the abbreviated organizational model. The results are shown in Table 21.

Table 21. Stiber Results for the M-2 BBN of Abbreviated Organizational Processes

M-2 Expert Aggregate Structure BBN Model - Abbreviated Organizational Processes											
	Prior								**Aggregate**		
Node Variable	**Expert 1**	**Expert 2**	**Expert 3**	**Expert 4**	**Expert 5**	**Expert 6**	**Expert 7**	**Expert 9**		**Mean**	**Std Dev**
Strategic	0.58	0.72	0.90	0.37	0.60	0.82	0.93	0.85	0.63	0.63	0.19
Core	0.51	0.81	0.66	0.51	0.53	0.64	0.79	0.90	0.60	0.60	0.13
System	0.51	0.74	0.68	0.35	0.57	0.64	0.85	0.90	0.57	0.57	0.15
Likelihood	-	-	-	-	-						
Prob (Mj)	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13			
	Posterior								**Aggregate**		
Node Variable	**Expert 1**	**Expert 2**	**Expert 3**	**Expert 4**	**Expert 5**	**Expert 6**	**Expert 7**	**Expert 9**			
Strategic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Core	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
System	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Likelihood	0.10	0.01	0.01	0.20	0.08	0.02	0.00	0.00			
Prob (Mj)	0.23	0.03	0.03	0.46	0.19	0.05	0.01	0.00			

The model structure shown in Figure 54 is the structure agreed upon by eight (8) SME. The

variance associated with this model in terms of the conditional probabilities of the SME is 0.16.

Table 21 shows an aggregate of the probability of formal processes using this model as 0.57.

The overall average of the probability of informal processes per the data collected with the

indirect detection method is 0.4, which translates to a 0.6 probability of formal processes.

As stated previously, this model is a general model that follows the process-based

organizational model. The abbreviated organizational processes model does not account for

interactions within the strategic processes nor within the core processes. This model also does

not allow for specific strategic processes to relate to specific core processes. Therefore, it was

determined that an expanded model for the overall system (output) of an organization was

needed. The expanded organizational processes model is discussed in subsection 8.4.4.

Subsection 8.4.4 Expanded Organizational Processes

The M-1 expanded organizational processes models were derived from a combination of

the individual SME strategic and core M-1 BBNs. Upon completion of the strategic and core

BBNs, the models were combined and the SME requested to determine the relationships between

172

the various strategic and core processes. Nine (9) different M-1 models were generated. Two of

the models are shown in Figures 57 and 58 below. The remaining M-1 models are provided in

Appendix M with the associated bar charts.

Figure 57. SME #5 M-1 Expanded Organizational Processes BBN
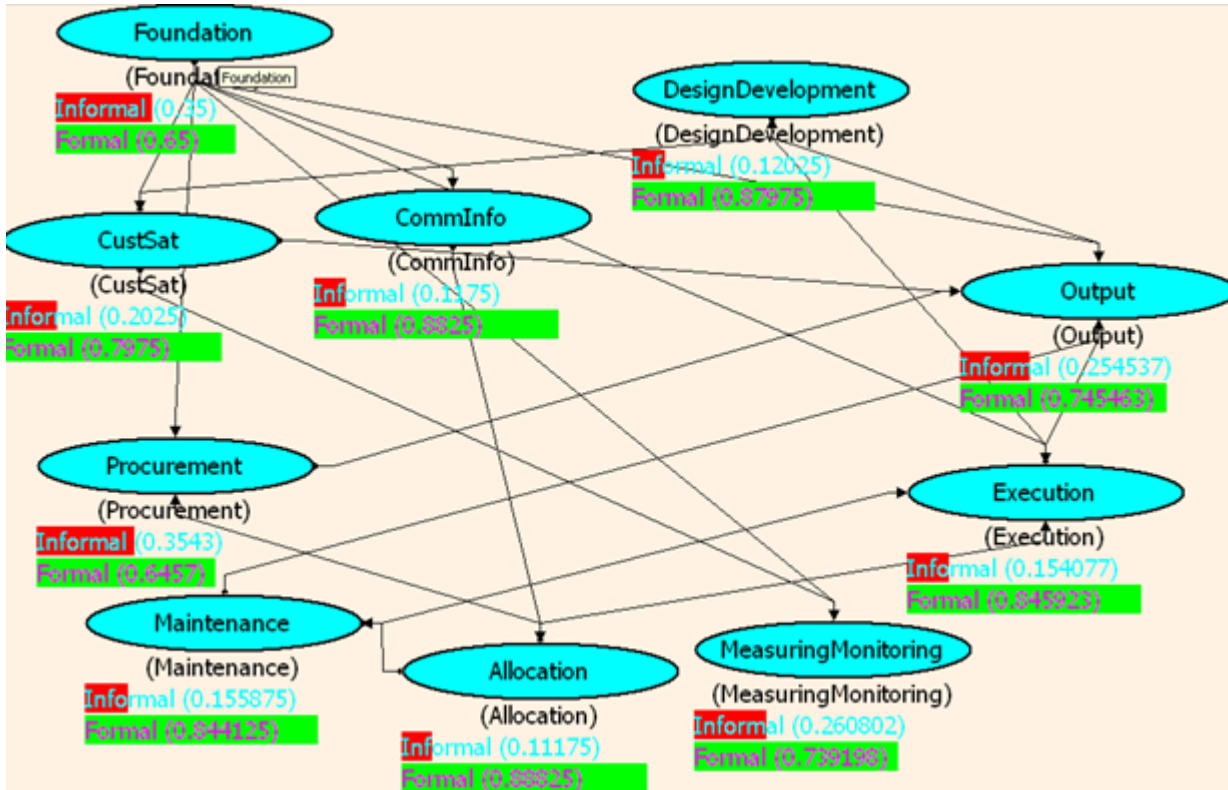
Once again, the Stiber method was applied to all of the M-1 models and their data as

developed by the SME. Table 22 shows the results. From Table 22, SME #3 had the highest

probability of their model being correct for the expanded organizational processes. The results

were reviewed to determine if there was any information that could be utilized based on the

classifications (small or large, manufacturing or service, high-tech or low-tech, or highly

regulated organizations or those with little to no regulation). No apparent distinction was found.

The results are shown in Figure 59.

Figure 58. SME #7 M-1 Expanded Organizational Processes BBN
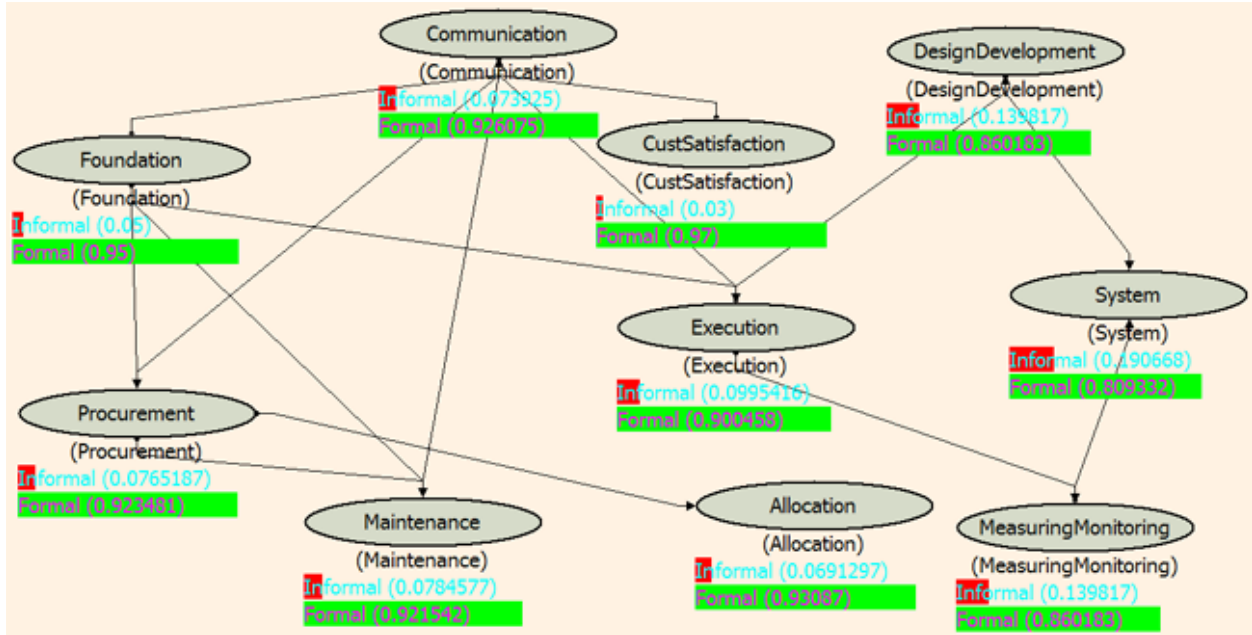
The next step in this process was to have the two (2) groups meet separately to reach a consensus

on M-2 structures. Group 1 agreed upon the structure seen in Figure 60, followed by the

individual SME generating conditional probability tables based on their experience. The

resulting BBNs with the associated bar charts are shown in Appendix N.   The Stiber method

was applied to the Group 1 results are shown in Table 23. The aggregate for the overall system

(output) for the Group 1 M-2 is 0.68. The associated variance is 0.15.

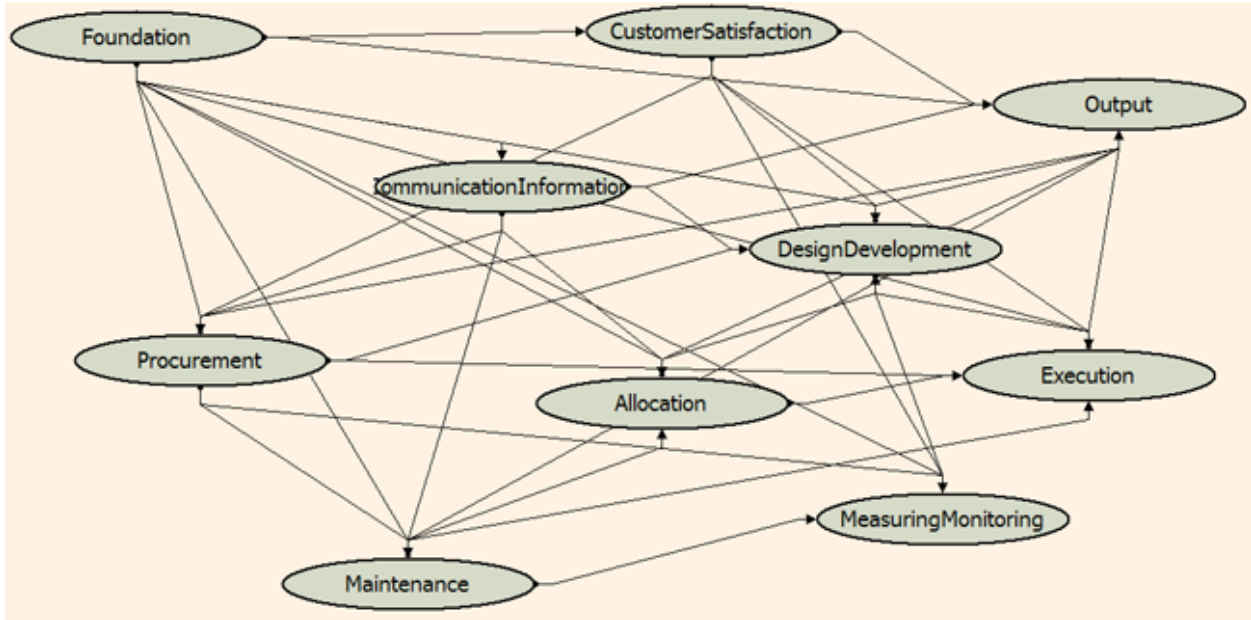*Table 22. Stiber Results for M-1 Models for Expanded Organizational Processes*

M-1 Expert Aggregate Structure BBN Model - Expanded Organizational Processes											
	Prior								Aggregate		
Node Variable	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 9		Mean	Std Dev
Foundation	0.85	0.80	0.70	0.50	0.65	0.70	0.95	0.99	0.77	0.77	0.16
Communication/Information	0.84	0.74	0.59	0.77	0.88	0.71	0.93	0.00	0.68	0.68	0.30
Customer Satisfaction	0.80	0.70	0.58	0.50	0.80	0.74	0.97	0.90	0.75	0.75	0.16
Procurement	0.81	0.60	0.60	0.73	0.65	0.75	0.92	0.74	0.73	0.73	0.11
Maintenance	0.79	0.60	0.64	0.78	0.84	0.81	0.92	0.57	0.74	0.74	0.13
Allocation	0.74	0.57	0.70	0.60	0.89	0.84	0.93	0.52	0.72	0.72	0.15
Design/Development	0.71	0.58	0.61	0.43	0.88	0.65	0.86	0.79	0.69	0.69	0.15
Execution	0.71	0.53	0.59	0.55	0.85	0.65	0.90	0.67	0.68	0.68	0.13
Measuring/Monitoring	0.61	0.61	0.56	0.54	0.74	0.68	0.86	0.66	0.66	0.66	0.10
System	0.76	0.50	0.52	0.64	0.75	0.68	0.81	0.66	0.67	0.67	0.11
Likelihood	-	-	-	-	-	-	-	-			
Prob (Mj)	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13			

	Posterior								Aggregate		
Node Variable	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 9			
Foundation	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.77		
Communication/Information	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Customer Satisfaction	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.77		
Procurement	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Maintenance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Allocation	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.77		
Design/Development	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Execution	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.77		
Measuring/Monitoring	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77		
System	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Likelihood	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
Prob (Mj)	0.02	0.22	0.47	0.04	0.01	0.05	0.00	0.33			

Figure 59. Comparison of M-1 Results of SME BBN (Expanded Org. Processes) By Category
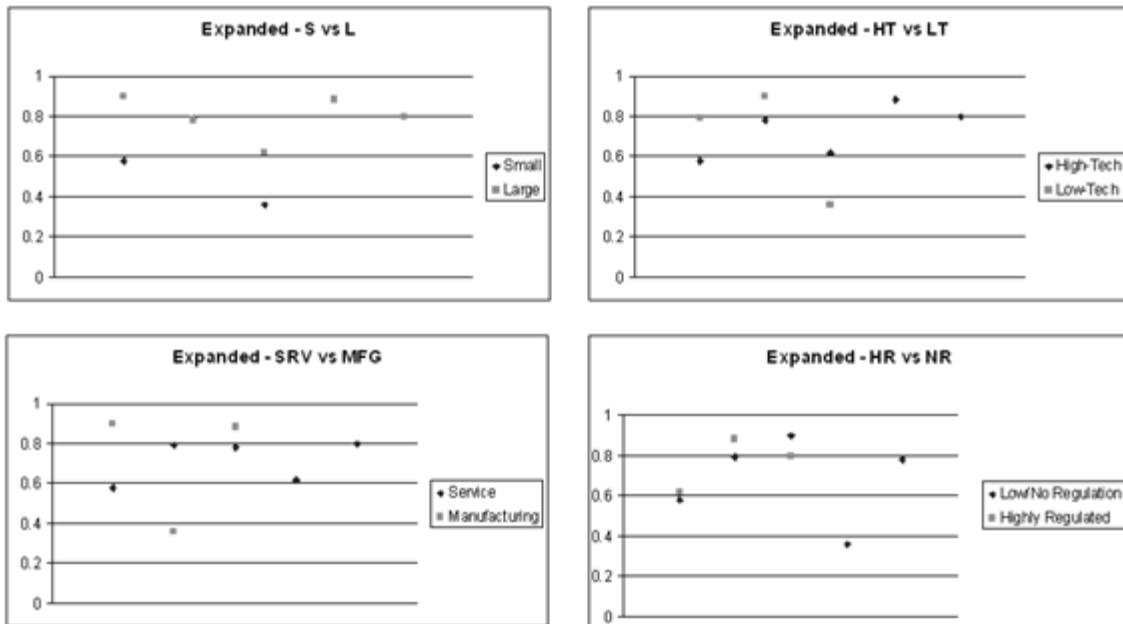
Figure 60. Group 1 M-2 Model for Expanded Organizational Processes
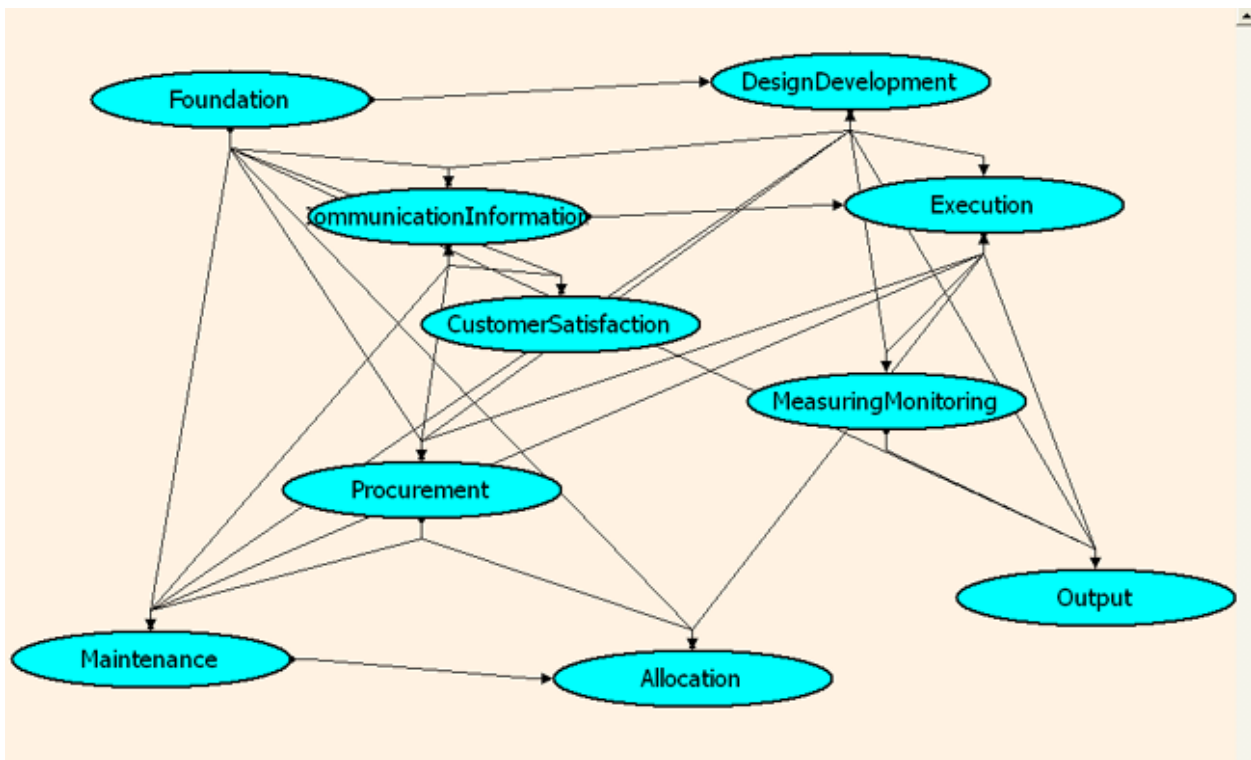

Table 23. Stiber Results for M-2 Model of Group 1 for Expanded Organizational Processes

M-2 Group 1 Expert Aggregate Structure BBN Model - Expanded Organizational Processes								
	Prior					Aggregate		
Node Variable	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5		Mean	Std Dev
Foundation	0.60	0.80	0.95	0.90	0.99	0.85	0.85	0.16
Communication/Information	0.56	0.74	0.91	0.74	0.95	0.78	0.78	0.16
Customer Satisfaction	0.58	0.71	0.91	0.69	0.94	0.77	0.77	0.15
Procurement	0.57	0.72	0.88	0.64	0.86	0.73	0.73	0.14
Maintenance	0.57	0.72	0.73	0.71	0.86	0.72	0.72	0.10
Allocation	0.58	0.67	0.80	0.73	0.87	0.73	0.73	0.11
Design/Development	0.58	0.88	0.86	0.62	0.85	0.76	0.76	0.15
Execution	0.59	0.79	0.83	0.62	0.80	0.73	0.73	0.11
Measuring/Monitoring	0.59	0.82	0.81	0.63	0.83	0.74	0.74	0.12
System	0.58	0.79	0.90	0.36	0.78	0.68	0.68	0.21
Likelihood	-	-	-	-	-			
Prob (Mj)	0.20	0.20	0.20	0.20	0.20			

	Posterior					Aggregate
Node Variable	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	
Foundation	1.00	1.00	1.00	1.00	1.00	1.00
Communication/Information	0.00	0.00	0.00	0.00	0.00	0.00
Customer Satisfaction	1.00	1.00	1.00	1.00	1.00	1.00
Procurement	0.00	0.00	0.00	0.00	0.00	0.00
Maintenance	0.00	0.00	0.00	0.00	0.00	0.00
Allocation	1.00	1.00	1.00	1.00	1.00	1.00
Design/Development	0.00	0.00	0.00	0.00	0.00	0.00
Execution	1.00	1.00	1.00	1.00	1.00	1.00
Measuring/Monitoring	0.00	0.00	0.00	0.00	0.00	1.00
System	0.00	0.00	0.00	0.00	0.00	0.00
Likelihood	0.00	0.00	0.00	0.00	0.00	
Prob (Mj)	0.49	0.02	0.00	0.48	0.00	

176

Group 2 reached a consensus on the model shown in Figure 61. The BBNs with associated bar charts relating to Figure 61 are also provided in Appendix N. The Stiber method was again applied to the results of the Group 2 SME and is shown in Table 24. The variance for this Group is 0.12. Since the variance for the Group 2 M-2 model is less than that of the Group 1 M-2 model , we will choose the Group 2 M-2 model for the expanded organization processes.

As shown in Table 24, the aggregate for the system (output) of the probability of formal processes, based on the conditional probabilities as defined by the SME, is 0.77. The average for the indirect detection method for the overall organization of informal processes existing is 0.4.

Figure 61. Group 2 M-2 Model for Expanded Organizational Processes

Table 24. Stiber Results for M-2 Model of Group 2 for Expanded Organizational Processes

M-2 Group 2 Expert Aggregate Structure BBN Model - Expanded				Prior Aggregate		
Node Variable	Expert 6	Expert 7	Expert 9		Mean	Std Dev
Foundation	0.70	0.96	0.90	0.85	0.85	0.13
Communication/Information	0.66	0.90	0.48	0.66	0.66	0.21
Customer Satisfaction	0.70	0.96	0.45	0.73	0.73	0.26
Procurement	0.42	0.92	0.66	0.70	0.70	0.20
Maintenance	0.68	0.91	0.83	0.77	0.77	0.17
Allocation	0.49	0.91	0.74	0.71	0.71	0.21
Design/Development	0.63	0.94	0.80	0.79	0.79	0.16
Execution	0.56	0.87	0.74	0.72	0.72	0.16
Measuring/Monitoring	0.89	0.74	0.71	0.78	0.78	0.30
System	0.62	0.00	0.00	0.77	0.77	0.13
Likelihood	-	-	-			
Prob (M)	0.33	0.33	0.33			

Node Variable	Expert 1	Expert 2	Expert 3	Posterior Aggregate
Foundation	1.00	1.00	1.00	1.00
Communication/Information	0.00	0.00	0.00	0.00
Customer Satisfaction	1.00	1.00	1.00	0.00
Procurement	0.00	0.00	0.00	0.00
Maintenance	0.00	0.00	0.00	0.00
Allocation	1.00	1.00	1.00	0.00
Design/Development	0.00	0.00	0.00	0.00
Execution	1.00	1.00	1.00	0.00
Measuring/Monitoring	0.00	0.00	0.00	0.00
System	0.00	0.00	0.00	0.00
Likelihood	0.00	0.00	0.00	
Prob (M)	0.72	0.00	0.27	

Due to the limited number of SME utilized in the research, and the small amounts of variance between models, it is recommended that further effort be made at a later date to develop additional information to select the best model for applications. It may be that one model is better suited for a given type of organization, and both models Group 1 and Group 2 would be useful. In Chapter 10, both models were utilized and the difference in the outputs from the two models is shown.

The models that have been developed in subsections 8.4.1 through 8.4.4 provide a tool for organizations to estimate their probability of having informal processes based on observed evidence. This tool is a bridge between the indirect detection method and direct detection method presented in chapter 7. In Chapter 10 we will see the results of using this tool in actual organizational examples.

Subsection 8.4.5 Quantitative Assessment of the Probability of the Output being Deficient

An objective of this research is to provide a method for quantifying the probability of the output of a process, or the overall output of the organization (system) of being deficient due to

the presence of informal processes. The overall output of the organization can be linked to the risk assessment impact based on a model of system performance. This same methodology will allow an organization to determine the effect of the actions taken with regards to the informal processes, i.e. the effect of bringing beneficial informal processes into the formal system, or the effect of modifying the formal system to preclude the use of detrimental informal processes. In Chapter 8, subsection 8.2.1, the basic BBN model was shown for an output that was influenced by both formal an informal processes.

The equation that was developed to determine the probability of the output being deficient is:

$$P(\overline{O}) = P\langle \overline{O} | \overline{F}, I \rangle P(\overline{F}) P(I) + P\langle \overline{O} | F, \overline{I} \rangle P(F) P(\overline{I}) + P\langle \overline{O} | \overline{F}, \overline{I} \rangle P(\overline{F}) P(\overline{I})$$

where: $\overline{O}$ = output defective,

F = formal process is good,

$\overline{F}$ = formal process failing,

I = informal process is good,

$\overline{I}$ = informal process failing, and

$P(*)$ = probability of * occurring.

With the information that has been presented at this time, it is also feasible to discuss a method for determining the probability of an informal process being present given the information that we know, i.e. the information based on SME opinion, the information from the indirect detection method, and the information observed during a process audit. For this scenario, our Bayes' model would appear as shown in Figure 62. The determination of the probability of an informal process being present is developed using the methodology in Mohaghegh (2007).
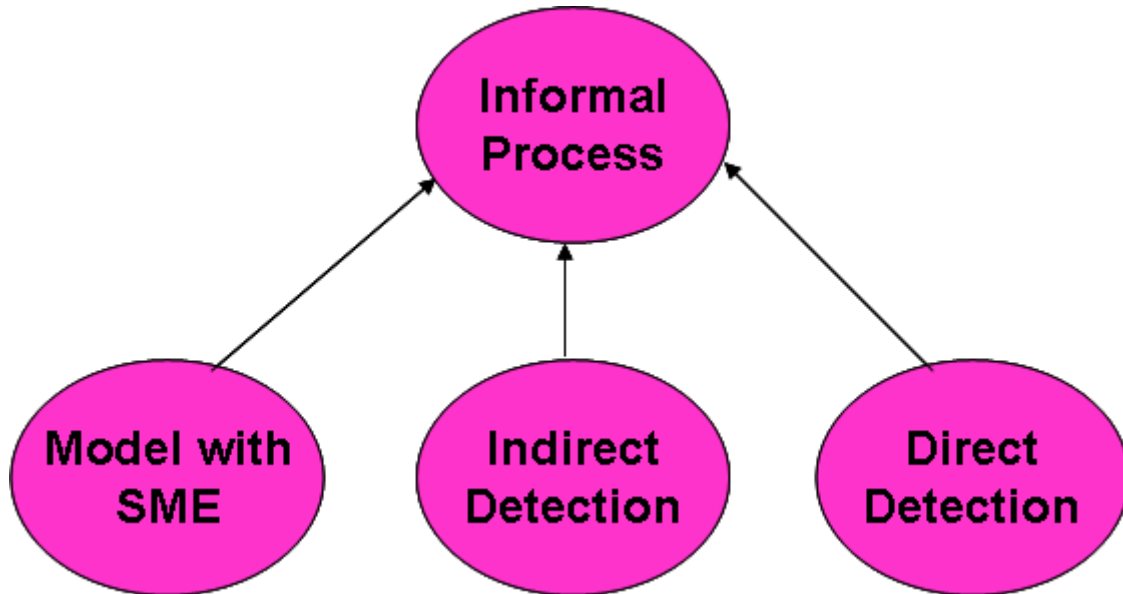
Using Bayes' theorem to assess the probability that informal processes exist and letting:

$\pi_0(p) =$ prior state of knowledge regarding if informal processes exist (prior to knowledge gained by either method of assessment ,i.e. indirect detection, direct detection, or model completion with SME judgment),

$p_S =$ the measurement of the probability of the presence of informal processes as determined by the use of the model with SME judgment,

$p_I =$ the measurement of the probability of the presence of informal processes as determined by the use of the indirect detection method,

$p_D =$ the measurement of the probability of the presence of informal processes as determined by the use of the direct detection method,

$L\langle p_S, p_I, p_D | p\rangle =$ the likelihood of having the model with SME judgment, the

indirect detection method, and the direct detection method occurring,

given that informal processes exist, and

$\pi\langle p | p_s, p_I, p_D\rangle =$ the posterior state of knowledge regarding the presence of

informal processes with respect to the model with SME judgment, the

indirect detection method, and the direct detection method,

we will have: $\pi\langle p | p_S, p_I, p_D\rangle = \dfrac{L\langle p_S, p_I, p_D | p\rangle \pi_0 p}{\int L\langle p_S, p_I, p_D | p\rangle \pi_0 p dp}$

To determine an estimate of the likelihood $L\langle p_{S,} p_I, p_D | p\rangle$ in order to estimate the

posterior distribution, we can assume that p_S, p_I, and pI_D are independent. This assumption is

valid when the SME that completed the model and associated conditional probability tables, the

individual that completed the indirect detection questionnaire, and the auditor performing the

direct detection method are separate individuals. When the assumption of independence is made,

the likelihood function will become: $L\langle p_S, p_I, p_D | p\rangle = L\langle p_S | p\rangle * L\langle p_I | p\rangle * L\langle p_D | p\rangle$, where

$L\langle p_S | p\rangle$ is a measure of the accuracy of the SME judgment, $L\langle p_I | p\rangle$ is a measure of the

accuracy of the indirect detection method, and $L\langle p_D | p\rangle$ is a measure of the accuracy of the

direct detection method with respect to the presence of informal processes.

Chapter 9: Qualitative Review of the Effect of Informal Processes

Section 9.1 Introduction

As previously discussed, two (2) means of assessing the effect of bringing informal processes into the formal system will be presented. It should be noted that it is not possible to make all processes completely formal, as an inherent skill level must be assumed. For example, personnel for a defense contractor developed a user's manual for a piece of equipment to be utilized by military personnel in the field. The user's manual was very specific in the instructions for each function of the equipment. However, when the completed draft was sent to the military logistics personnel for review, the user's manual was found to have one problem…it did not instruct field personnel to turn on the equipment.

A quantitative method of assessing the effect of bringing informal processes into the formal system is presented is Chapter 10. The second method is qualitative in nature due to limited data access. Real world examples of the effect of informal processes are utilized. The steps taken in the review are:

- Systematic review of the literature/data,

- Identification of the informal processes,

- Directly linking the informal processes identified to the developed process taxonomy,

- Determining the effect of the informal processes,

- Review of the changes made to the formal system, and

- Review of the organizational output after the changes were incorporated.

Three examples are presented in the sections below. The first example deals with wrong runway departures for commercial airliners. The second example is from a special investigation

report by the National Transportation Safety Board on post accident testing for alcohol and other drugs in the marine industry. The third and final example relates to NASA and the space shuttle program.

Section 9.2 Wrong Runway Departure

Following the 2006 crash of Comair flight 1591 in Lexington, Kentucky due to the plane taking off from the wrong runway, the Federal Aviation Administration's Aviation Safety Information Analysis and Sharing Center conducted an investigation into reports involving the FAA Federal Aviation Regulations (FAR) Part 121 "airplanes taxiing into or departing from an incorrect runway". The data were gathered from multiple databases for the time period 1981 through 2006. It should be noted that data for wrong runway incursions may not be complete as departures from a wrong runway are not required to be reported to the FAA if there is no loss of separation or accident report. Although wrong runway events occurred at many airports under varying circumstances, four (4) airports had the highest frequency of these events: Cleveland Hopkins International Airport with twenty-four percent (24%) of the wrong runway events, Houston Hobby Airport with eleven percent (11%) of the wrong runway events, Salt Lake City International Airport with eight percent (8%) of the wrong runway events, and Miami International Airport with six percent (6%) of the wrong runway events. We will concentrate our investigation into those episodes at the Cleveland Hopkins International Airport. Table 25 below shows the top seventy-eight percent (78%) contributing factors of these events, as defined by the FAA and the associated process taxonomy as developed in this research.

An example to demonstrate how the wrong runway factors contribute to an attempted take off from a different runway than assigned is shown here. It is a summary of an event submitted to the Aviation Safety Reporting System (ASRS) in 1993).

Because of confusion at the intersection of runways 23L and 23R and 28 at the approach end of the runways, we initiated a takeoff on the wrong runway for which we had been cleared. We had been cleared for takeoff on runway 23L. Because of the short taxi distance between the terminal and the runways, we had a very short taxi time. Just as we reached the hold short lines, we had completed our taxi checklist and were immediately cleared for takeoff on 23L. As the Captain taxied out to line us up (he has the nose steering on his side only), I ran my line-up checklist and he said "hello" to the passengers over the PA system. Lined up on the wrong runway, I took the throttles and we proceeded down the wrong runway. The tower controller called us to tell us we were taking off on the wrong runway.

Table 25. Wrong Runway Contributing Events and Associated Process   Taxonomy

CONTRIBUTING EVENT	# OF CITATIONS	PROCESS TAXONOMY
Crew	51	Procurement – Human Resources
Airport Geometry	50	Design/Development
Check between heading indicator and runway heading	39	Measuring/Monitoring
Human Factors	31	Training
Communications	28	Communication/Information
Airport Signage and Markings	20	Communication/Information
Time Pressures	19	Allocation
Airport Complexity	13	Planning
Information Dissemination	13	Design/Development

The reports of wrong runway departures at the Cleveland Hopkins International Airport increased during the early 1990s. With this increase, the Air Line Pilots Association International (ALPA), Cleveland airport administration and the FAA began a cooperative effort with the goal of decreasing the occurrences of wrong runway departures. Table 26 shows the

changes to the formal system made to alleviate the informal processes and the associated process taxonomy. Looking at the two highlighted areas within Table 26, we can further clarify these examples. The first highlighted area was a change made to the length of time of taxi. Prior to the changes, there was inadequate time for the flight crews to complete the pre-takeoff checklists. As a result, informal processes were occurring where the checklist was not completed in its entirety, or the checklist was inadequately completed. Lengthening the time allows the flight crew to complete the pre-takeoff checklist per their required procedures. The second highlighted area indicates that there was a deficiency in the formal process (pilot procedures) that allowed an occurrence of a wrong runway departure.

A review of the databases available to the researcher shows that there have been no instances of wrong runway departures from the Cleveland Hopkins International Airport since the above changes were implemented (2007 – September 2009). The changes to the procedures (eliminating the opportunity of a wrong runway departure), alleviating the informal processes had a positive impact on the overall process.

Section 9.3 Marine Industry Post Accident Testing for Alcohol and Drugs

In 1998, due to continuing issues encountered when conducting post accident testing for alcohol and drugs, NTSB undertook an investigation into the problems specifically within the maritime industry. Twenty-eight (28) major accident investigations were hampered due to the lack of or lack of timeliness in completing testing for alcohol and drugs (NTSB PB98-917003). The informal processes identified include: (1) lack of understanding by maritime employers and employees of the post accident testing requirements and responsibilities, and (2) conflicting information within the control documents.

In regards to the lack of understanding by maritime employers and employees, Table 27 provides a summary of actions taken or not taken that did not meet the regulations regarding post accident alcohol testing. For reference, when an accident occurs, all crew on the ship must receive alcohol testing (breathalyzer) within two (2) hours of the accident. If a breathalyzer cannot be performed at that time, a urine sample can be submitted within eight (8) hours, providing that there is no alcohol consumption between the accident and the time the urine sample is collected.

Table 26. Changes to Formal System and Associated Process Taxonomy

CHANGES TO THE FORMAL SYSTEM	PROCESS TAXONOMY
Addition of runway location signs	Communication/Information

Removal of Taxiway T
  - Taxiway T was positioned at the intersection of two runways – removal of this taxiway alleviated the inadvertent use of the wrong runway
  - Lengthened time of taxi from terminal to runway which lessened time pressures on flight crews regarding completion of pre-takeoff checklists while taxiing
	Planning
	
	Execution

New marking standards for active runways– use of surface painted holding position and runway signs on taxiway surfaces	Communication/Information
Installation of lighting on runways (holding positions, taxiway centerline, runway guard lighting)	Maintenance Communication/Information
Addition of Taxiway W	Logistics - facilities
New runway construction	Logistics - facilities
Air Traffic Control (ATC) briefings held when wrong runway departure occurred	Maintenance – training Communication/Information
Two new policies implemented regarding confirmation of correct runway prior to takeoff	Foundation - policies
Pilot procedures revised to reduce threat of wrong runway departure	Communication/Information

Table 27. Summary of Actions Related to Post Accident Alcohol Testing

VESSEL	DATE OF ACCIDENT	REMARKS
Exxon Valdez	March 24, 1989	Testing equipment not available on ship per regulations; blood and urine test performed 10.5 hours after accident
World Prodigy	June 23, 1989	Urine testing complete 22 hours after accident
Aleutian Enterprise	March 22, 1990	Testing equipment not available on ship per regulations; urine testing complete 42 hours after accident
Jupiter/Buffalo	September 16, 1990	Coast Guard reminded crew of testing for alcohol ~ 6 hours after accident; some crewmembers consumed alcohol following the accident add prior to testing; hospitalized crew not tested
Sea King	January 11, 1991	Owner refused to test
Fremont/Juraj Dalmatinac	December 21, 1992	Testing equipment not available on ship per regulations; urine testing complete ~ 16 hours after accident
Yorktown Clipper	August 18, 1993	Testing equipment not available on ship per regulations; urine testing complete 18.5 hours after accident
Omi Charger	October 9, 1993	Post accident drinking; testing initiated by Coast Guard
All Alaskan	July 24, 1994	Testing equipment not available on ship per regulations; urine testing complete 28 hours after accident
Seal Island	October 8, 1994	Testing equipment not available on ship per regulations
Julie N	September 27, 1996	Testing equipment not available on ship per regulations; breathalyzer not performed as technicians opted to collect urine samples first
Sundowner	December 7, 1996	Owner permitted crew to engage in post accident drinking; blood testing and urine specimens collected 16 – 17 hours after accident
Cowslip/Evergrade	May 14, 1997	Breathalyzer not performed; blood and urine collected 8.6 – 18.5 hours after accident

Regarding the conflict between regulations, there are two (2) regulations of the Coast Guard that deal with post-accident testing. The first is 33 CFR 95 that is applicable to commercial and recreational vessels that are operated on waters subject to the jurisdiction of the United States. The second regulation is 46 CFR 4.06 that applies to US commercial vessels and foreign-flag commercial vessels that are operating in US waters. Neither of these regulations addresses the need for the elimination of pos- accident drinking prior to being tested for alcohol use. There are three (3) specific items within these two (2) regulations that we will address:

1. Intoxication standards for alcohol

    a. 33 CFR 95 – 0.04% blood alcohol concentration

    b. 46 CFR 4.06 – no standard given

2. Testing responsibility and timeliness

    a. 33 CFR 95 – as soon as practical

    b. 46 CFR 4.06 – within two (2) hours

3. Testing equipment required

    a. 33 CFR 95 – none specified

    b. 46 CFR 4.06 – breath-testing devices on ocean-going vessels and urine specimen collection and shipping kits (if not obtainable in twenty-four (24) hours

The two (2) informal processes above, the lack of understanding of the requirements and the conflict between regulations can be directly linked to the developed process taxonomy. The lack of understanding of the requirements is a training issue, which falls under the maintenance area of the resource management processes for strategic processes. The conflict between the

regulations is also within the strategic processes, specifically the communication/information processes portion of the organizational management processes.

The effect of these informal processes is that they do not allow the NTSB, or others, to adequately determine the cause, or contributing factors of an accident. Although the NTSB offered conclusions and recommendations in their report on post accident testing for alcohol and other drugs, these were acted upon in a sufficient manner. Specifically, the NTSB recommended that Coast Guard regulations for post-accident testing be communicated clearly by establishing a requirement in the post-accident testing regulations that vessels have a post accident testing plan. The testing plan should identify crewmembers who will conduct the testing, as well as the qualifications of those crewmembers; establish the procedure for the care of specimens and the chain of custody; and identify the records to be prepared. For testing times, the NTSB recommended that language be incorporated into the regulations that post-accident alcohol testing begin within two (2) hours of a serious marine incident/accident, with attempts to test for alcohol ceasing after eight (8) hours, and that post-accident drinking can not occur until after testing is complete. To address the issue of the conflicts between 33 CFR 95 and 46 CFR 4.06, the NTSB recommended that the requirements as set forth in 46 CFR 4.06 be incorporated into 33 CFR 95.

Both 33 CFR 95 and 46 CFR 4.06 were reviewed to determine if the recommended changes had been adopted. They had not. Despite the number of occurrences related to accidents and the potential of alcohol being a factor, there have been no changes to the formal system. Accidents are continuing to occur (allision of Bahamas-registered tankship M/T Axel Spirit with the Ambrose Light Entrance to New York Harbor, and the allision of Hong Kong-registered containership M/V Cosco Busan with the Delta Tower of the San Francisco – Oakland

Bay Bridge) that may have be alcohol related, but not confirmed due to the lack of sufficient requirements regarding post accident alcohol testing. As seen in this example, if informal processes are identified, but are not addresses, the issues do not disappear. For an organization to detect and identify informal processes, but not resolve them, they will not have the opportunity to improve their overall output.

Section 9.4 Informal Processes Associated with the NASA Space Shuttles

Two (2) disasters occurred within the space shuttle program of NASA due to informal processes – the Challenger on January 28, 1986, and the Columbia on February 1, 2003. A brief overview of these disasters will be given.

The sun was shining, the sky was a clear blue, and the temperature was freezing cold on the morning of January 28th, 1986 at Kennedy Space Center in Florida. Preparations were being made for the launch of the 25th space shuttle into space, Mission 51-L, the Challenger. This was one of the most publicized launches as history was to be made with the first flight of a civilian, a school teacher, into space. Ironically, history was made – tragedy occurred when the space shuttle Challenger and its seven (7) member crew were lost seventy-three (73) seconds after launch when a pressure seal (o-ring) in the aft field joint of the right solid rocket booster failed allowing pressurized hot gas from within the solid rocket motor to reach the external fuel tank and the solid rocket booster aft hardware attachment. This led to a separation of the solid rocket booster's aft attachment and structural failure of the external tank allowing aerodynamic forces to break up the vehicle.

A vast amount of data had been collected over the years regarding the effect of temperature on the solid-rocket booster o-rings. NASA managers had been aware of a potentially fatal flaw in the o-rings since 1977, but had never addressed the issue. During the

January 27th, 1986 teleconference, when NASA was polling all of the contractors for a "go/no-go" decision, the engineers at Morton Thiokol (the contractor responsible for the solid rocket booster) stated that the shuttle should not be launched with an ambient temperature of less than 53 degrees Fahrenheit.

The informal processes identified that contributed to the Challenger disaster were:

- Insufficient preventive action (the O-ring issue in low temperatures was a known problem that was not sufficiently addressed).

- Insufficient corrective action (a new problem was discovered during November 1981, after the flight of the second shuttle mission. Examination of the booster field joints revealed that the O-rings were eroding during flight. The joints were still sealing effectively, but the O-ring material was being eaten away by hot gasses that escaped past the putty. Morton Thiokol studied different types of putty and its application to study their effects on reducing O-ring erosion. The shuttle flight 51-C of January 24, 1985, was launched during some of the coldest weather in Florida history. Upon examination of the booster joints, engineers at Thiokol noticed black soot and grease on the outside of the booster casing, caused by actual gas blow-by. This prompted Morton Thiokol to study the effects of O-ring resiliency at low temperatures. In July 1985, Morton Thiokol ordered new steel billets which would be used for a redesigned case field joint. At the time of the accident, these new billets were not ready)

- Inadequate validation and testing procedures (although a basic study was made of the effect of temperature on the O-rings, there was inadequate data to determine if the O-rings would seal properly at low temperatures. The O-rings were

designated as a criticality 1 component, meaning that there was no backup if both

the primary and secondary O-rings failed), and

- Lack of communication (engineers at both Morton Thiokol and Rockwell International (space shuttle's prime contractor) had concerns which were expressed to management regarding the launch of Challenger to be a no-go. Both organizations' management downplayed the concerns to NASA).

The above informal processes can be directly linked to the developed process taxonomy in three areas: (1) the corrective action and preventive action informal processes are linked within the core processes, measuring and monitoring area; (2) the inadequate validation and testing procedures are also found within the core processes under the design/development area; and (3) lack of communication is within the strategic processes, organizational management area, specifically communication/information. The obvious effect of these informal processes was the loss of seven (7) lives and the space shuttle.

Based on recommendations from investigative committees following the Challenger disaster, NASA initiated a total redesign of the space shuttle's solid rocket boosters and created an Office of Safety, Reliability, and Quality Assurance. Despite these changes, although there has not yet been another disaster attributable to an O-ring failure, NASA continued to have informal processes that were not addressed.

Columbia launched on January 16, 2003, and disintegrated during re-entry on February 1, 2003. The primary cause of the loss of Columbia was damage sustained when a piece of foam insulation broke off the main propellant tank (external tank) and struck the leading edge of the left wing, damaging the shuttle's thermal protection system. The shuttle's thermal protection system protects the shuttle from heat generated with the atmosphere upon re-entry. Engineers

reviewing the high-resolution video the day after launch noticed the debris strike the wing of the shuttle and made three (3) separate requests for Department of Defense imaging of the shuttle in orbit in order to determine the damage. The engineer's requests were forwarded to NASA management who did not honor the request. Additionally, the chief thermal protection engineer submitted a request in writing asking NASA management if an astronaut could visually inspect the damage. There was not a response from management.

The loss of insulation from the main propellant tank and subsequent striking of the shuttle was not a new phenomenon for NASA. At least four (4) other instances were documented n 1983, 1988, 1990, and 1992. Management at NASA seemed to treat these instances as familiar when there had been no evidence of serious consequences. Despite the changes made within NASA after the Challenger disaster, the same informal processes contributed to the Columbia disaster:

- Insufficient preventive action (the shuttle safety regulations require that loss of external tank foam and the subsequent debris strikes were safety issues that needed to be resolved before a launch was cleared),

- Insufficient corrective action (a minimum of four (4) strikes of insulation upon the shuttle were documented, yet no action was taken to resolve the issue),

- Inadequate validation and testing procedures (damage prediction software was utilized to evaluate damage to the tile on the lower wing surface of the space shuttle and damage to the leading edge panels of the wing based on impact of debris. The software used information relating to small ice impacts on the leading edge panels of the wing – not larger impacts such as those created by insulation foam. Even though the software predicted that a small ice impact to the leading

193

edge panels of the wing could completely penetrate the protective panels, this information was not followed up on as it was believed that an impact of the less dense insulation foam would result in less damage), and

- Communication (engineers could not get NASA management to understand the criticality of the situation).

The above informal processes can be directly linked to the developed process taxonomy in three areas: (1) the corrective action and preventive action informal processes are linked within the core processes, measuring and monitoring area; (2) the inadequate validation and testing procedures are also found within the core processes under the design/development area; and (3) lack of communication is within the strategic processes, organizational management area, specifically communication/information. The obvious effect of these informal processes was again, the loss of seven (7) lives and the space shuttle.

Investigative reports on the Columbia disaster cited the primary cause of failure as a breach in the leading edge of the left wing caused by impact from insulation foam. The report also cited organizational and cultural issues within NASA, specifically the decision-making and risk-assessment process. From Mohaghegh (2007) we can see that these issues are clear examples of emergent processes – processes that include leadership/supervision and homogeneity in the organization. From the information reported on the two space disasters, it is evident that there is a disparity between the information the engineers provide to management and action required versus action taken.

Chapter 10: Application of Methodology – Manufacturing Organization

Section 10.1 Introduction

Application of all the methodology presented in this research was completed for a small chemical manufacturer located in Texas. The company is an ISO 9000 registered organization and is classified as low-tech. The initial contact with the organization was on February 21, 2008. During this meeting, the purpose of this research was explained, and a plan was agreed upon for the application of the research to the organization. The basic plan was as follows:

- Completion of the indirect detection questionnaire (results are found in Section 10.2)

- Prepare organizational model (results are seen in Section 10.3)

- Classify the organization's processes in accordance with the process taxonomy (discussed in Section 10.4)

- Prepare for and perform initial process audits (reviewed in Sections 10.5.1 and 10.5.2)

- Perform initial quantitative assessment for the presence of informal processes (shown in Section 10.5.3)

- Perform follow-up audits (Section 10.5.4)

- Perform final quantitative assessment for the presence of informal processes (Section 10.5.5)

Reports were made to the organization at the completion of the initial audits and at the completion of the follow-up audits. Section 10.6 provides a summary and conclusions of the application of this research methodology in respect to the small chemical manufacturer.

The president of the organization completed the questionnaire on February 21, 2008. The responses to the questions were scored after the initial process audits were completed so as not to add any bias to the audit. The results of the questionnaire responses can be found in Table 8, Company #1. A summary of these results is found in Table 28.

Table 28. Summary of Indirect Detection Method Results for Small Chemical Manufacturer

TAXONOMY AREA	CALCULATED PROBABILITY OF INFORMAL PROCESSES
Foundation	0.5
Communication/Information	0.5
Customer Satisfaction	0.0
Procurement	0.3
Maintenance	0.4
Allocation	0.2
Strategic	0.3
Design/Development	0.5
Execution	0.3
Measuring/Monitoring	0.8
Core	0.6
Overall	0.4

From the information seen in Table 28, there are four (4) areas that have over a fifty percent (50%) probability of having informal processes. These areas are; foundation, communication/information, design/development, and measuring/monitoring. We will see in Section 10.5 that these process taxonomies were where the highest amount of informal processes was found.

Section 10.3 Organizational Model

During the meeting on February 21, 2008 with the president of the small chemical manufacturer, the researcher and president generated a process-based organizational model that is shown in Figure 63.

Figure 63. Organization Model for Small Chemical Manufacturer
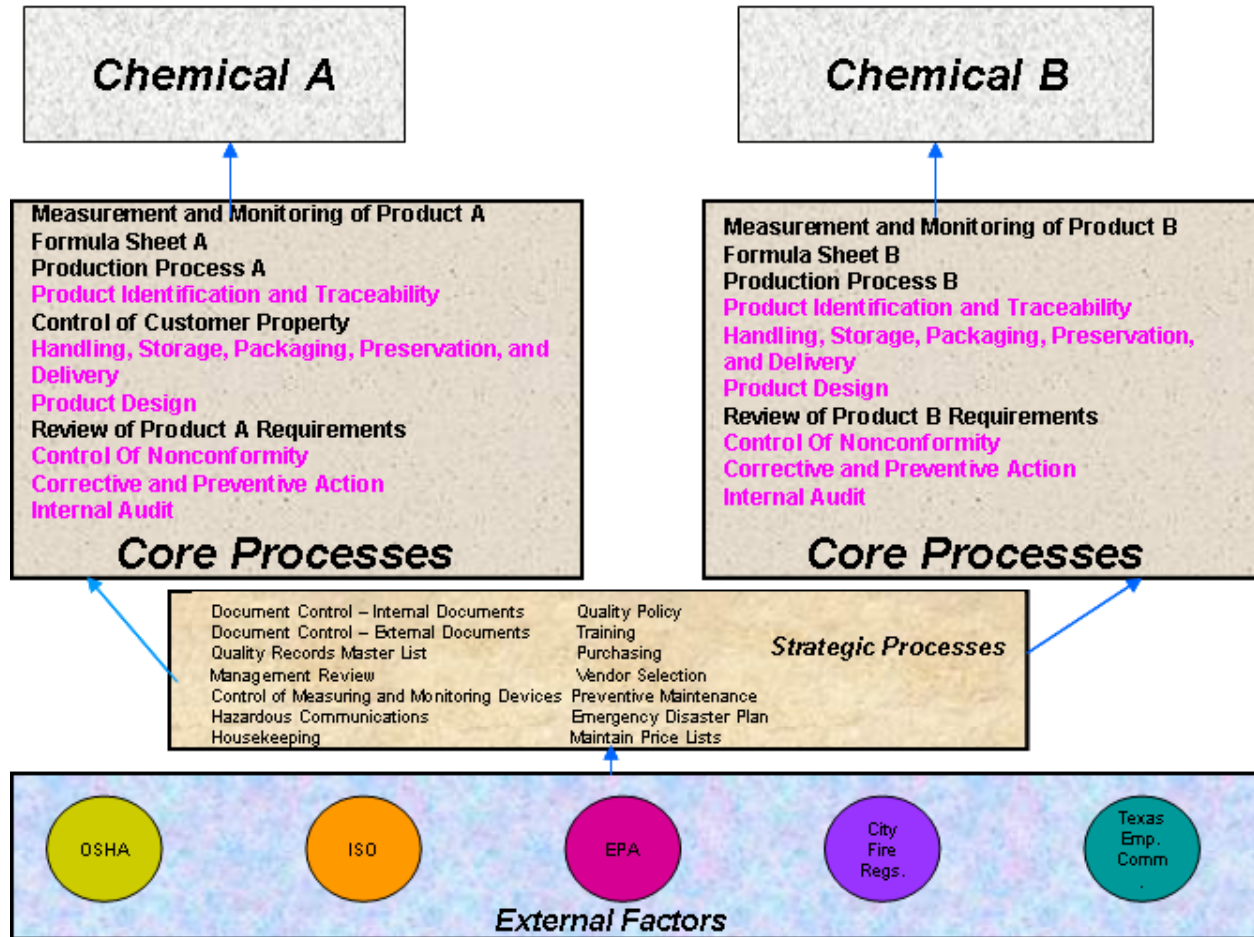
The model shown in Figure 63 has two systems – chemical A and chemical B. Although it does not contain all of the systems (outputs) for the organization, it is representative of the organization.

The external factors (items that contribute logically or causally to a process or system, but that are not within the control of the organization) were identified as the regulations defined

by the Occupational Safety and Health Administration (OSHA), the Environmental Protection Agency (EPA), the Texas Employment Commission, and the local city fire regulations. Additionally, the requirements as set forth by the ISO standards are factors in this organization, as they are ISO registered. The processes within the strategic and core process areas will be reviewed in detail in Section 10.4.

Section 10.4 Process Classification

The processes within the small manufacturer were classified in accordance with the process taxonomy presented in Chapter 4 of this research. The strategic and core processes are identified on Figure 63. We will begin with the strategic processes and link them to the process taxonomy. Fourteen (14) processes were identified within the small chemical manufacturer that fell into the strategic process taxonomy. These processes are shown in the taxonomy areas as follows:

- Foundation
    - o Quality Policy
    - o Emergency Disaster Plan
    - o Hazardous Communications
    - o Management Review
- Communication/Information
    - o Document Control – Internal Documents
    - o Document Control – External Documents
    - o Quality Records Master List
    - o Maintain Price Lists
- Customer Satisfaction – None

198

- Procurement

    o Purchasing

    o Vendor Selection

- Maintenance

    o Training

    o Preventive Maintenance

    o Control of Measuring and Monitoring Devices

- Allocation

    o Housekeeping

Within the core process taxonomy areas there are eleven (11) processes for each system (output). Notice on Figure 63 that seven (7) of these processes (shown in magenta) are identical for both chemical A and chemical B. This is an important fact when auditing, as it allows the auditor to perform the audit once versus multiple times for multiple chemicals. The core processes are linked to the taxonomy as follows:

- Design/Development

    o Review of Product X Requirements

    o Product Design

    o Formula Sheet X

- Execution

    o Production Process X

    o Product Identification and Traceability

    o Control of Customer Property

    o Handling, Storage, Packaging, Preservation, and Delivery

- Measuring/Monitoring

  o Measurement and Monitoring of Product X

  o Control of Nonconformity

  o Corrective and Preventive Action

  o Internal Audit

Upon completion of the process-based organizational model and the identification and linking of processes to the process taxonomy, audit preparation was performed in accordance with the direct methodology presented in Chapter 7. In the following section, the audit preparation and results will be discussed.

Section 10.5 Direct Methodology Results

In this section, the audit preparation and initial audit results will be presented. Following the initial audit, a quantitative assessment was completed. Upon completion of the initial audit, the small chemical manufacturer made changes to the formal practice that included adopting informal processes into the practice that were beneficial to the organization, and modifying the formal practices to preclude the use of detrimental informal processes. It should be noted that the researcher provided recommendations for the organization to improve their processes in exchange for the organization giving the researcher full access to their company, personnel, and records. During a true audit, the auditor should refrain from making recommendations to the organization being audited. Follow-up audits occurred from June 2008 to July 2009 to verify the changes made decreased the probability that the organization's output would be deficient.

Subsection 10.5.1 Process Audit Preparation

Five processes were chosen to be audited for this research. Within the strategic process area, the document control process for internal audits and the purchasing process were chosen. For the core processes, the product design process, production process, and internal audit process were selected. The organization did not put any limitations on the boundaries of these processes, which allowed the researcher to pursue any lines of interest during the audit process.

The initial DROMĒ models were constructed utilizing the documents provided by the organization to the auditor. The DROMĒ model for the internal audit process is shown in Figure 64. For explanatory purposes, for this one model, we will review the process and how it is shown in the DROMĒ model. The input to the internal audit process is the requirement that an ISO registered organization must have an internal audit program. The first DROMĒ corresponds to the planning of the internal audits by the plant supervisor in accordance with the three (3) documents shown in the controls portion of the DROMĒ model. A metric appears on the controls section to signify that a metric is kept for the accuracy of the controls. The output from this DROMĒ is the audit schedule. From the first DROMĒ to the second, we see that the output (audit schedule) of the first is the input to the second. There is a metric associated with the audit schedule regarding if the audits are all completed, and if they are completed on time.

In the second DROMĒ, the performance of the audit occurs. The audits are conducted by trained and certified auditors (hence the metric associated with the human portion of the model), and the output of this DROMĒ is the actual audit data. The audit data is the input for the next DROMĒ, which is the preparation of the audit report. The report is prepared and distributed in accordance with the controls shown on the third DROMĒ by the internal auditor (notice that the metric M3 is the same in both the second and third DROMĒ). The completed audit report is

presented to the audited area's manager for any corrective actions to be made, and the manager

will then sign the report in accordance with the controls shown on the fourth DROMĒ. The last

step in the internal audit process is shown in the fifth DROMĒ, where the audit results are

reviewed by the management team and a decision is made regarding any changes required in the

audit process.

The control portion of the DROMĒ model seen in Figure 64 was determined by the use

of a document tree. The document tree was generated by reviewing the upper level document of

the organization (quality manual), and noting all of the procedures that were referenced

regarding the internal audit process. Each of these procedures was then reviewed to find the

documents that referenced. This process was continued until there were no more references.

The document tree for the internal audit process is shown in Figure 65. The document trees for

all other audited processes were generated as stated above and are provided in Appendix P.

At the completion of the modeling process and the generation of the document tree, all

documents were reviewed to gain insight into how the process was developed to work. There

were no conflicts between the control documents for the internal audit process, document control

process for internal documents, or production process. However, there were three (3) different

processes identified in three (3) different formal documents for the purchasing process. A

review was made of the results of prior internal audits, ISO registration and periodic audits, and

corrective action reports. To date, there were no findings on either internal or ISO audits, which

raised a flag, as no organization is ever perfect. Additionally, the corrective action reports were

sporadic in nature as shown in Table 29.

Figure 64. DROMĒ Model of Internal Audit Process
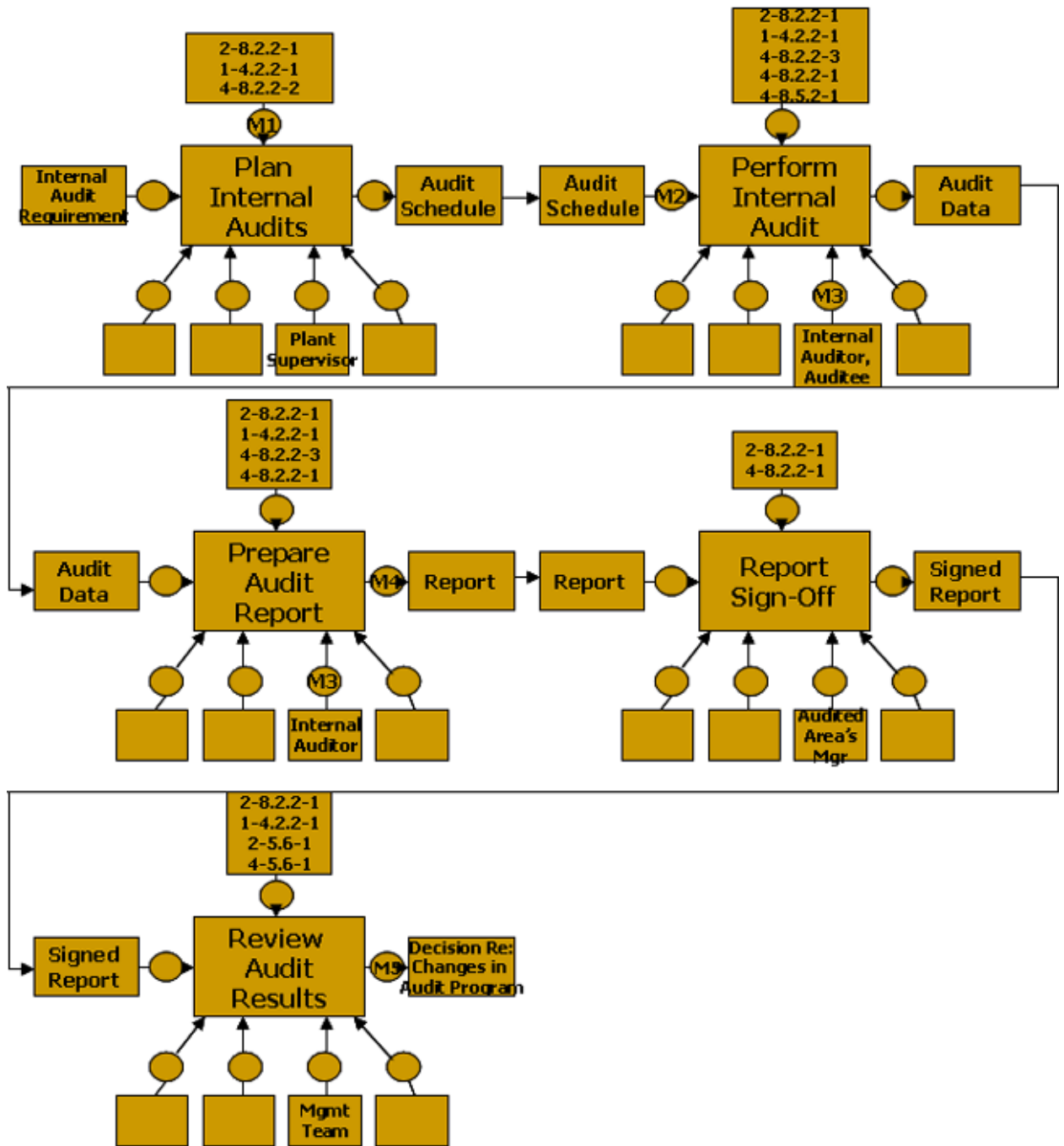
Figure 65. Document Tree for Internal Audit Process
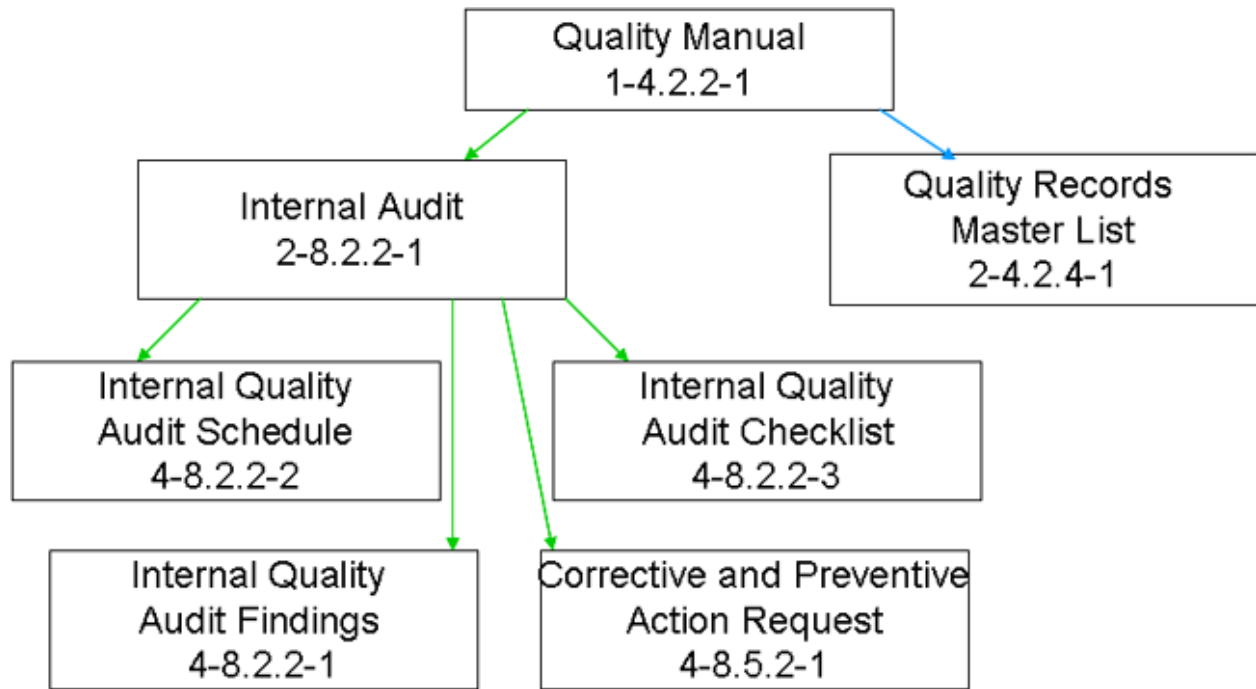
Table 29. Number of Corrective Action Reports by Year

YEAR	NUMBER OF CORRECTIVE ACTION REPORTS
2000	4
2001	15
2002	12
2003	53
2004	1
2005	2
2006	0
2007	2
2008	0

The disparate number of corrective actions written from year to year can be an indication that the

corrective action process, as defined, is neither effective nor efficient in serving its intended

purpose within the organization. With the audit preparation complete, audit dates were agreed

upon by the president of the organization and the researcher.

Subsection 10.5.2 Initial Process Audit Results

Results for the five (5) processes are given in this subsection. We will look at the results

for each process audit individually, then we will combine the information for the initial

quantitative assessment in subsection 10.5.3.

The audit for the internal audit process began with interviews of two (2) of the trained

auditors; the plant supervisor (who was also responsible for determining the audit schedule), and

an office worker that performed the audits on the production processes. The internal audits were

being performed on schedule, utilizing the checklists as required by their formal procedures, and

being conducted by an auditor that was independent of the area being audited. From a

compliance audit standpoint, there would be no findings of noncompliance for the audit of the

internal audit process. However, there were observations made in the process audit of the

internal audit process that demonstrated the internal audit process was not efficient or effective.

The audit schedule had all audits being performed during the months of October,

November, and December. The rationale for this (as explained to the researcher) is that the

manufacturer has a cyclical work load, and these three (3) months are when the work load is

minimal. To have audits conducted during a time when work is minimal can be ineffective, as

pressures are present that may lead to informal processes occurring. In addition, there have been

no audit findings issued from any internal audit to date. A comment was noted in the

Management Review dated 10/29/04 which highlighted an issue with the internal audit process.

The comment stated that the organization had managed to stay on top of the audit schedule, ut

the results never seemed to change. The management team wondered is there was a need for concern, or if they were really that good.

Due to the time frame that the process audit was conducted by the researcher, it was not possible to observe an audit being performed. However, during the interview process, the interviewee's were asked to explain how they audited. The internal auditors indicated that the internal audits are performed sitting at a desk reviewing documents, or sitting at a table conducting an interview. The internal auditors did not go into the area being audited to observe operations or to view any logbooks or information that was kept on the manufacturing floor. Although these types of audits can highlight any discrepancies between the organization's documents, they do not accurately portray what is taking place in the production area. It was recommended by the researcher that the internal audit process be converted to process audits and the auditors trained in that venue.

The next process audited was the document control process for internal documents. The audit began with an interview with the document control manager to ensure that the DROMĒ model was a correct representation of the document control process. Review of the documents on the document tree revealed an inconsistency between a requirement in the quality manual and the document control procedure for internal documents. The requirement in the quality manual (which is required by the ISO 9000 standard) is for periodic review of all documents to take place. Due to the small size of the organization, there are only two (2) hard copies of the formal internal documents that are located within binders (one in the office area and one in the production area). The documents within each binder are controlled by a master index. Per the formal procedure, the revision date on all documents must match that of the master index, the documents must be initialed to indicate approval, and the latest changes to the documents must

be highlighted with a felt marker. In the front of the binders is a table of contents that should match the master index. From a compliance standpoint, in the office binder, the table of contents did not match the master index (four (4) documents were incorrectly identified and three (3) were omitted); there were nine (9) instances of the revision date on the document not matching the master index; two (2) documents were missing from the binder; two (2) did not indicate approval; and four (4) of the documents did not have the latest revision highlighted. The production binder had the same types of issues – but with different documents than the office binder.

During the observation portion of the audit, uncontrolled copies of documents were found in the production area. One of the documents was still current, but the other was out of revision. It is a violation of both the organization's quality manual and the ISO standard 9000 to have uncontrolled documents posted.

The document control process for internal documents was not in compliance, and was ineffective at providing the correct documents with the correct approval and/or revision indication. The amount of work required to make the copies, have them initialed, and revisions marked with a felt tip marked is inefficient, as the organization has a more than adequate computer network with appropriate word processing capabilities. The researcher recommended that the organization go to a paperless document control process as this would eliminate the mistakes on the filing of the documents, the initials required, and the highlighting by hand. All work areas within the office and the production floor have access to a computer where documents could be viewed as needed.

The product design process was the next process to be audited and the audit preparation found no conflicting requirements between the controls for this process. An interview was

conducted with the president of the organization regarding the product design portion of the audit (the president is responsible for the product design). During the interview the president admitted that the procedures were not followed, and had not been followed for over five (5) years, due to the fact that they were cumbersome and required too much time. Observations of the product design portion of the process were not completed as this was not occurring during the audit time. Review of the records related to product design verified the president's comment. The formal process, per the organization's written procedure, is that any change to a product, or any new product must have a completed product design checklist. The checklist design was not appropriate for an organization of this size, or the type of chemicals that were involved. The researcher agreed to work with the organization to develop a checklist that would meet all of the requirements, but that would be user-friendly.

Interviews for the production process audit were conducted with two (2) employees that worked in the production area. The employees were well trained in their job functions. Observations of the production process revealed that the completed date was not entered on over 40% items in the daily production log; 25% of the inspection log results were missing; and the equipment requiring calibration was not identified in accordance with both the organization's formal procedures and the ISO 9000 standard. The flow of product within the factory is not conducive to the required record keeping processes. The researcher will work with the organization to resolve this issue.

The purchasing process was the final process audited by the researcher. During the development of the DROMĒ model utilizing the formal documents of the organization, three (3) different process flows were described. During the interview process of the president and the purchasing manager, it was discovered that none of the three (3) methods in the documents were

the actual method utilized. The researcher, in conjunction with the president and purchasing manager developed the DROMĒ model of the process that was theoretically occurring. The observation portion of the audit revealed that none of the three (3) documented procedures were being followed, nor was the process flow shown on the DROMĒ model generated by the researcher, president, and purchasing manager followed. Although a vendor selection process exists and is documented prior to placing a vendor on the approved vendor list, it is not used. In reality, when the organization has a need for a product, the plant supervisor places an order with whatever vendor can meet the time and price requirements of the organization, and then the product is used by the organization. If there are no issues with the incoming product during production, the vendor is place on the approved vendor list. Of the sixty-nine (69) vendors on the approved vendor list, less than 25% have an approved vendor selection form completed. Formal procedures of the organization require that vendor performance be reviewed during management review. Two (2) issues were found in regard to this requirement. The first is that there is not an accurate record of the vendors being utilized, and secondly, there is not an item on the management review agenda and completion form that requires review of vendor performance. The documented procedures (formal procedures) for this organization in the purchasing processes are not being followed, nor do they provide the organization with an effective means of approving vendors. Additionally, the procedures for the purchasing process for this organization are inefficient. The process that is actually occurring is efficient and should be brought into the formal system.

Subsection 10.5.3 Initial Quantitative Assessment

Following the process audits performed above, an initial quantitative assessment on the

probability of the output of the organization being deficient was performed utilizing the

information discussed in subsection 8.2.1. The probability that the output will be deficient is:

$$P(\overline{O}) = P\langle \overline{O} | \overline{F}, I \rangle P(\overline{F})P(I) + P\langle \overline{O} | F, \overline{I} \rangle P(F)P(\overline{I}) + P\langle \overline{O} | \overline{F}, \overline{I} \rangle P(\overline{F})P(\overline{I}).$$

An alternate approach would be to utilize Figure 31 and see that the output is a function of the

mix of formal and informal processes. Quantification of the terms related to the output being

deficient given the presence of formal and informal processes, or the lack of formal and informal

processes is difficult. However, we have developed a BBN for the overall output of an

organization that is based on the presence of formal and informal processes. Using the expanded

organizational processes BBN shown in Figure 61, we will determine the effect of informal

processes on the output of the organization. To determine if there was a distinct difference

between the Group 1 (Figure 60) expanded organizational processes BBN and the Group 2

(Figure 61) expanded organizational processes BBN, the Group 1 BBN was also propagated with

the probabilities.

The BBNs were propagated with probabilities from a representative of the small chemical

manufacturer (see Figures 66 and 67). The results of the process audits performed for the small

chemical manufacturer were then substituted into the appropriate nodes within the model.

- For the internal audit process (measuring/monitoring node), there were no

  informal processes present.

- For the document control process (communication/information) based on the

  audit findings, thirty-five percent (35%) of the document control processes were

  informal.

210

- For the purchasing process (procurement), sixty-six percent (66%) of the processes were informal based on the audit findings.

- In product design (design/development), there were no formal processes utilized.

- For the production process (execution), based on the audit findings, thirty-eight percent (38%) of the processes were informal.

When these results were placed into the conditional probability tables, the output was calculated to be sixty percent (60%) formal, and forty percent (40%) informal for both the Group 1 and Group 2 BBNs. At this time, the organization was running at an 87% yield (13% deficient outputs). It should be noted that the indirect survey results showed a normalized score of 0.40 for informal processes within this organization.

Figure 66. BBN (Group 2) for Small Chemical Manufacturer Prior to Changes Made to System
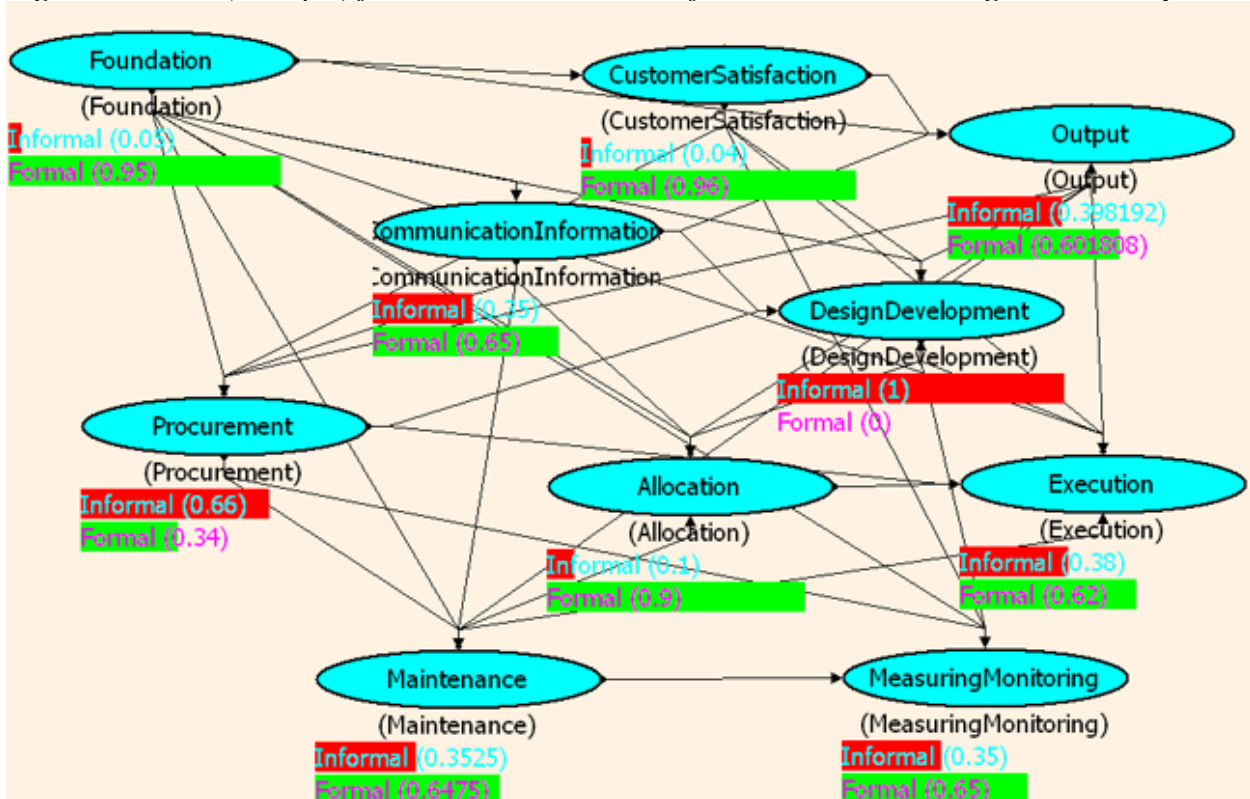
Subsection 10.5.4 Follow-Up Audit Results

Prior to performing the follow-up audits, the small chemical manufacturer brought the beneficial informal processes within the purchasing area into the formal system. Modifications were made in the factory flow that eliminated the informal processes associated with the record keeping aspect of the process. The document control process was changed to a electronic system, thus eliminating the issues with incorrect revision dates, lack of approval, and revisions not be highlighted. The product design checklist was revised to allow changes to product on an attachment to the original product, thereby eliminating redundant information. The audit program at the company has been completely revamped and they are now utilizing a process-based audit system.

The above changes to the formal system of the small chemical manufacturer were made over a year's time. Follow-up audits on the processes were performed at approximately a six-

month period from the time the changes were implemented. During the follow-up audits, only

one (1) informal process was observed in the document control of internal documents process.

The electronic system allowed employees to print a copy of a document, but it was not marked

for reference only. An out-of-date document was found on the production floor. The low

number of informal processes observed during the follow-up audit can be attributed to the fact

that the modified processes are new and the employees have been recently trained in the changes,

and the other fact is that the internal audit process is now operating very efficiently and

effectively. The process–based audits are performed year-round and have resulted in finding

informal processes that are resolved through the corrective action process.

Subsection 10.5.5 Final Quantitative Assessment

After action was taken regarding the informal processes identified in the initial audit,

follow-up audits were performed whose results were used in the final quantitative assessment.

For the internal audit process, there were no informal processes present. For the document

control process based on the audit findings, five percent (5%) of the processes were informal.

In the purchasing processes, production processes, and product design processes, there were no

informal processes present.

The results of the audit were then propagated into both the Group 1 and Group 2

conditional probability tables for the expanded organization processes (Figures 68 and 69), and

the output is now showing eighty-four percent (84%) formal and sixteen percent (165) informal

utilizing the Group 1 BBN, and eighty-seven percent (87%) formal and thirteen percent (13%)

informal utilizing the Group 2 BBN. At the conclusion of the modifications to the formal

system, the yield of the manufacturer had increased to 98%. This appears to lead us to choose

the Group 2 BBN, but again, there is only a small difference between the results from the Group

1 and Group 2 BBNs. Regardless of the BBN model chosen, we see that an increase in the

formal processes is reflected in an increase in the yield of the organization.

Figure 68. BBN (Group 1) for Small Chemical Manufacturer After Changes Made to System
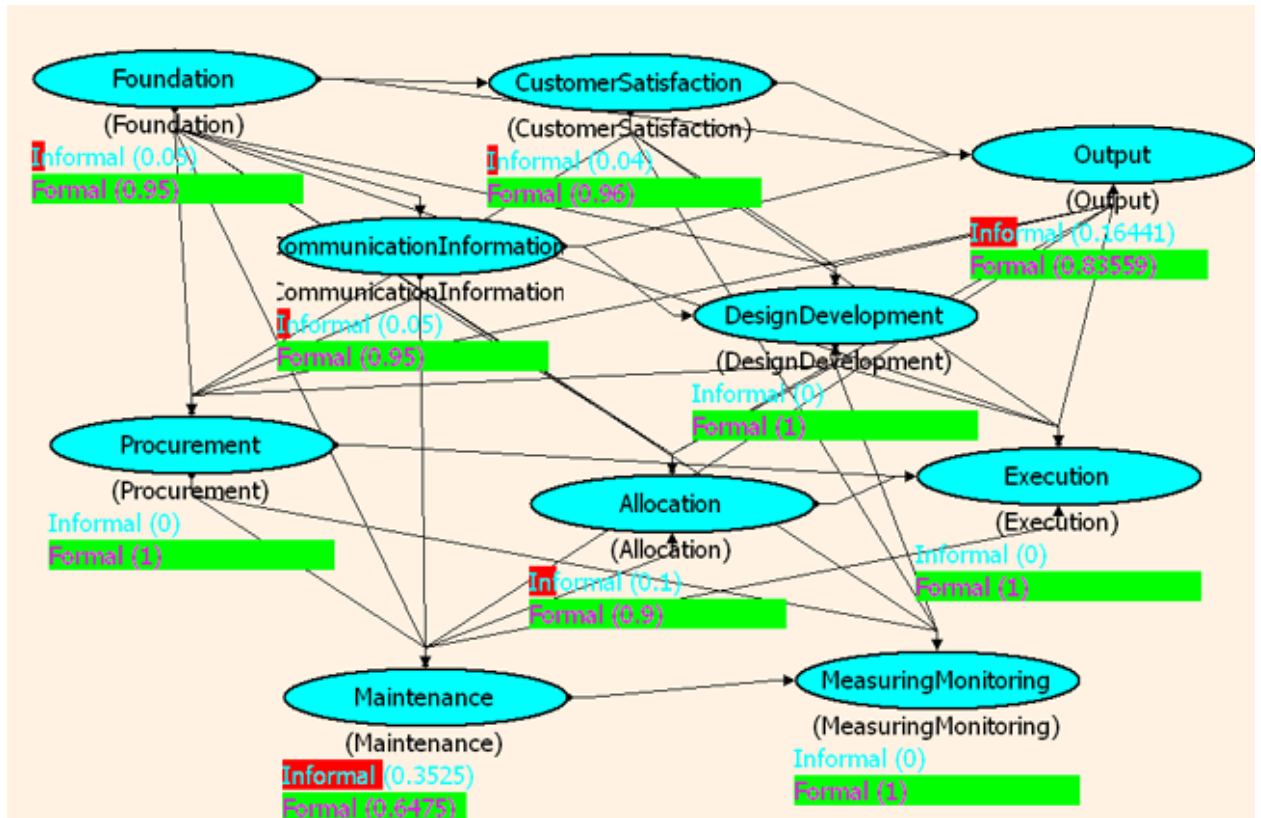
Figure 69. BBN (Group 2) for Small Chemical Manufacturer After Changes Made to System
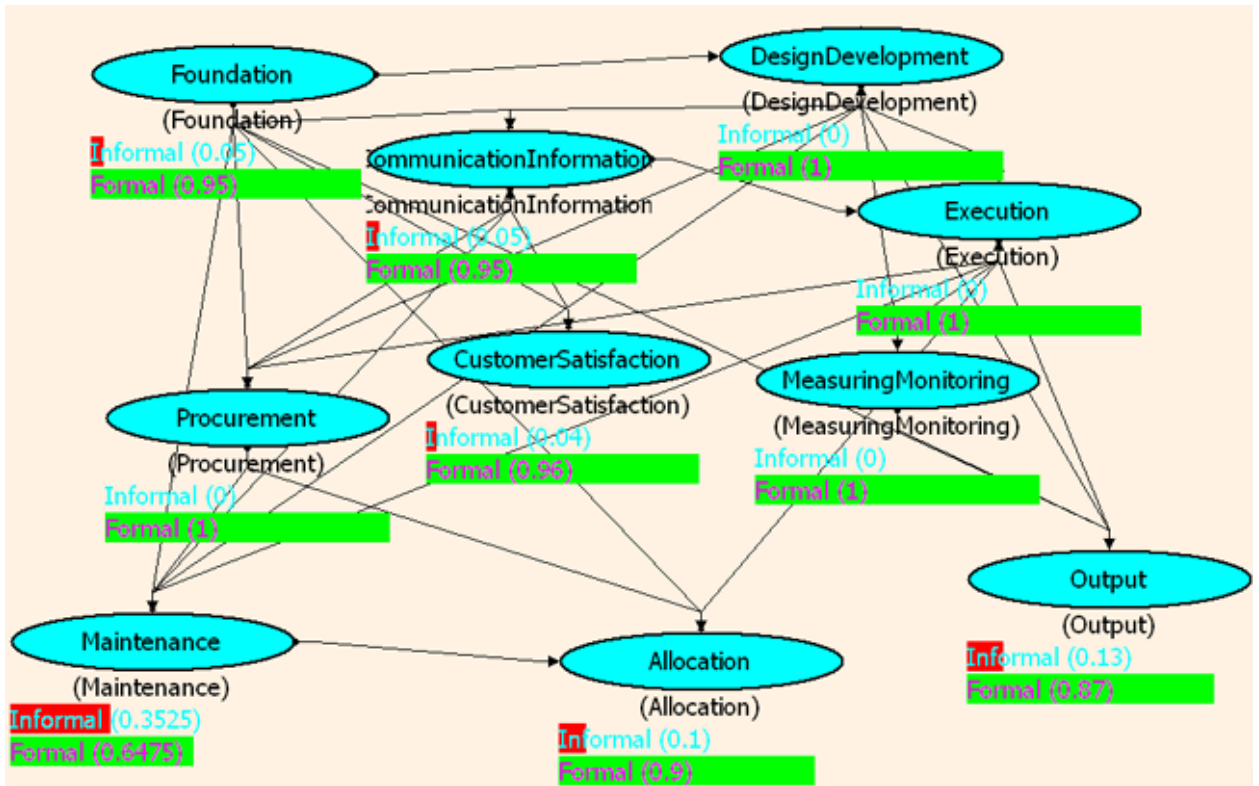
Section 10.6 Conclusions

This chapter has presented information showing that the application of the methodology developed by this research is viable and can assist in increasing the probability of an organization's output being successful. The modeling and detection methods were used in a small manufacturing organization to identify the informal processes. Actions were taken to incorporate the beneficial informal processes into the formal system, while the formal system was modified in other areas to preclude the use of informal processes. After the actions were taken, a follow-up audit was performed and the results of this audit showed that the methodology contributed to increasing the probability that the output of the chemical manufacturer was successful. The change associated with the percentage of informal processes at the completion

of the initial audit and at the completion of the follow-up audit showed an increase utilizing both the Group 1 BBN (from sixty percent (60%) formal processes to eighty-four percent (84%) formal processes) and the Group 2 BBN (from sixty percent (60%) formal processes to eighty-seven percent (87%) formal processes). At the same time, there was an associated increase in the yield of the organization (from eighty-seven percent (87%) to ninety-eight percent (98%)). The increase in the formal processes is aligned with the increase in the yield of the organization.

The methodology was also applied to a small service company that had no formal documentation procedures. After the initial audit the results were propagated into the probability tables for both the Group 1 and Group 2 expanded organizational processes BBNs (Figures 70 and 71). The Group 1 BBN calculated the output to be fifty-two percent (52%) formal, while the Group 2 BBN calculated the output to be fifty-eight percent (58%) formal. At that time, the organization had an overall success rate of seventy-five percent (75%). Changes were made to the formal system in the form of communication and documentation of key processes. Following the implementation of the changes, another process audit was performed, the conditional probabilities of the BBNs updated with the audit results (Figures 72 and 73), and the calculated output for the Group 1 model had risen to sixty-one percent (61%), while the Group 2 model calculated output was seventy-six percent (76%). Following the changes to the formal system in the areas of communication and documentation of key processes, the organization's overall success rate rose to eight-five percent (85%). Again, regardless of the BBN model chosen, we see that an increase in the formal processes is reflected in an increase in the overall success rate of the organization.

Figure 70. BBN (Group 1) for Small Service Company Before Changes Made to System
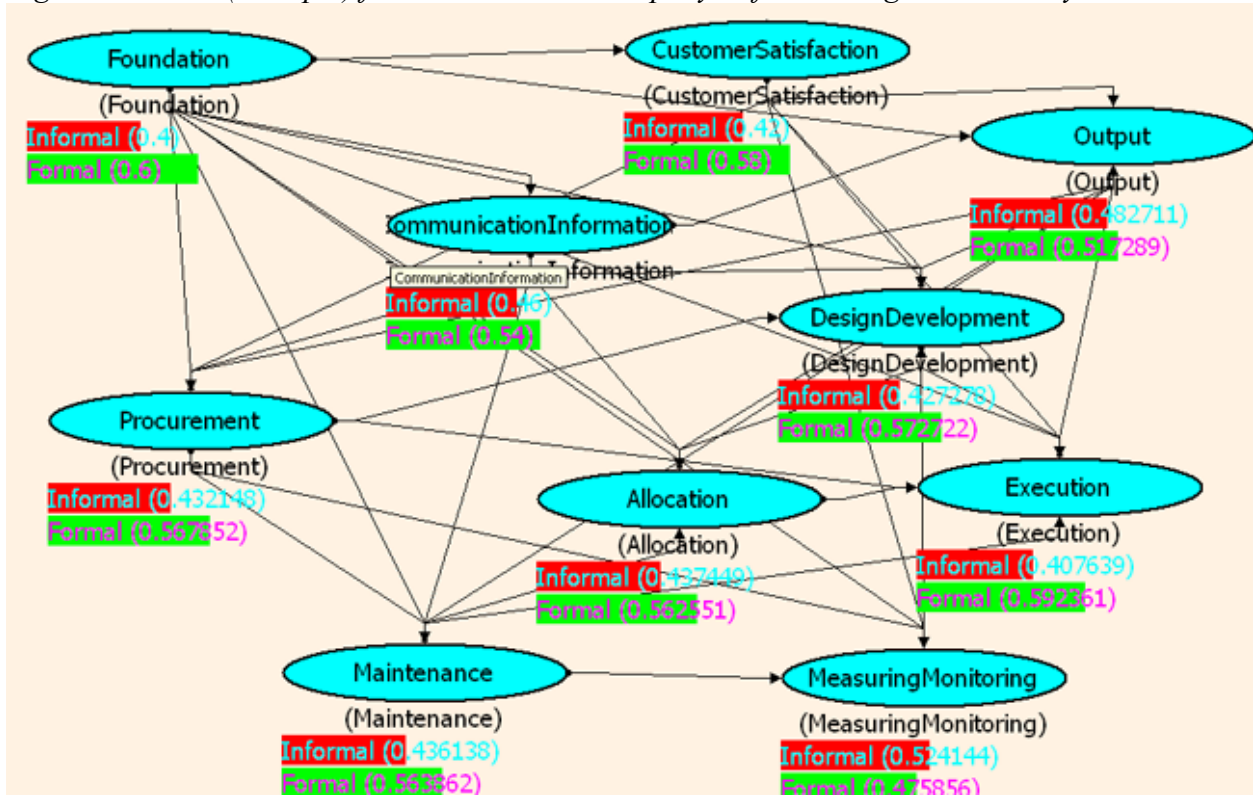
Figure 71. BBN (Group 2) for Small Service Company Before Changes Made to System
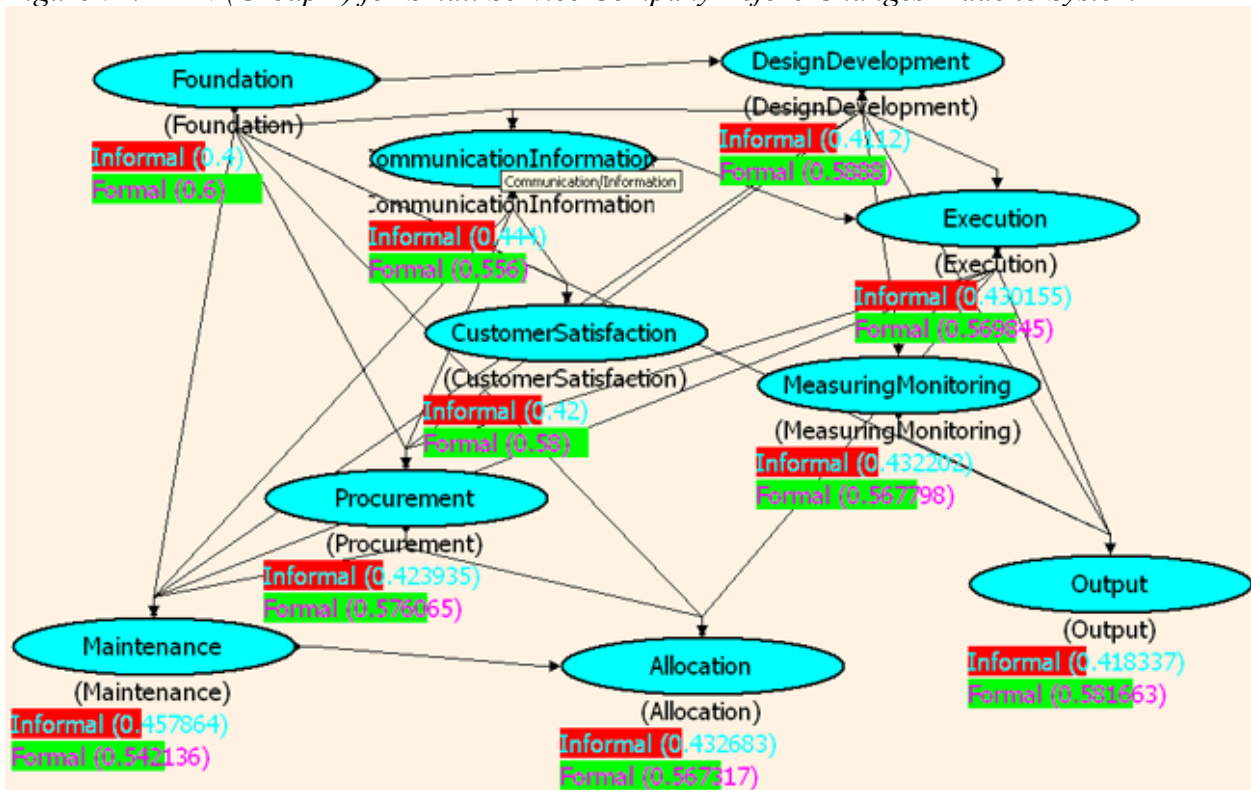
Figure 72. BBN (Group 1) for Small Service Company After Changes Made to System
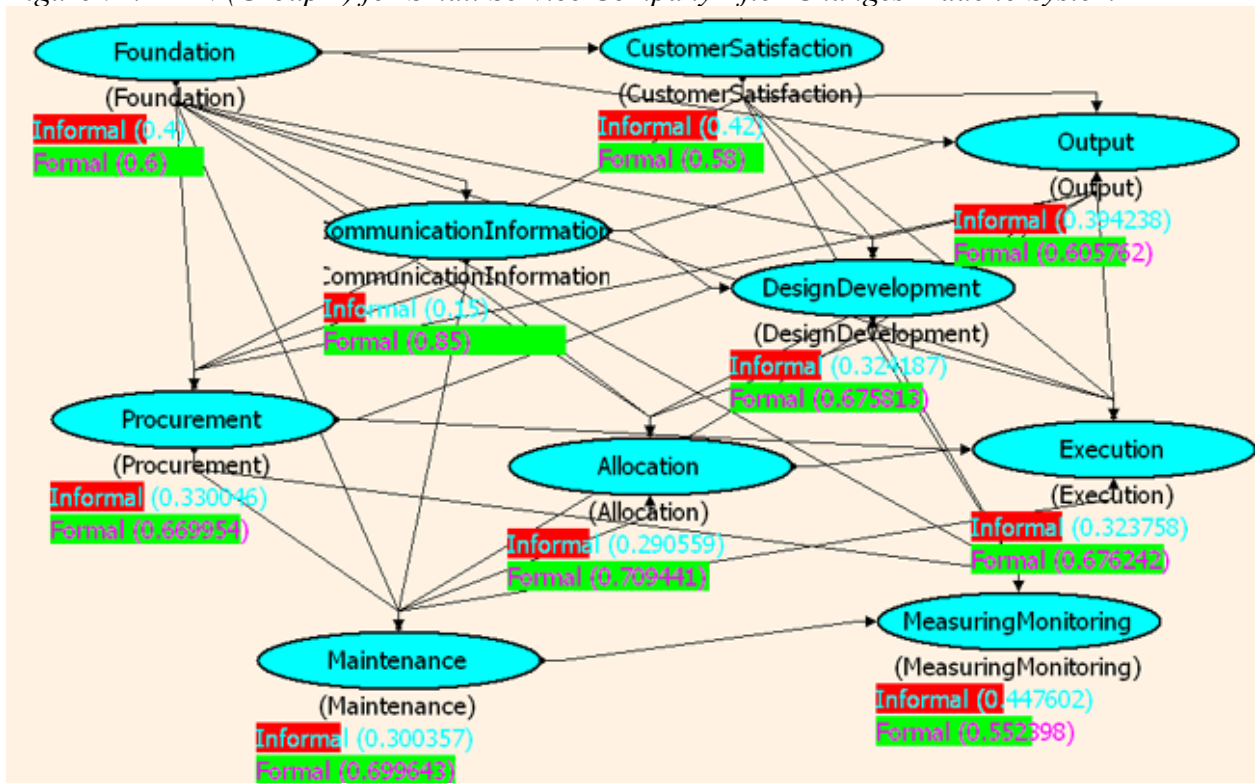
Figure 73. BBN (Group 2) for Small Service Company After Changes Made to System
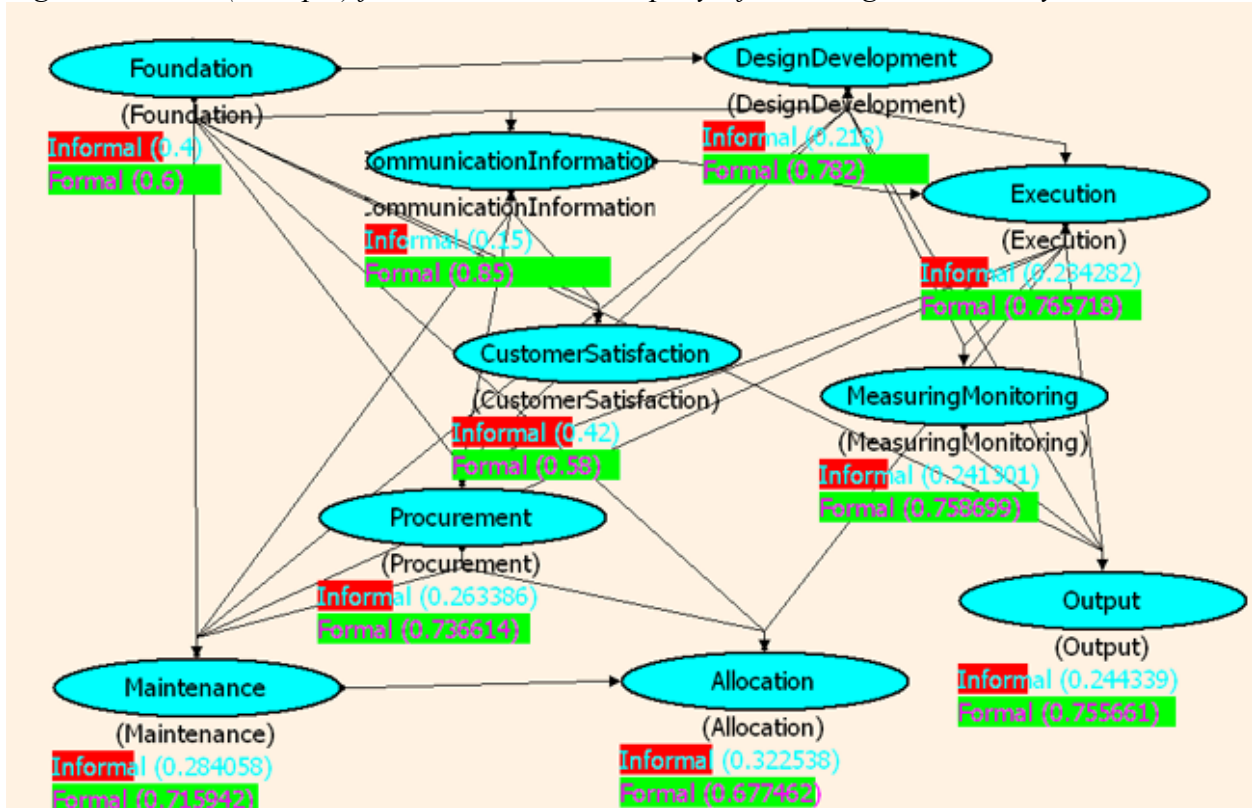
Chapter 11: Concluding Remarks

Section 11.1 Summary and Conclusions

We began this journey along a path laid on the foundation of a process and our destination as the identification and assessment of the impact of informal processes. To aid in our journey, we defined the most basic element of the research, a process. One objective of this research was to develop a process model that incorporates all of the beneficial elements of the current process models while addressing those elements that are disadvantageous within the current models. For this objective, the DROMĒ process model was presented in Chapter 3.

The next stepping stone along our journey was the development of a process taxonomy that is generic to all organizations, small or large, high-tech or low-tech, manufacturing or service, highly regulated or those with little to no regulation. The taxonomy can be utilized to categorize all processes within any organization. Additionally, a process taxonomy will was developed for informal processes that can occur within any process of an organization.

Continuing along our path, an organizational model that is based on a process perspective rather than the traditional organizational models that are based on departments, areas of operations, or along organizational hierarchy was presented.

The ultimate goal of this research was the detection and assessment of the informal processes within an organization. To accomplish this goal, it was required that we understand the causes of informal processes for each of the process taxonomies to have a complete background prior to beginning the effort of detecting the informal processes within the organization. The causes of informal processes were addressed and mapped to one another to aid in the identification of the informal processes within an organization.

Utilizing the information that was gathered along our journey thus far provided the background and knowledge to proceed in the development of a methodology for the detection and identification of informal processes. Two (2) detection methodologies are presented. The first being an indirect methodology that consists of a questionnaire and allows an organization to determine the probability that informal processes exist within the various process taxonomies. The advantage of this indirect methodology is that it is quick, inexpensive, and can direct an organization to the significant areas that should be examined further utilizing the direct detection methodology. The second detection methodology is a direct detection methodology. The direct detection methodology is a process audit of an area of interest, or may be expanded to encompass the entire organization. Guidelines for the performance of a process audit were developed and appear in Appendix E.

The final aspect of this research was the development of a methodology for the assessment of the impact of informal processes on an organization. The assessment methodology was developed using Bayes' Theorem. It is shown in Chapter 10 that the application of the entire methodology to an organization results in an increase of formal processes (decrease in informal processes) and as associated decrease in deificnet output of the organization. This was accomplished by incorporating into the formal system informal process that contributes positively to the formal process. For informal processes that were detrimental to the organization, the formal system was modified to preclude the use of the informal process.

Application of the entire methodology developed within this research was applied to two (2) organizations. The first was a small chemical manufacturer with fully documented procedures and the second was a small service organization that had no documented procedures. In each of these cases, the organizations and processes were modeled with the processes linked

222

directly to the process taxonomy. Process audits were performed on each, and the informal processes were detected and identified. An initial quantitative assessment was performed to determine the effect of the informal processes on the output of the organization. Modifications were made to the formal systems so that beneficial informal processes were included in the formal system, and the formal system was revised to preclude the use of detrimental informal systems. After approximately six (6) months, a follow-up audit was performed and the second quantitative assessment was made. In both cases, the probability of the output being deficient decreased.

Section 11.2 Contributions

Contributions that were made through this research will assist any organization in their effort to identify and quantify informal processes. The identification and quantification of informal processes is crucial to any organization when they are attempting to correct potential issues with a process, or when they desire continuous improvement of their processes. The six (6) objectives of this research provide six (6) separate tools that can be used individually or as a whole.

The DROMĒ process model is a comprehensive model that can be used to model any process within an organization. It was developed to include all aspects and elements of a process so that a total picture of the process is seen.

The direct methodology is a process-based audit. To date there are no guidelines available to the public to assist in the performance of a process audit. Guidelines were developed during this research and are written so that any auditor can apply the techniques within any organization.

Within today's economy, it is important for organizations to be efficient and effective. Application of the methodology provided in this research can assist an organization in their journey toward improving efficiency and effectiveness by identifying and assessing the impact of the informal processes within their organization.

Section 11.3 Future Work

The multiple accomplishments of this research provide a basis for planning for future work. Suggestions are as follows:

- Within the process taxonomy, the core processes are at a high level in order to provide a generic taxonomy. Future work could further refine this for various industries or applications.

- Causes of informal processes and how they affect one another were presented in this research based on brainstorming sessions with SME from multiple industries. It would be interesting to see if the mapping of the causes of informal processes varies from industry to industry. Are the mappings the same for a small low-tech industry and a large high-tech industry? Further refinement of this portion of the research would greatly aid in the detection of informal processes at their root level.

- The indirect detection methodology (questionnaire) was developed as an initial step in the detection of informal processes as a guide to where the organization is the most vulnerable. The scoring system used is extremely basic. It would be interesting if future work could refine the scoring system to provide a more accurate means of establishing the areas within an organization's processes that are more at risk for having informal processes.

- In regards to the Group 1 and Group 2 BBN models, further work would be beneficial in ascertaining the appropriate model to use. The small data set utilized in this research should be expanded to allow the "most appropriate" model to be selected.

- As the developed methodology is generic, future work could be performed to refine the methods and models particular to a given industry (air carrier, nuclear, health care, etc).

The purpose of this work was to assist organizations in their quest for continuous improvement of their processes by providing a basic methodology for the detection and assessment of impact of informal processes. Following this concept, any future work using this research as a starting point for another journey should be based on the idea of continuous improvement.

Appendix A.1: Relationship Between Causes of Informal Processes and Core Processes

CAUSES OF INFORMAL PROCESSES	DESIGN/DEVELOPMENT	EXECUTION	MEASURING/MONITORING
Facilities Related			
Back Up	X	X	X
Capacity			X
Loss of Power		X	X
Software Upgrades	X	X	X
Environment Related			
Catastrophic Event		X	X
Contamination		X	X
Environmental Conditions		X	
Materials			
No Material		X	
Quality of Material		X	
Wrong Material		X	
Economics/Management			
Costs	X	X	X
Delays		X	X
Demand	X	X	X
Measurables		X	X
Lack of Management Commitment		X	
Lack of Quality System	X	X	X
Planning	X	X	X
Quality of Requirements		X	X
Resource Constraints		X	
Schedules		X	
Suppliers			
Humans			
Drugs		X	
Illness		X	
Mistakes	X	X	X
Ethics	X	X	X
Lack of Productivity		X	
Lack of Responsibility		X	X
Sleep Deprivation			
Equipment			
Faulty Equipment		X	X
Lack of Equipment		X	X
Training			
Lack of Training	X	X	X
Quality of Training	X	X	X
Communication/Information			
Direct Order		X	X
Improper Procedures	X	X	X
Lack of Communication	X	X	X
Regulation	X		
Understanding Communication	X	X	X

Appendix A.2: Relationship between Causes of Informal Processes and the DROMĒ Process Model

CAUSES OF INFORMAL PROCESSES	INPUT	CONTROLS	EQUIPMENT/TOOLS	ENVIRONMENT	HUMANS	MATERIALS
Facilities Related						
Back Up			X	X		X
Capacity	X		X			X
Loss of Power			X	X	X	
Software Upgrades	X	X	X	X		
Environment Related						
Catastrophic Event			X	X	X	X
Contamination				X	X	
Environmental Conditions			X	X	X	X
Materials						
No Material						X
Quality of Material						X
Wrong Material						X
Economics/Management						
Costs	X	X	X	X	X	X
Delays			X		X	X
Demand	X		X		X	X
Measurables		X				
Lack of Management Commitment		X	X		X	X
Lack of Quality System		X	X		X	X
Planning	X		X		X	X
Quality of Requirements	X	X	X		X	X
Resource Constraints			X		X	X
Schedules			X		X	X
Suppliers			X			X
Humans						
Drugs					X	
Illness					X	
Mistakes					X	
Ethics					X	
Lack of Productivity					X	
Lack of Responsibility					X	
Sleep Deprivation					X	
Equipment						
Faulty Equipment			X		X	
Lack of Equipment			X		X	
Training						
Lack of Training		X			X	
Quality of Training		X	X	X	X	X
Communication/Information						
Direct Order	X	X			X	
Improper Procedures		X			X	
Lack of Communication		X			X	
Regulation	X	X				
Understanding Communication		X			X	

Appendix B: Indirect Detection Methodology Questionnaire

1. How long has the entity been in business?
   a. 0 – 1 year
   b. 2 – 5 years
   c. 6 – 10 years
   d. > 10 years
   Scoring: a or d = 1, b or c = 0

2. Is the entity regulated?
   a. Yes
   b. No
   Scoring: a = 0, b = 1

3. Is the entity registered?
   a. Yes
   b. No
   Scoring: a = 0, b = 1

4. Does the entity outsource any of its strategic processes?
   a. Yes
   b. No
   Scoring: a = 1, b = 0

5. Is the entity classified as traditional or lean/agile?
   a. Traditional
   b. Lean/Agile
   Scoring: a = 0, b = 1

6. Is teamwork an integral part of the entity's structure?
   a. Yes
   b. No
   Scoring: a = 1, b = 0

7. Is there a formal documentation system in place?
   a. Yes
   b. No
   Scoring: a = 0, b = 1

8. If question #7 was answered "yes", are the documents reviewed on a periodic basis?
   a. Yes
   b. No
   Scoring: a = 0, b = 1

9. Does the entity experience high turnover within the workforce?

a. Yes
b. No
Scoring: a = 1, b = 0

10. Is there a system for responding to and tracking customer complaints?
    a. Yes
    b. No
    Scoring: a = 0, b = 1

11. Has the entity gone through a recent merger/acquisition?
    a. Yes
    b. No
    Scoring: a = 1, b = 0

12. Does the entity utilize approved vendors?
    a. Yes
    b. No
    Scoring: a = 0, b = 1

13. Is there a methodology for approving vendors?
    a. Yes
    b. No
    Scoring: a = 0, b = 1

14. How many employees work at the main location?
    a. < 20
    b. 21 – 50
    c. 51 – 200
    d. > 200
    Scoring: a or d = 1, b or c = 0

15. Has the physical location for the entity changed?
    a. No
    b. Yes (0 – 6 months)
    c. Yes (7 months – 1 year)
    d. Yes (> 1 year)
    Scoring: a = 0, b, c, or d = 1

16. Does the entity contain equipment/tools that must be calibrated?
    a. Yes
    b. No
    Scoring: a = 1, b = 0

17. If question # 16 was answered "yes", is regular calibration performed as required?
    a. Yes
    b. No
    Scoring: a = 0, b = 1

18. What is the average experience of the workforce?
    a. 0 – 1 year
    b. 2 – 5 years
    c. 6 – 10 years
    d. > 10 years
    Scoring: a or d = 1, b or c = 0

19. Is there a formal training system in place?
    a. Yes
    b. No
    Scoring: a = 0, b = 1

20. Is the skill level of the employee aligned with their job function?
    a. Yes
    b. No
    Scoring: a = 0, b = 1

21. Are required materials and equipment available to complete all processes when needed?
    a. Yes
    b. No
    Scoring: a = 0, b = 1

22. Have there been recent layoffs?
    a. Yes
    b. No
    Scoring: a = 1, b = 0

23. Are layoffs planned?
    a. Yes
    b. No
    Scoring: a = 1, b = 0

24. Are the entity's facilities in compliance with all local, state, and federal regulations?
    a. Yes
    b. No
    Scoring: a = 0, b = 1

25. Does the entity's location have backup contingencies in the event of a failure?
    a. Yes
    b. No
    Scoring: a = 0, b = 1

26. How long has the product/service been offered?
    a. 0 – 3 months
    b. 4 – 6 months
    c. 7 months – 2 years
    d. > 2 years
    Scoring: a or d = 1, b or c = 0

27. Has the entity incorporated a new technology in the core processes within the past 6 months?
    a. Yes
    b. No
    Scoring: a = 1, b = 0

28. Does the entity outsource any of the core processes?
    a. Yes
    b. No
    Scoring: a = 1, b = 0

29. Is the entity's product/service high-tech or low-tech?
    a. High-tech
    b. Low-tech
    Scoring: a = 0, b = 1

30. If a formal documentation system exists, is the level of documentation in line with the skill/training/experience of the workforce?
    a. Yes
    b. No
    Scoring: a = 0, b = 1

31. Does the entity measure efficiency?
    a. Yes
    b. No
    Scoring: a = 0, b = 1

32. Does the entity measure effectiveness?
    a. Yes
    b. No
    Scoring: a = 0, b = 1

33. Is there a formal internal audit program in place?
    a. Yes
    b. No
    Scoring: a = 0, b = 1

34. If question # 33 was answered "yes", is the audit program compliance based or process based?
    a. Compliance based
    b. Process based
    Scoring: a = 1, b = 0

35. When corrective actions are taken, are they followed up on to ensure they were adequate?
    a. Yes
    b. No
    Scoring: a = 0, b = 1

36. Does the entity have a continuous improvement program?
    a. Yes
    b. No
    Scoring: a = 0, b = 1

Appendix C.: Guidelines for Completing the Informal Process Detection Questionnaire

Question 1: Indicate the length of time the entity has been in business.

Question 2: Regulation refers to entity's that are under the auspices of FDA, EPA, OSHA, FCC, etc.

Question 3: Registrations refer to third-party registrations such as ISO 9000, ISO 14000, ISO-16949, etc.

Question 4: Strategic processes are those processes which include organizational management processes (planning, policy establishment, determination of objectives, communication, ensuring availability of resources), and resource management processes (processes for the provision of resources for the management of the organization, realization, monitoring, measuring and control).

Question 5: Traditional refers to a process that is step-wise, where the completion of the product/service moves forward one phase at a time, with assurance that the prior phase is acceptable before the next phase begins. The traditional entity has the ability to schedule personnel, equipment, and materials over time. Lean/agile refers to a process that solely focuses on the output. It does not consider what an individual will be working on the next week; individual assignments are subsumed by team efforts. A lean/agile organization allows individuals to decide what matters rather than accepting pre-existing ideas. (Howleg, 2007)

Question 6: Teamwork refers to coordinated, joint action by individuals from various departments/functional areas working together to achieve a common goal

Question 7: A formal documentation system is one in which documents are generated, approved, distributed, and revised, in accordance with an accepted standard.

Question 8: Periodic basis refers to a specified amount of time a defined by the entity.

Question 9: High turnover should be determined based on either industry averages, or entity experience.

Question 10: Indicate if the entity has a customer complaint/resolution/tracking process.

Question 11: Recent is defined as within the past year.

Question 12: Approved vendors include all suppliers for equipment, materials, and human resources. This does not include vendors for general office supplies/utilities.

Question 13: Methodology refers to an accepted process for approving vendors.

Question 14: Indicate the number of employees at the main facility location.
Question 15: Indicate the status of the physical location of the entity.

Question 16: Indicate if calibrated equipment is utilized within the entity.

Question 17: Indicate if the calibrations required are performed in the specified time frame specified and per approved procedures (entity or manufacturer's).

Question 18: Indicate the average experience of the workforce as it pertains to their current job functions.

Question 19: Formal training system refers to a training program that is accepted throughout the entity, and that includes follow-up to the training to ensure the adequacy of the training.

Question 20: Indicate whether or not the individual functions within the workplace are staffed by qualified individuals per entity standards, or by external regulations.

Question 21: Indicate the availability of materials and equipment when required.

Question 22: Indicate if layoffs have occurred within the past six (6) months.

Question 23: Indicate if layoffs are planned within the next six (6) months.

Question 24: Indicate the compliance status of the facility.

Question 25: Does the entity have backup contingencies (power, data, etc.) in case of a failure?

Question 26: Indicate the length of time the primary product/service of the entity has been offered.

Question 27: Respond "yes" if a new technology has been introduced into the entity's design, execution, and/or measuring processes in the past six (6) months?

Question 28: Indicate if any of the design, execution, or measuring processes of the entity are outsourced.

Question 29: High-tech refers to an entity whose product or service is on the forefront of technological innovation and employs qualified, professional, scientific, and skilled staff. Low-tech refers to an entity that is uncomplicated and does not involve advanced technology.
Question 30: Respond to this question if the answer to question #7 was "yes". The level of documentation refers to documentation that is understood by all individuals in the workforce.

Question 31: Efficiency refers to measurements related to the achievement of outputs in terms of productivity and the inputs/resources allocated.

Question 32: Effectiveness refers to measurements related to the degree of which an activity's output matches the specified goal.

Question 33: A formal internal audit program is one which includes the scheduling of audits, the performance of the audits, written results of the audit, and required corrective actions from items identified during the audit.

Question 34: Compliance based refers to audits that review the documentation of the entity against requirements. Process based refers to an audit that reviews the inputs, controls, resources, and outputs associated with a specified process.

Question 35: Indicate if there is a requirement that is adhered to where all corrective actions taken are followed up to ensure their adequacy.

Question 36: Indicate if a continuous improvement program is in place.

Appendix D: Justification of Questions Utilized in Indirect Detection

1. ***How long has the company been in business?*** Justification: Connaster (2005) – tribal knowledge is knowledge that is not commonly known by others within a company. The longer the entity has been in business, the more likely the experience level if the employees will be high, and the more likely there will be cases of tribal knowledge.

2. ***Is the entity regulated?*** Justification: Lomnitz (1988)– the more formalized, regulated, and planned a social system is, but unable to fully satisfy social requirements, the more social system tends to create informal mechanisms to escape the control of the system. Regulation of an entity requires scheduled audits to ensure that the system is compliant. The audits provide verification that the formal processes are occurring and informal processes are not present.

3. ***Is the entity registered?*** Justification: Lomnitz (1988) - the more formalized, regulated, and planned a social system is, but unable to fully satisfy social requirements, the more social system tends to create informal mechanisms to escape the control of the system. Registration of an entity requires scheduled audits to ensure that the system is compliant. The audits provide verification that the formal processes are occurring and informal processes are not present

4. ***Does the entity outsource any of its strategic processes?*** Justification: Landvater (1993) – three basic reasons why a formal system will not work (the formal system s based on an invalid model; the formal system is based on sound logic, but the data feeding the system is inaccurate; and/or the formal system is valid, the data is valid, but management is poor). When dealing with entities outside of a specified company, there is a high probability that communication errors will occur, the goals of the two entities are not the same, and/or the "hiring" entity will have little or no control over the outside entity's processes.

5. ***Is the entity classified as traditional or lean/agile?*** Justification: Lomnitz (1988) – informality is a response to the inadequacies of a formal system. Traditional companies tend to be more formal than lean/agile companies.

6. ***Is teamwork an integral part of the entity's structure?*** Justification: Lomnitz (1988)– informality is a response to the inadequacies of a formal system. Companies that employ teamwork give the teams power to do whatever it takes to keep a process moving. At times, these actions will be an informal process that is ultimately adapted into the process without being documented.

7. ***Is there a formal documentation system in place?*** Justification: Connaster (2005) - Transforming tribal knowledge into written instructions has benefits including best practices being documented, distributed, and used by all workers; worker turnover will not imperil the continuous operation of the company, nor quality of the products; during documentation, inconsistent or ineffective practices can be discovered, and hopefully resolved.

8. ***If above question answered "yes", are the documents reviewed on a periodic basis?*** Justification: Connaster (2005) – transforming tribal knowledge into written instructions has benefits including best practices being documented, distributed, and

used by all workers; worker turnover will not imperil the continuous operation of the company, nor quality of the products; during documentation, inconsistent or ineffective practices. Gilpatrick and Furlong (2004) – examples of things that are heard when an organization attempts change that directly points to the use of informal processes, such as: "oh, we haven't followed that policy in years" or "we have not updated that rate schedule".

9. ***Does the entity experience high turnover within the workforce?*** Justification: Connaster (2005) – tribal knowledge is knowledge that is not commonly known by others within a company. Therefore, if there is a high turnover in the workforce, the tribal knowledge can be lost.

10. ***Is there a system for responding to and tracking customer complaints***? Justification: Connaster (2005) – tribal knowledge is knowledge that is not commonly known by others within a company. Therefore, if no system exists (i.e. if there is an informal process), customer complaints will only be known by a few individuals, and these individuals may not be the correct people for that knowledge.

11. ***Has the entity gone through a recent merger/acquisition***? Justification: Connaster (2005) - tribal knowledge is knowledge that is not commonly known by others within a company. Therefore, if there is a high turnover in the workforce, the tribal knowledge can be lost.

12. ***Does the entity utilize approved vendors?*** Justification: Landvater (1993) – three basic reasons why a formal system will not work (the formal system s based on an invalid model; the formal system is based on sound logic, but the data feeding the system is inaccurate; and/or the formal system is valid, the data is valid, but management is poor). When dealing with entities outside of a specified company, there is a high probability that communication errors will occur, the goals of the two entities are not the same, and/or the "hiring" entity will have little or no control over the outside entity's processes.

13. ***Is there a methodology for approving vendors?*** Justification: Connaster (2005) – transforming tribal knowledge into written work instructions has benefits including best practices being documented, distributed, and used by all workers; worker turnover will not imperil the continuous operation of the company, nor quality of products; during documentation, inconsistent or ineffective practices can be discovered, and hopefully, resolved.

14. ***How many employees work at the main location***? Justification: Laubch (2005)– informal organizations are the actual patterns of human interaction upon which the work is performed. Therefore, the smaller the entity, the more likely the informal process.

15. ***Has the physical location for the entity changed?*** Justification: Landvater (1993) – three basic reasons why a formal system will not work (the formal system s based on an invalid model; the formal system is based on sound logic, but the data feeding the system is inaccurate; and/or the formal system is valid, the data is valid, but management is poor). When an entity moves to a new facility, there are "unknowns" that must be worked out prior to the processes running efficiently. Therefore, even if a formal system is in place, informal processes will occur until all of the "glitches" are worked out.

16. ***Does the entity contain equipment/tools that must be calibrated?*** Justification: Connaster (2005) – transforming tribal knowledge into written work instructions has benefits including best practices being documented, distributed, and used by all workers; worker turnover will not imperil the continuous operation of the company, nor quality of products; during documentation, inconsistent or ineffective practices can be discovered, and hopefully, resolved.

17. ***If the answer to the above question was "yes", is regular calibration performed as required?*** Justification: Connaster (2005) – transforming tribal knowledge into written work instructions has benefits including best practices being documented, distributed, and used by all workers; worker turnover will not imperil the continuous operation of the company, nor quality of products; during documentation, inconsistent or ineffective practices can be discovered, and hopefully, resolved.

18. ***What is the average experience of the workforce?*** Justification: Muller and Millen (2000) – experienced staff members may have deeper knowledge than the rules and may therefore help the business by circumventing or even breaking the rules.

19. ***Is there a formal training program in place***? Justification: Connaster (2005) – transforming tribal knowledge into written work instructions has benefits including best practices being documented, distributed, and used by all workers; worker turnover will not imperil the continuous operation of the company, nor quality of products; during documentation, inconsistent or ineffective practices can be discovered, and hopefully, resolved. Lomitz – informal modes of exchange grow within the formal system, and thrive on the inefficiencies of the formal system.

20. ***Is the skill level of the employee aligned with their job function?*** Justification: Muller and Millen (2000) – the rank and file personnel perform their work in accordance with the rules that have been authored and authorized by designated experts. There is a possibility that the capability of the designated experts is above that of the rank and file workers, and the workers will perform an informal process in order to get the job done.

21. ***Are required materials and equipment available to complete all processes when needed?*** Justification: Moody, Green, Muller, Tang, and Moran (2006) – if the resources needed to complete a job are not available, people engage in "artful" processes to get the job done.

22. ***Have there been recent layoffs?*** Justification: Connaster (2005) - transforming tribal knowledge into written work instructions has benefits including best practices being documented, distributed, and used by all workers; worker turnover will not imperil the continuous operation of the company, nor quality of products; during documentation, inconsistent or ineffective practices can be discovered, and hopefully, resolved.

23. ***Are layoffs planned?*** Justification: Connaster (2005) - transforming tribal knowledge into written work instructions has benefits including best practices being documented, distributed, and used by all workers; worker turnover will not imperil the continuous operation of the company, nor quality of products; during documentation, inconsistent or ineffective practices can be discovered, and hopefully, resolved.

24. ***Are the entity's facilities in compliance with all local, state, and federal regulations?*** Justification: Lomitz (1988) – the more formalized, regulated, and planned a social system is, but unable to fully satisfy the social requirements, the more social system tends to create informal mechanisms to escape the control of the system.

25. ***Does the entity's location have backup contingencies in the event of a failure?*** Justification: Moody, Green, Muller, Tang, and Moran (2000) – if the resources needed to complete a job are not available, people engage in "artful" processes to get the job done.

26. ***How long has the product/service been offered***? Justification: Landvater (1993) – three basic reasons why a formal system will not work (the formal system s based on an invalid model; the formal system is based on sound logic, but the data feeding the system is inaccurate; and/or the formal system is valid, the data is valid, but management is poor).

27. ***Has the entity incorporated a new technology in the core processes within the past six months?*** Justification: Landvater (1993) – three basic reasons why a formal system will not work (the formal system s based on an invalid model; the formal system is based on sound logic, but the data feeding the system is inaccurate; and/or the formal system is valid, the data is valid, but management is poor).

28. ***Does the entity outsource any of the core processes?*** Justification: Landvater (1993) – three basic reasons why a formal system will not work (the formal system is based on an invalid model; the formal system is based on sound logic, but the data feeding the system is inaccurate; and/or the formal system is valid, the data is valid, but management is poor). When dealing with entities outside of a specified company, there is a high probability that communication errors will occur, the goals of the two entity's are not the same, and/or the "hiring" entity will have little to no control over the outside entity's processes.

29. ***Is the entity's product/service high-tech or low-tech***? Justification: High tech entities generally have formal, documented systems. Therefore, Connaster's (2005) argument regarding written instructions applies here.

30. ***If a formal documentation system exists, is the level of documentation in line with the skill/training/experience of the workforce?*** Justification: Connaster (2005) - transforming tribal knowledge into written work instructions has benefits including best practices being documented, distributed, and used by all workers; worker turnover will not imperil the continuous operation of the company, nor quality of products; during documentation, inconsistent or ineffective practices can be discovered, and hopefully, resolved.

31. ***Does the entity measure efficiency?*** Justification: McKenna (1975) – informal processes may operate to the detriment of goals

32. ***Does the entity measure effectiveness?*** Justification: McKenna (1975) – informal processes may operate to the detriment of goals

33. ***Is there a formal internal audit program in place?*** Justification: McCann (1999) – an informal process has evolved over time and become habitual, is performed by one, or at most, a handful of employees, and appears, superficially, to be functional. An internal audit program has the opportunity to identify the informal processes

that may not appear because the efficiency and effectiveness measurements are within spec.

34. ***If the above question was answered "yes", is the audit program compliance-based or process-based?*** Justification: McCann (1999) – an informal process has evolved over time and become habitual, is performed by one, or at most, a handful of employees, and appears, superficially, to be functional. Internal audits that are process-based look at the process as a whole, and are more likely to find informal processes than compliance audits that can, and are oftentimes, performed at a desk.

35. ***Are corrective actions followed up to ensure they were adequate?*** Justification: Connaster (2005) - transforming tribal knowledge into written work instructions has benefits including best practices being documented, distributed, and used by all workers; worker turnover will not imperil the continuous operation of the company, nor quality of products; during documentation, inconsistent or ineffective practices can be discovered, and hopefully, resolved. If a corrective action is taken, documents should be updated, and then the follow-up will verify any issues with the changes and ensure they were effective.

36. ***Does the entity have a continuous improvement program?*** Justification: Connaster (2005) - transforming tribal knowledge into written work instructions has benefits including best practices being documented, distributed, and used by all workers; worker turnover will not imperil the continuous operation of the company, nor quality of products; during documentation, inconsistent or ineffective practices can be discovered, and hopefully, resolved.

Appendix E: PROCESS AUDIT GUIDLELINES
GUIDELINES AND TOOLS FOR CONDUCTING PROCESS AUDITS

INTRODUCTION

The majority of audits performed are for the sole purpose of ensuring if an entity is in compliance with applicable rules and regulations.   While this is an important and critical factor, it does not provide the entity with information on the effectiveness and efficiency of their processes.   In today's economic times, it is critical for an entity to understand their processes and know how effective and efficient the processes are in order to compete.   This guideline offers a generic approach to conducting process audits, including the preparation phase, audit phase, auditor techniques and tools, and auditor characteristics.   Information regarding the scheduling and reporting of audits is not covered in this guideline.

SCOPE

This guideline focuses on proven tools that can be utilized to conduct a true and thorough process audit.

DEFINITIONS

Analysis: investigation of the individual component parts of the process and their relationship in the process as a whole to determine the effectiveness and efficiency of the process and its associated components

Appraisal: determining the value of the contribution of the individual component parts of the process to the process as a whole

Audit: fact-finding exercises which examine objective evidence in an unbiased manner

Compliance Audit: an examination of the organization's documentation, matching the documentation with actions taken, compares and contrasts written documentation to objective evidence to verify compliance with the documentation

Corrective Action: a solution meant to reduce or eliminate an identified problem

Effectiveness: the degree to which a task, goal or objective is achieved

Efficiency: being effective while utilizing resources wisely

Finding: occurrence of a non-compliance

Follow-Up Audit: an audit conducted to verify that corrective action commitments from a prior audit were met and that the action taken eliminated the cause of the deficiency

Non-Compliance: deviation from the requirements

Observation: recognition of a potential issue (non-compliance)

Process: an accepted collection of activities which converts inputs into outputs, utilizing appropriate, consistent resources and directed by controls

Process Audit: verification that the resources perform according to the controls, using the specified inputs, to achieve the require output; concerned with the validity and overall reliability of the process itself; consists of two modes – efficiency and effectiveness

Product Audit: a detailed inspection of a finished product performed prior to delivering the product to the customer

Resources: any physical or virtual entity of limited availability

System Audit: addresses the who, what, where, when, and how of the organization's system to produce the product or service; macro in nature

AUDIT OBJECTIVES

The objective of any audit is to provide information regarding the status of an entity's processes and compliance to all required laws and regulations. Compliance audits will provide a portion of this objective. It is essential that an entity audit all of their processes and determine the state of the process, the state of the process elements and the interaction of the elements. This audit will allow the entity to assess and measure the effectiveness of their processes as well as the process efficiency.

Achieving an organization's goals is a critical factor in the world today. The continuation of an entity at times depends on the entity becoming more efficient. Improvements to an entity's processes will only be advantageous when the status of that process' effectiveness and efficiency are known. The results of a process audit can provide this information to the organization.

AUDITOR CHARACTERISTICS

The characteristics of an auditor play a crucial role in the effectiveness of any audit. At a minimum, an auditor should receive audit training, either internally or from an external source. For a process audit, it is not required that the auditor be an expert in the process they are auditing. In fact, it is best that they not be for the reason that the auditor can approach the audit without preconceived notions of how the process should be performed. Conversely, it is desired that the auditor have sufficient general knowledge regarding the general type of process. For example, if the process to be audited was a manufacturing process that converted metals into solder, it would be advantageous to have an auditor with a manufacturing or engineering background – you would not want a financial auditor to perform this audit. Likewise, you would not want an auditor with a specific manufacturing background performing an audit on financial processes.

Auditor traits that are desirable for process auditors include:

- Good judgment

- Open minded

- Resilient

- Diplomatic

- Self-disciplined

- Honest

- Unbiased

- Good listener

- Patient

- Articulate

- Professional

- Interested

- Analytical, and

- Self confident

In addition, the auditor should be able to organize their thoughts and notes in a manner that aides in the performance of the audit.

AUDIT PREPARATION

The first step in preparing for a process audit is to determine the process that will be the subject of the audit. A process may be large (i.e. an audit of the entire document control process from the development of a procedure to the distribution of the procedure), or small (i.e. distribution of new or revised documents). It is critical that the boundaries of the process be defined and agreed upon with the individual's affected by the audit prior to starting the audit.

Upon agreement, the auditor will model the process using an appropriate process model. Appendix 1 provides information on the DROMĒ process model. The DROMĒ process model provides the auditor with a tool that can identify all elements of the process and their associated metrics. Additionally, numerous DROMĒ models can be linked together to show the interrelationships of various activities associated with a process, or to show the interrelationship of numerous processes. During the modeling process, the information for the "control" element within the DROMĒ model should be obtained utilizing a document tree. A document tree is a diagram of all documents related to a process. The purpose of a

document tree is two-fold: (1) to ensure the process is performed in accordance with all written policies, procedures, and regulations, and (2) to ensure there is no conflict between these documents that could render a process inefficient or ineffective. A document tree can start at any point within the documentation system. An example of a document tree for the purchasing process for an ISO 9000 registered company is shown in Figure E-1. The quality manual was the upper level document. As seen in Figure E-1, the quality manual appears at the top of the tree. Within the purchasing section of the quality manual, five (5) documents are referenced (production process, quality records master list, purchasing, approved vendor list, and vendor selection). The document tree also shows the interrelationships between documents – the vendor selection procedure and purchasing are directly referenced by the quality manual; and the purchasing procedure references the vendor selection procedure. It is not required to utilize different colors when preparing a document tree, but it is useful, especially when the document trees are large and there are numerous interrelationships between documents.

Figure E-1. Example of Document Tree for Purchasing Process

When the DROMĒ model(s) is (are) complete, the auditor should review the models, associated documents from the control section, and metrics to ensure an understanding of the process prior to performing the audit, and note any areas of concern (conflict between documents, delivery of material in an efficient manner, etc).

Prior to beginning the audit, the process auditor should perform a review to include any contractual or legislative requirements; codes, standards, and regulations, management practices; past audit results (both internal and external audits), corrective and preventive actions and the associated conclusions, customer satisfaction and complaint information, and prior metrics for the elements within the process being audited. The performance of this background information will provide the auditor with requirements of the process and a history of the process audited as well as suggesting strengths and weaknesses of the process and its elements.

Process audits do not require a checklist, and in fact, should not have a checklist. Checklists do not allow an auditor the leeway to examine items of interest that occur during

the progression of the audit. Additionally, checklists tend to confine an audit to yes or no responses, which do not allow efficiency and effectiveness to be adequately considered. From the information collected and completed (history, DROMĒ process model, document tree), the process auditor can begin the audit.

AUDIT PROCESS

There are three (3) basic components of an audit; (1) interview of personnel, (2) observation of the process being performed and (3) document review. Each of these components combines to form an audit that achieves its intended purpose. For a process audit, the above components should be applied to every element within the process model, the interaction of the elements, as well as the interactions with the processes immediately before the subject process and after the subject process. The information below provides a basic guide for the three (3) components.

When interviewing personnel, it is important that the auditor establish a rapport with the individual being interviewed and make that individual feel important. The auditor should have a goal of gaining the trust of the interviewee. The auditor should be aware of the surroundings during the interview process – are they in an area where they can be overheard, is the interviewee's supervisor/manager looking over their shoulder? The interview should take place in a neutral area that is private. Gaining the interviewee's trust can also be achieved by the attitude of the auditor (being prepared and being open). When speaking with the interviewee, pay attention to not only their words but their actions and body language. If an interviewee appears to be under stress or nervous, tell them a little about yourself, and paraphrase their words in other follow-up questions. Open-ended questions and leading questions are preferable to those that require a yes or no response from the interviewee. The ultimate goal of the interview process is to gather information. During the interview portion of the process audit, there are three (3) areas that should be explored. These areas are the process itself; the identification of any non-conformances, inefficiencies, and ineffective activities; and an exploration of the non-conformances, inefficiencies and ineffective activities.

One of the first areas visited during the interview will be the process itself. The questions during this stage should be well defined, process targeted, and simple. These types of questions typically begin with the words how, what, and why. As the interview continues, it is important to be aware of questions that would make the interviewee uncomfortable. For these types of questions, the auditor should split the uncomfortable question into smaller questions that allow them to gather information while maintaining the trust of the interviewee. For example, an auditor could ask the question, "this procedure has changed. When were you trained in the new procedure?" This question can appear to an interviewee as one that is targeting them specifically. An alternative to this question would be to divide the question into smaller, less threatening questions, such as: "About how long ago was this procedure changed?", "How were the workers notified of the change?", "Are there records of the change that you are aware of?", "Would there be records of training on the procedure changes?" Some of these questions will require follow-up questions and a chance to verify specific records associated with the change. At this stage, the process auditor should share

the DROMĒ process model with the interviewee and obtain their opinion in regards to the elements and their interfaces.

When identifying nonconformities, inefficiencies, or ineffective actions, the auditor should phrase their questions about the circumstances of the process. If, for example, the auditor determined that there was a conflict between a customer specification and the organization's internal specifications, an appropriate question would be "How do customers provide you with requirements", versus "Why do you not follow the specifications that the customer has provided?" The first question is non-threatening, allows an auditor to learn more about the actual process of how customer requirements are brought into the organization's internal procedures, and could highlight potential ineffectiveness and inefficiencies within the process. The second question is threatening and tends to just a compliance issue. During this portion of the audit, the auditor must be careful to remember that everything has a minimum of two sides. More information can be gathered from an interviewee if the auditor starts with a positive statement about the process and moves to the problem.

When inefficiencies, ineffective situations, or nonconformities are identified, and further exploration is needed, it is helpful if the auditor takes the side of the interviewee. Instead of asking a question such as "Why do you not keep track of the metrics like the procedure requires?", the auditor could say, "I think that the requirements in this procedure for keeping track of these metrics would make it difficult for anyone. Tell me about this."

Upon completion of the interview the auditor will have additional information to aide in the observation and document review portion of the process audit. The DROMĒ model will be the roadmap for the auditor during the observation portion and should be referenced throughout the observation. During the observation phase of the audit, the auditor must verify that all elements shown on the DROMĒ model are utilized, that they meet the requirements set forth in the documentation, and that all elements of the DROMĒ model are effective and efficient in the activity being performed. The auditor should follow the path of the elements both forward and backward though their progression. It is imperative that the auditor note any areas of risks or concerns during the observation phase. These risks may be from various perspectives including safety, efficiency, effectiveness, or not adhering to the documented procedures. It is reasonable for the process auditor to question an employee as they are performing an activity as long as the interruption does not have an impact on the safety of the employee or others, or have a detrimental impact on the activity of the employee.

The observation phase leads to the question of sampling during the process audit. Any size sample is adequate for audit purposes since an audit is not intended for product acceptance nor process control. A sampling plan may be used if it is required by management or if the auditor prefers. If a sampling plan is to be used, it must be adhered to. It is unacceptable for an auditor to add to the sample size if no issues were found with the original sample.

The last phase of performing a process audit is document review. Throughout the audit preparation and actual audit process, the auditor has gathered information that will lead them

to specific document types to be reviewed. To obtain an unbiased view of the documents, the auditor should not request typical documents. If allowed, the auditor should pull their own samples from the files, or be present when requested samples are pulled. For an overview, the auditor should pull or request documents from each of the process elements and metrics identified on the DROMĒ model.

SUMMARY

This guideline is intended for use by trained auditors when conducting a process audit. It is not meant to provide training of audit techniques for individuals without prior experience/training. Basic steps in the preparation and performance of process audits have been presented. During preparation the use of the DROMĒ model combined with analysis of requirements and history provides the foundation for the process audit. The three (3) elements of a process audit have been described (interview of personnel, observation, and document review), and techniques provided to aid in the completion of the audit. Accomplishment of a process audit utilizing the information in this guideline will aide in determining the effectiveness, efficiency, and compliance of a process.

APPENDIX E-1. *DROMĒ Process Model*

A process model has three primary functions. The model must be descriptive, prescriptive, and explanatory. The term descriptive refers to the ability of the process model to describe the basic elements of the process, prescriptive means that the process model has the capability to establish to the exact elements of the process, and explanatory refers to the ability of the process model illustrating how the process elements interact. The DROMĒ Direct Representation of the Model Elements) process model is shown in Figure E-2.

Figure E-2. DROMĒ Process Model
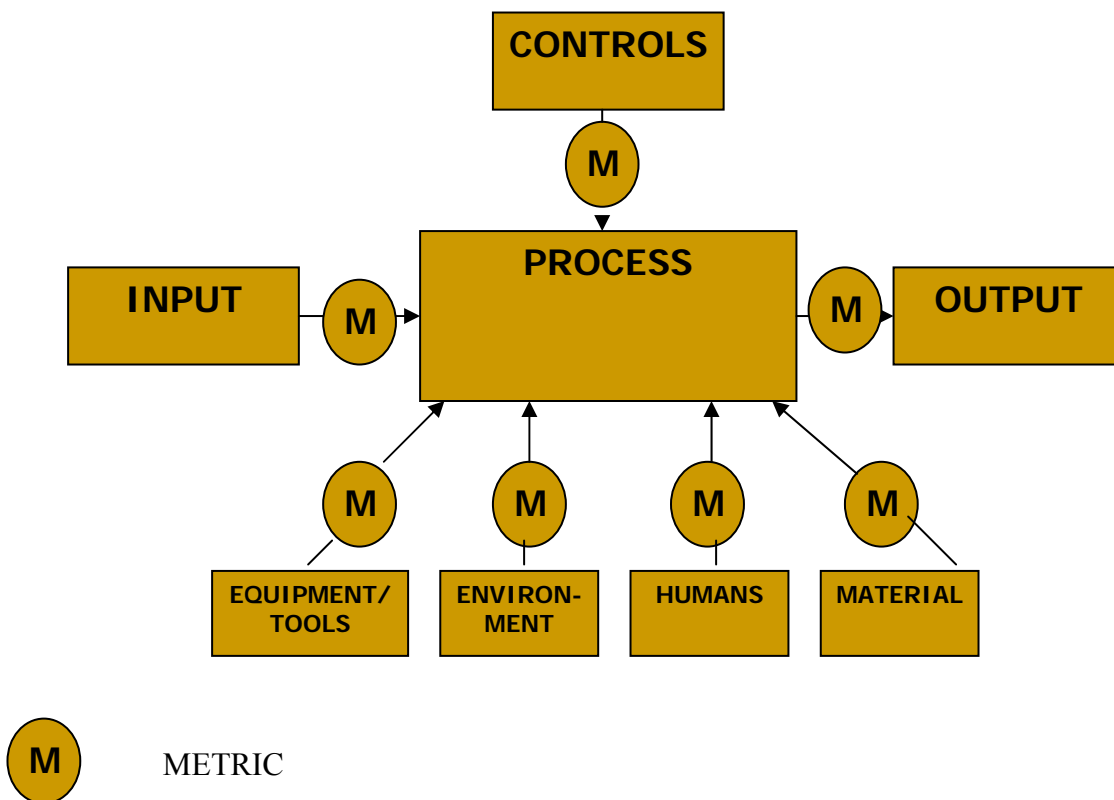
M METRIC

Let us verify that the DROMĒ process model contains the three required functions. Is it descriptive – does it describe the basic elements of the process? As seen, the elements of the process (input, controls, output, equipment/tools, environment, humans, material, and metrics associated with each element) are clearly identified within the model. When a process is modeled, the prescriptive function can be seen. As shown in Figure E-3, the exact elements of a process are identified on the DROMĒ example. The example shown in Figure E-3 is the upper level process model of a customer complaint procedure. Notice that although there are no specific requirements for equipment/tools, environment, or material for the customer complaint procedure, these elements are still shown on the model. This provides a visual

247

reminder for the individual performing the modeling to ensure all aspects of the model are addressed.

The third function of a model is to be explanatory – to be able to show the interactions of the elements of the process. To show this function, the customer complaint model shown in Figure E-3 has been expanded to lower level models (see Figure E-4).

Figure E-3. DROMĒ Example for Customer Complaint Handling
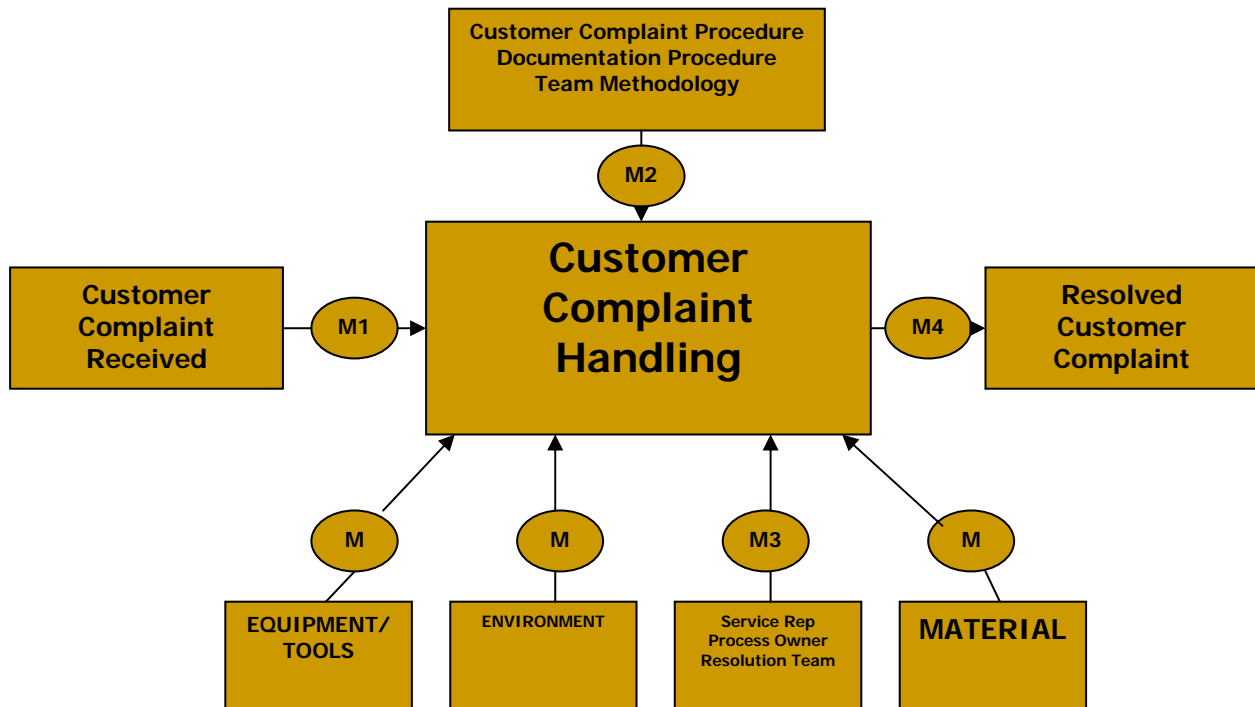
Figure E-4. Expanded Customer Complaint Handling DROMĒ

The DROMĒ process model was developed to represent all of the essential elements of any given process as well as metrics associated with the various elements. There are seven (7) basic elements of the DROMĒ process model:

9. Input – an event or circumstance that initiates activity required to achieve an objective. An input can take the form of a request for quote, customer complaint, or be the output of a preceding process.
10. Controls – documented or oral information that establishes the method(s) required to achieve the output; all applicable internal and external regulations, standards, specifications, etc.
11. Equipment/Tools
    a. Equipment – an item of tangible property that retains its original shape, appearance, and character with use; does not lose its identity through fabrication or incorporation into a different or more complex unit; is non-expendable
    b. Tools – devices which provide an advantage in accomplishing a physical task, or provides an ability that is not naturally available to the user.
12. Environment – physical conditions that impact or influence the activity performed in achieving the objective (temperature, cleanliness, light, etc).
13. Humans – personnel.
14. Material – tangible substance that may lose is original shape, appearance, and character when incorporated into a different item.
15. Output – the completed objective.
16. Metrics – the various parameters of a process that are to be measured to assess the performance in any given area.

Figure E-2, coupled with the definitions of the elements given above; show that the DROMĒ process model contains all of the elements currently found in other process models. It has a well-defined resources area (equipment/tools, environment, humans, materials), and allows for any type of control (documented or undocumented).

Appendix F: Strategic M-1 BBNs

<u>**SME #1**</u>

SME #2

SME #3

SME #4

SME #6

SME #8

Communication
(Communication)
Informal (0.05)
Formal (0.95)

Foundation
(Foundation)
Informal (0.01)
Formal (0.99)

CustSatisfaction
(CustSatisfaction)
Informal (0.0603829)
Formal (0.939617)

Strategic
(Strategic)
Informal (0.0599789)
Formal (0.940021)

Procurement
(Procurement)
Informal (0.09275)
Formal (0.90725)

Maintenance
(Maintenance)
Informal (0.095)
Formal (0.905)

Allocation
(Allocation)
Informal (0.1)
Formal (0.9)

255

SME #9

Appendix G: Group 1 Strategic M-2 BBNs

SME #1
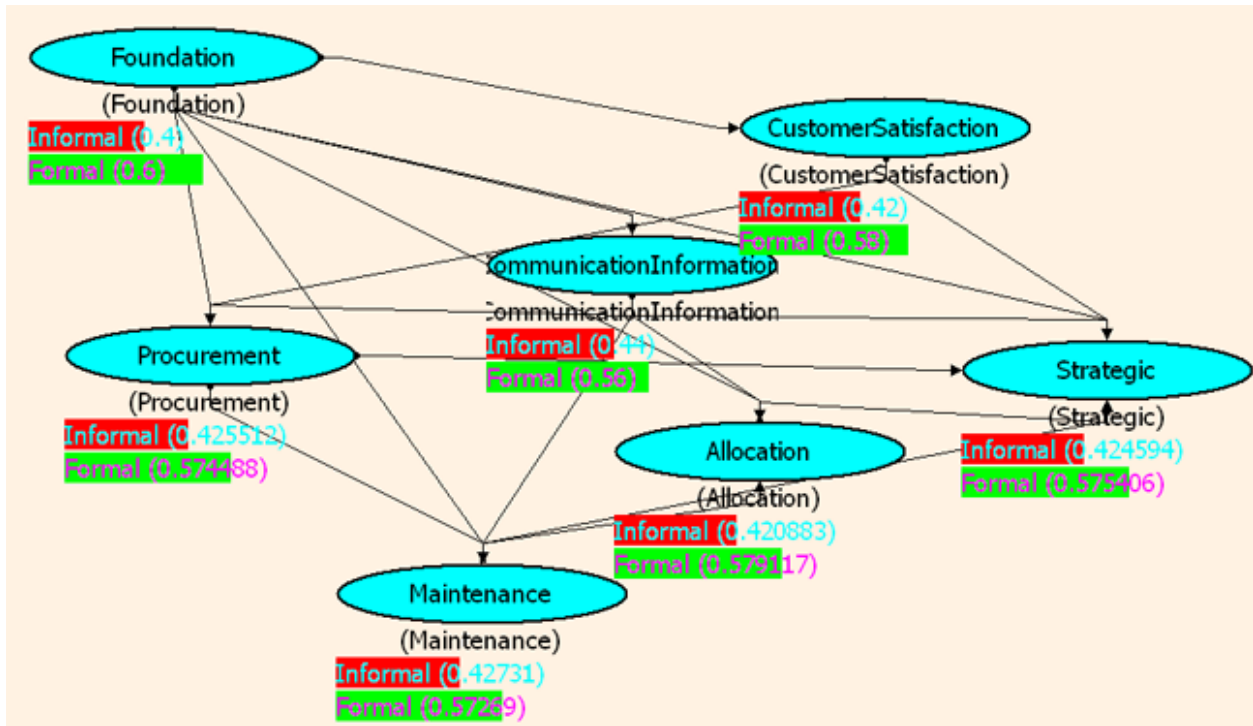
SME #2
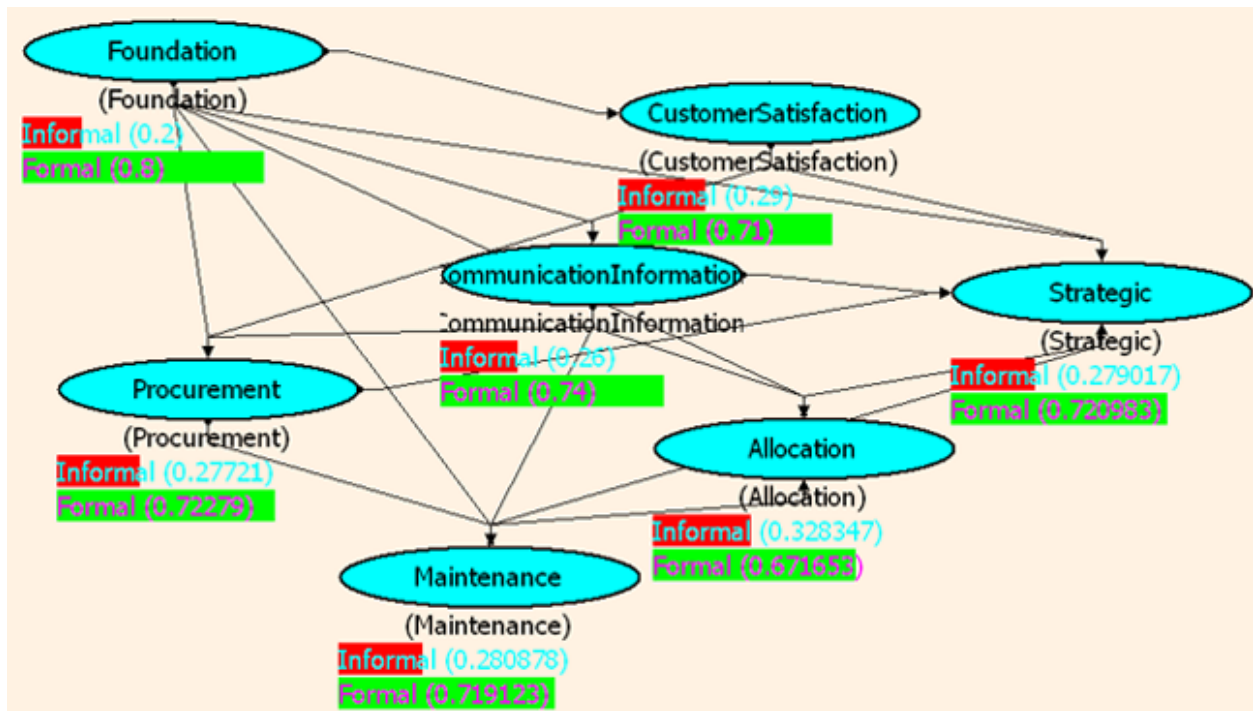
SME #3
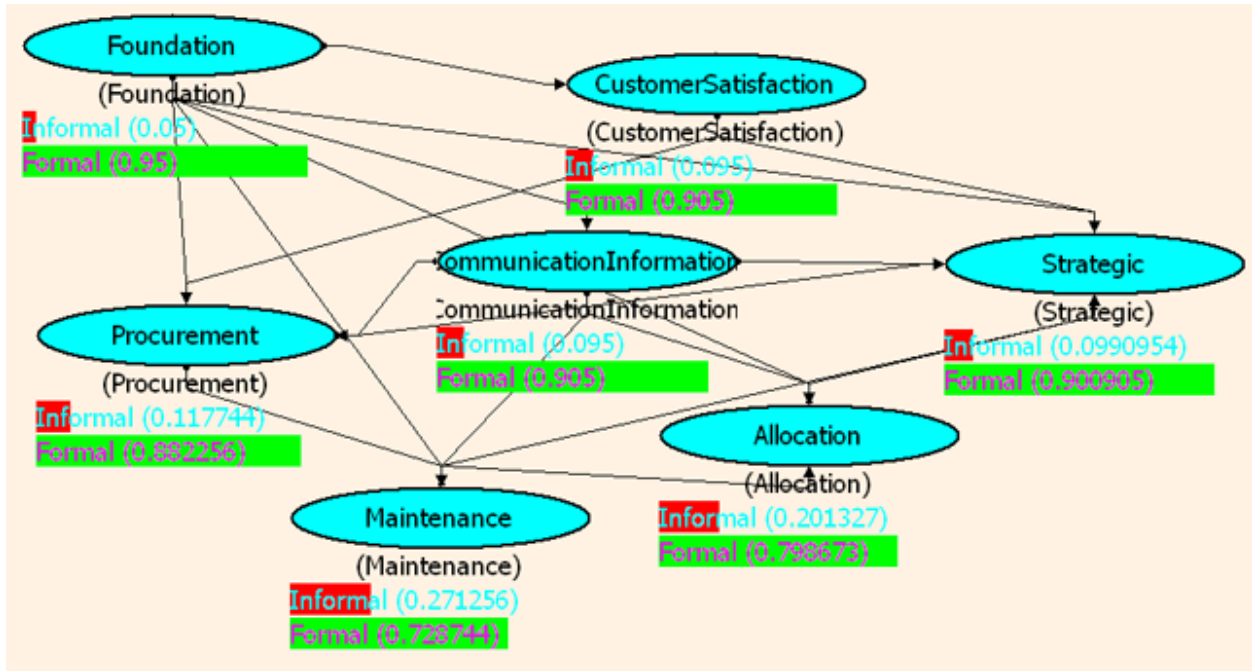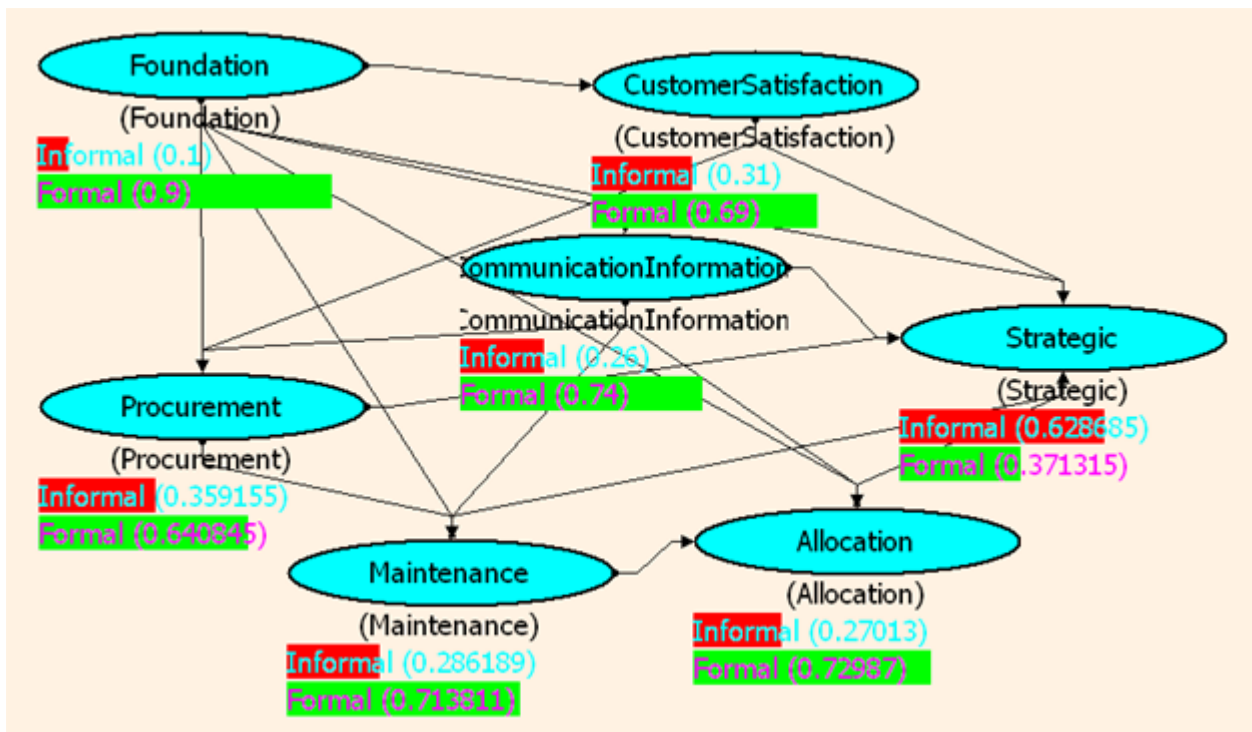
SME #4

Appendix H: Group 2 Strategic M-2 BBNs

SME #6
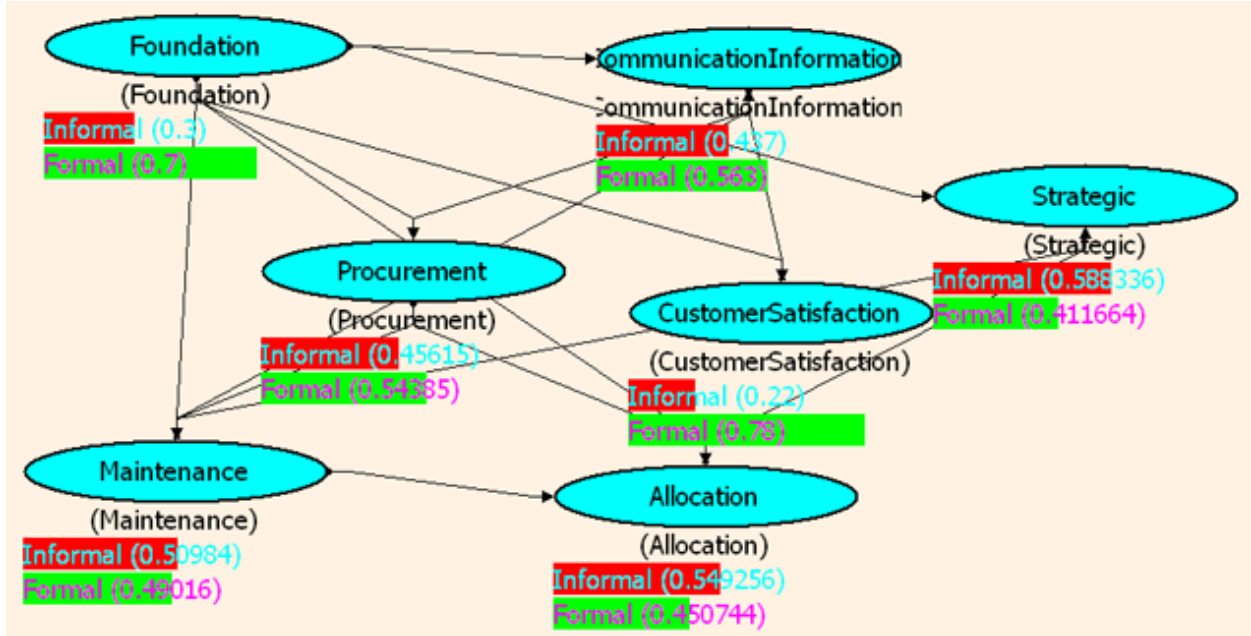
SME #9
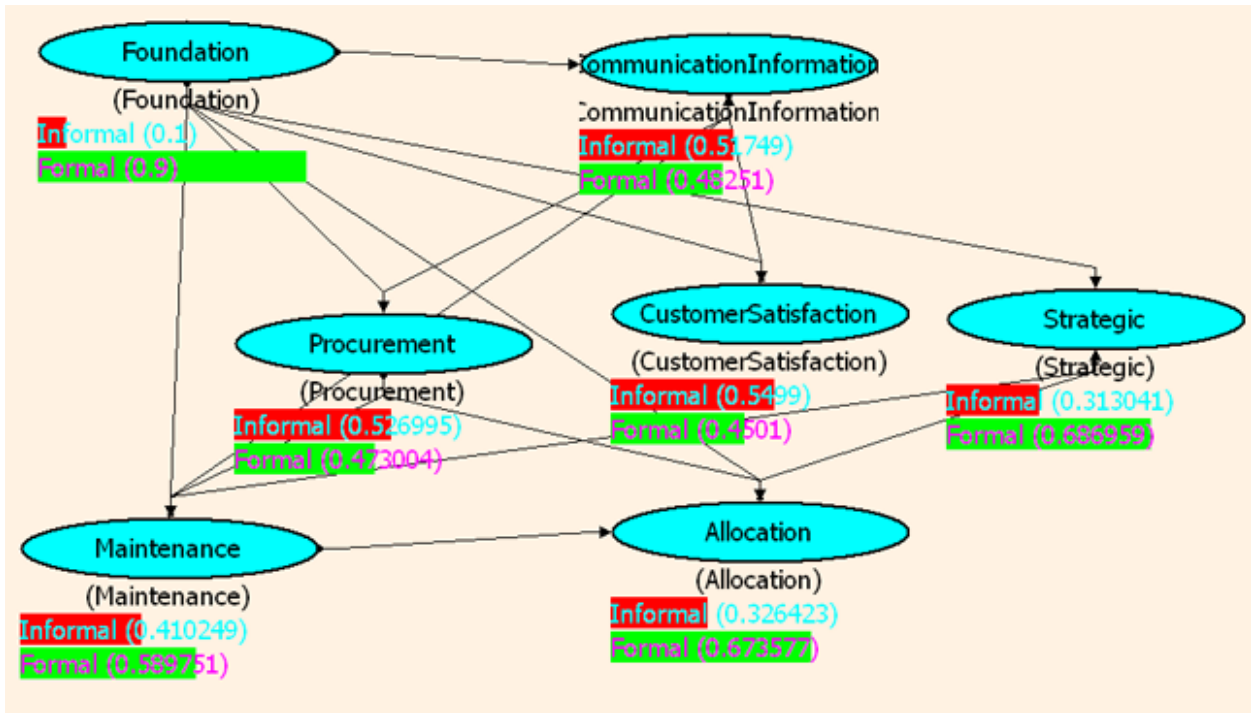
Appendix I: M-1 Core BBNs

SME #1
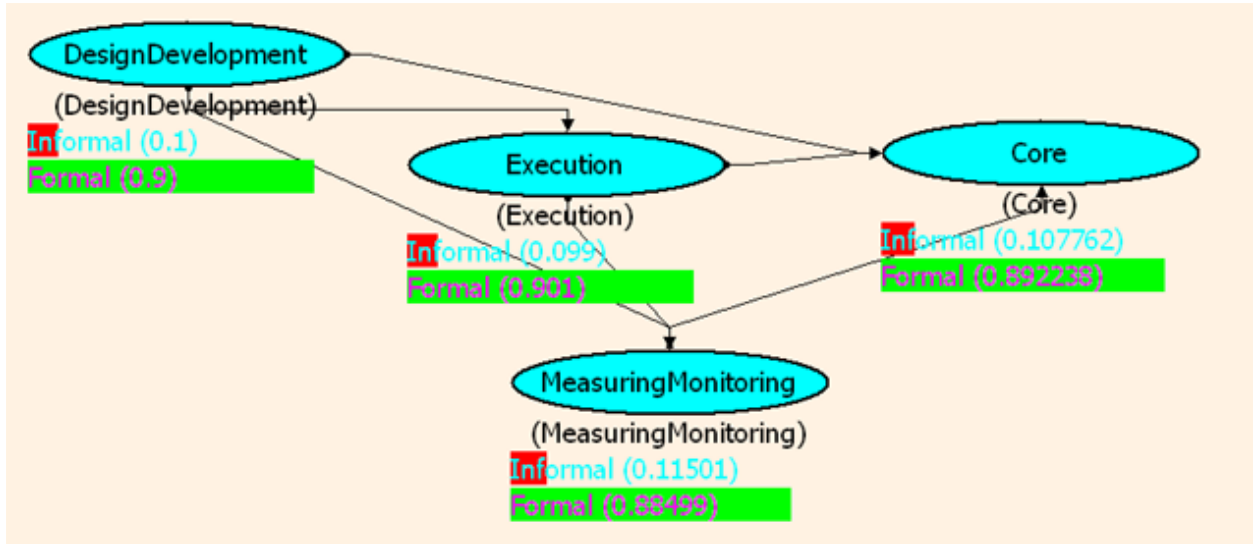
SME #2
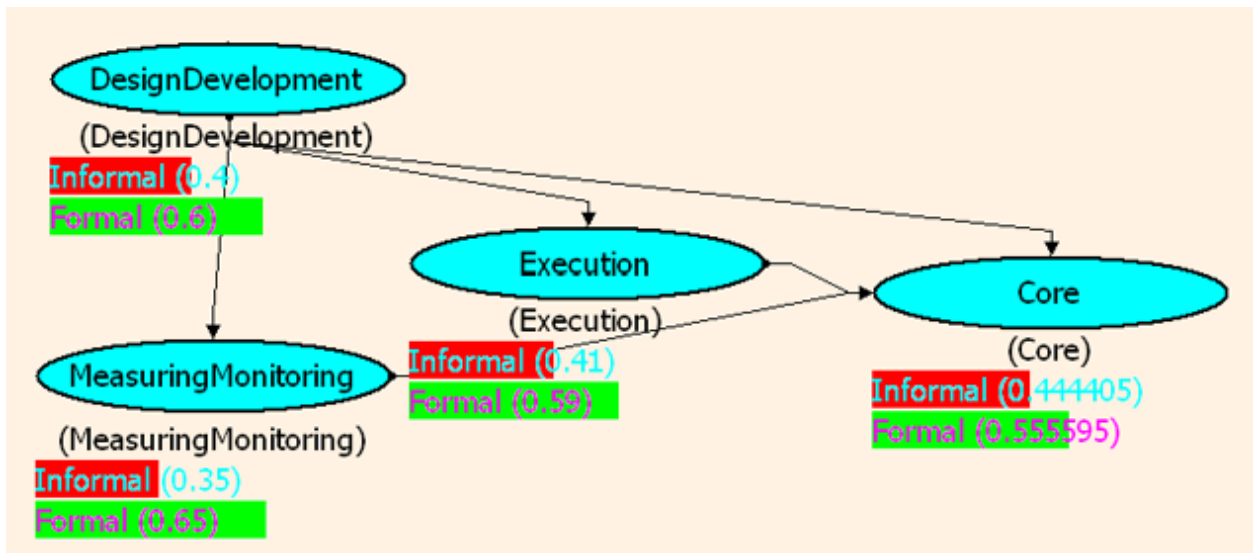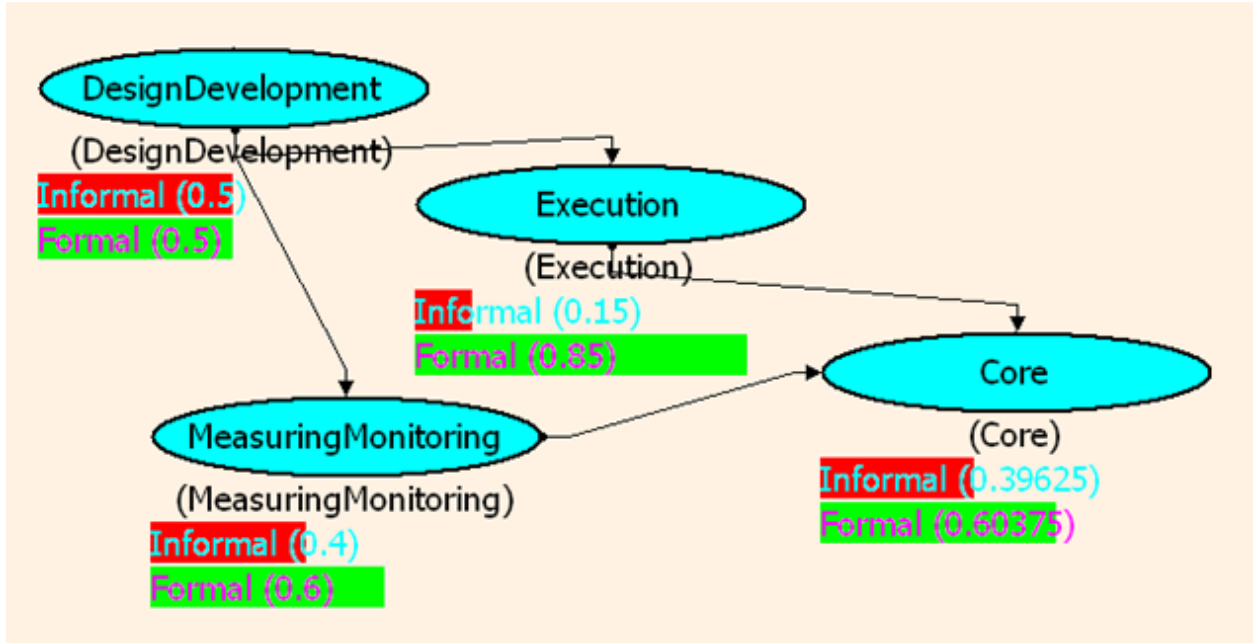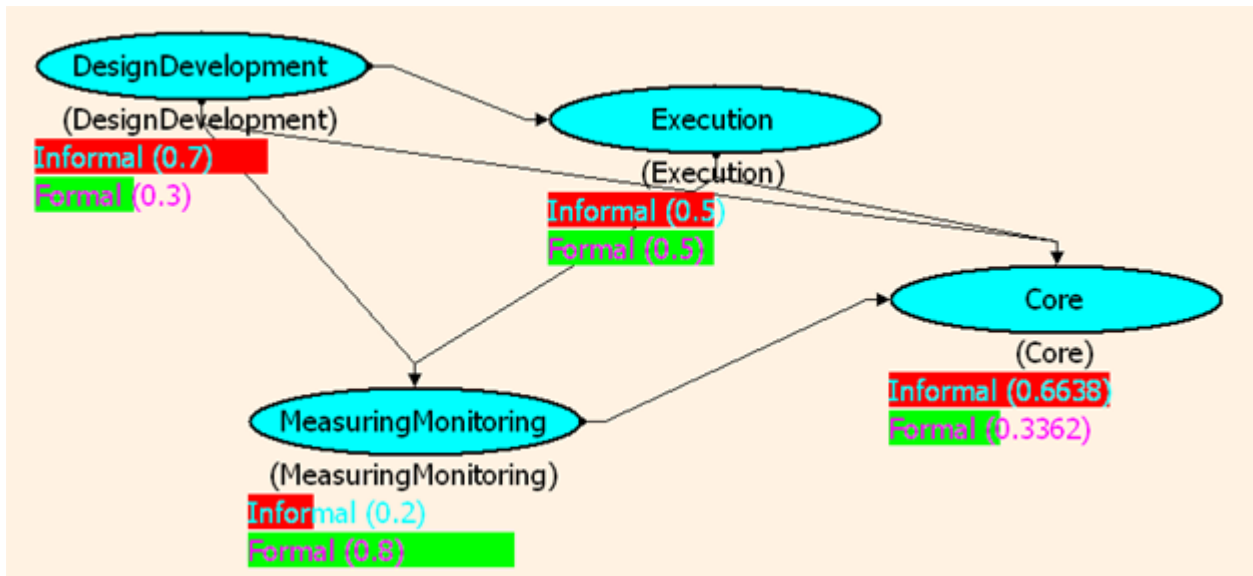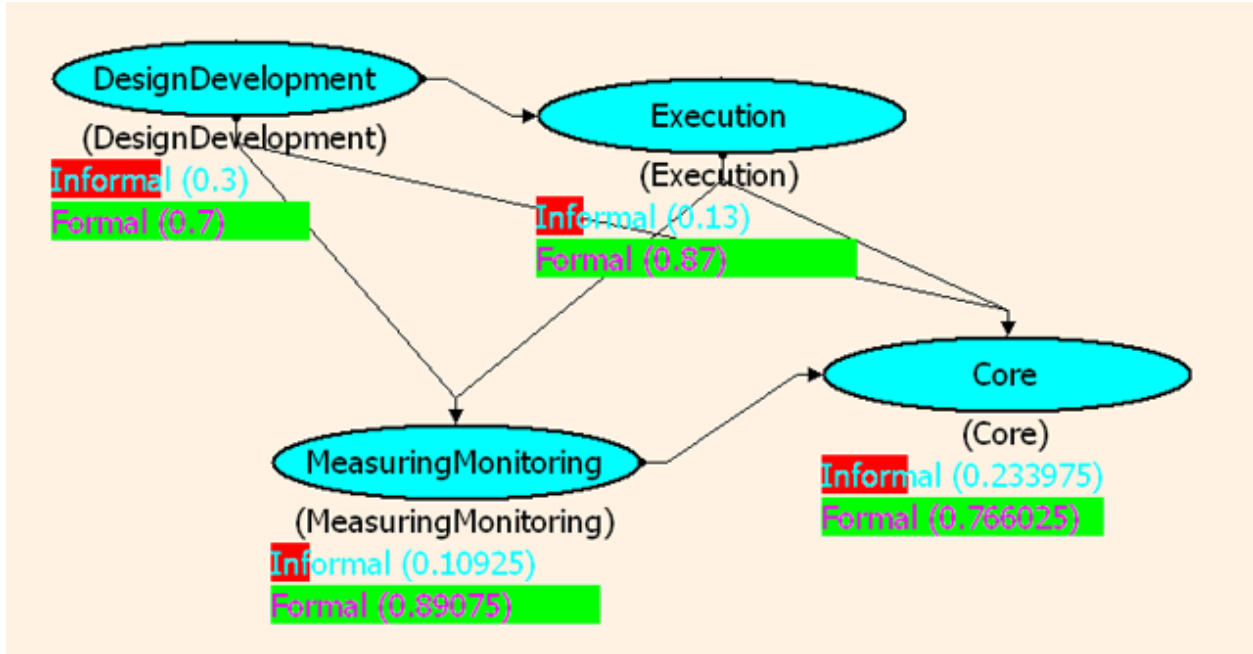
SME #3

SME #4

SME #6

SME #9
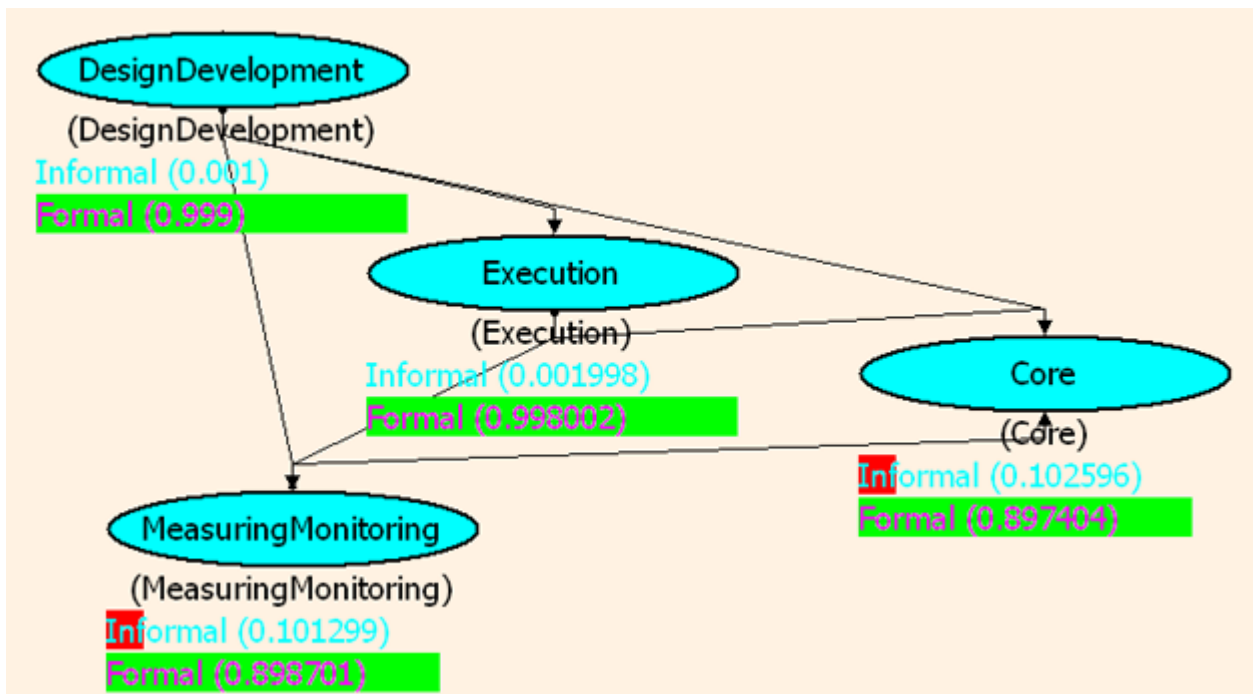
Appendix J: M-2 Core BBNs

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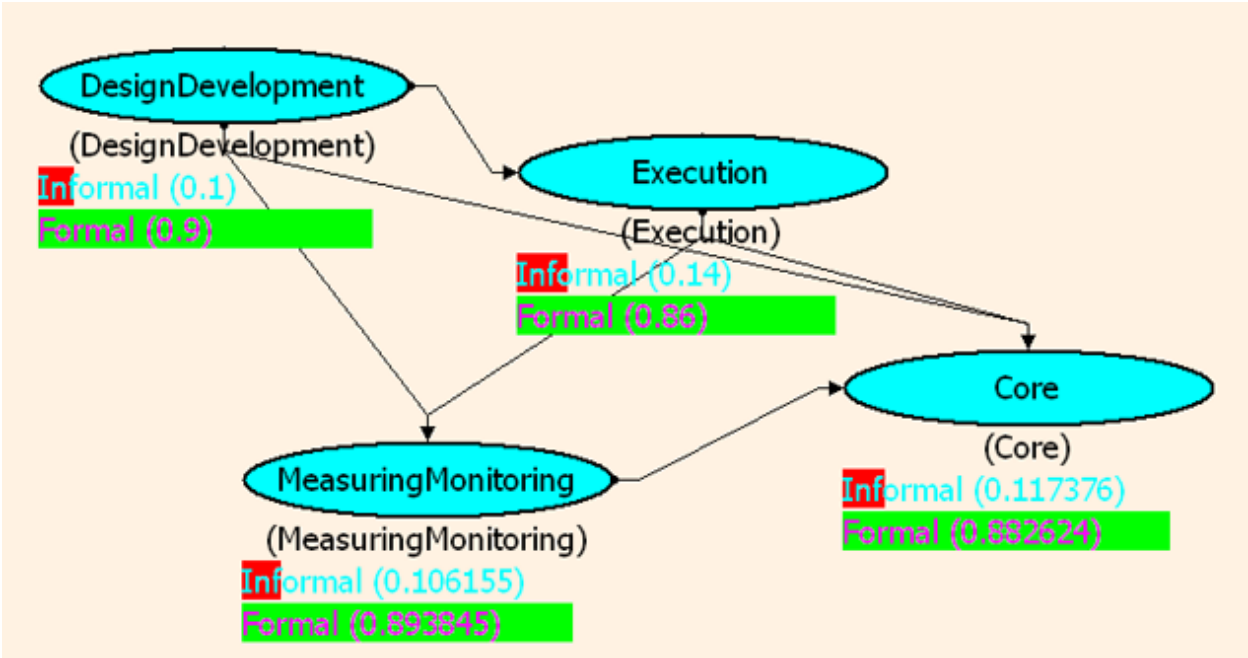
SME #2
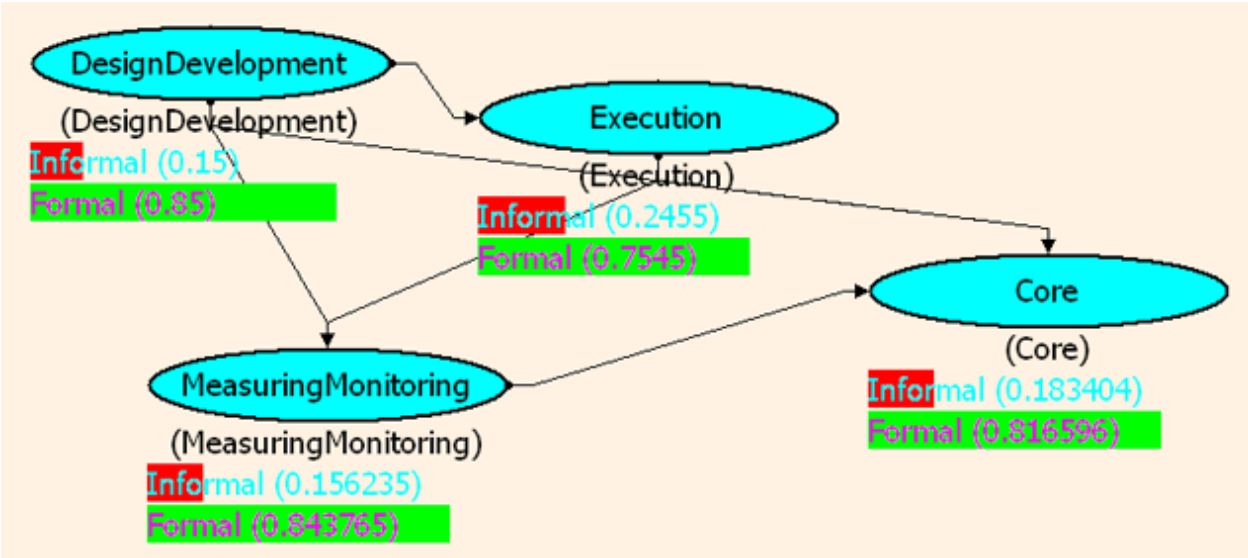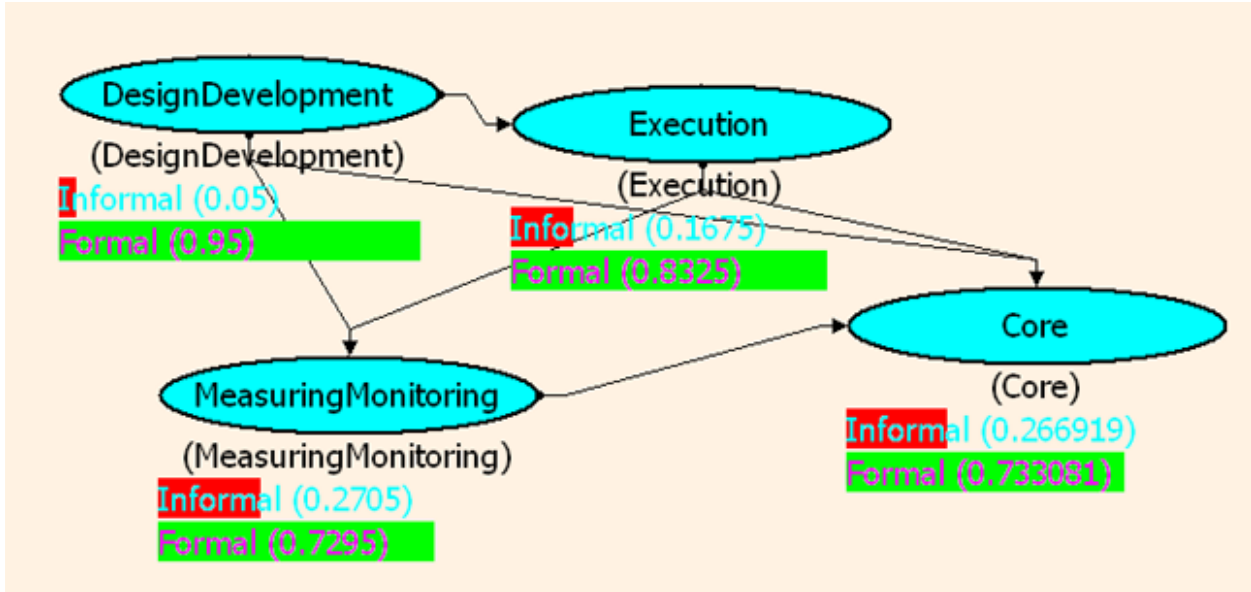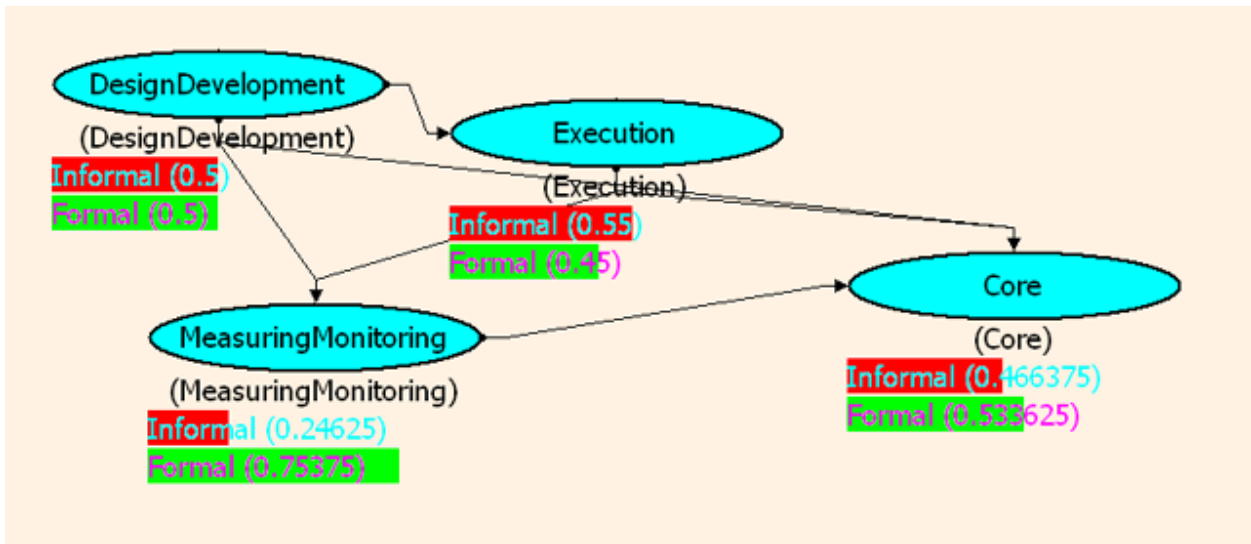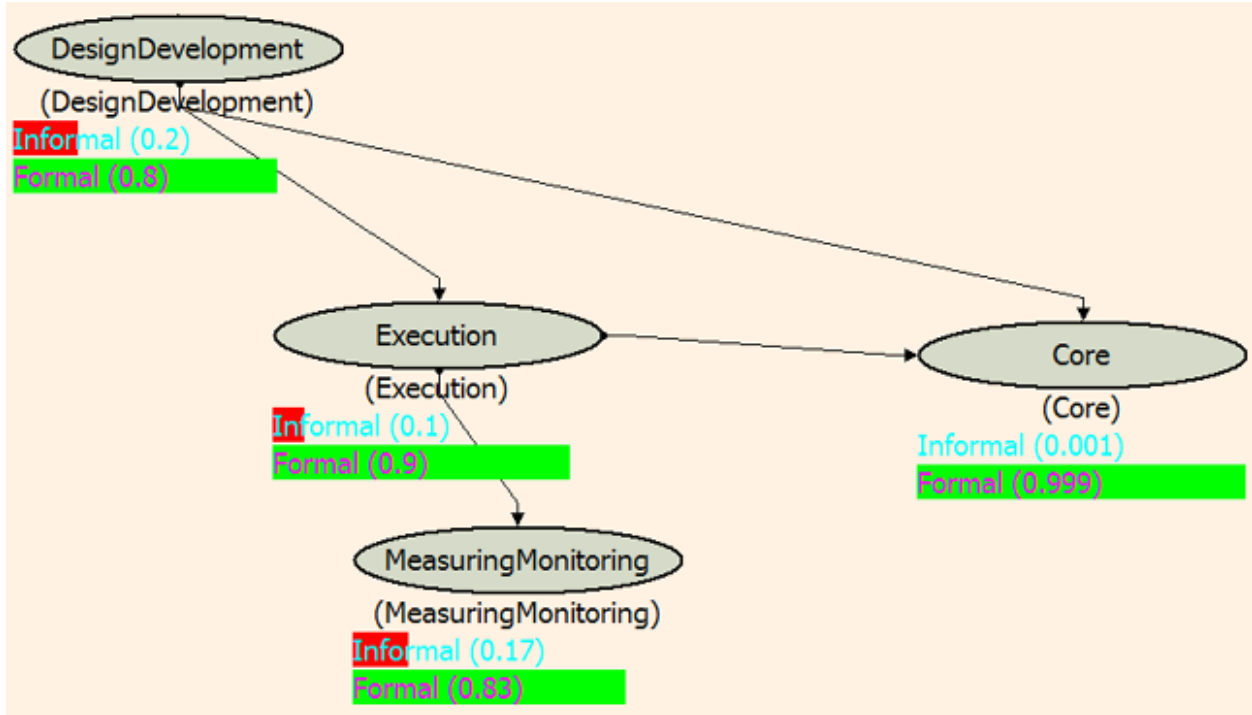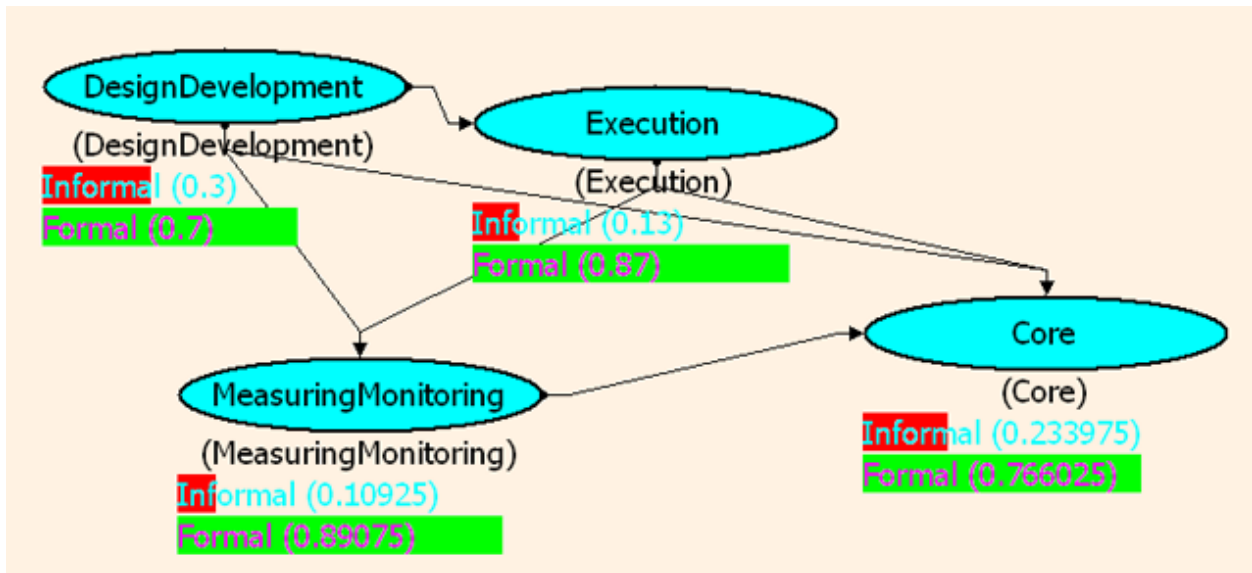
SME #3
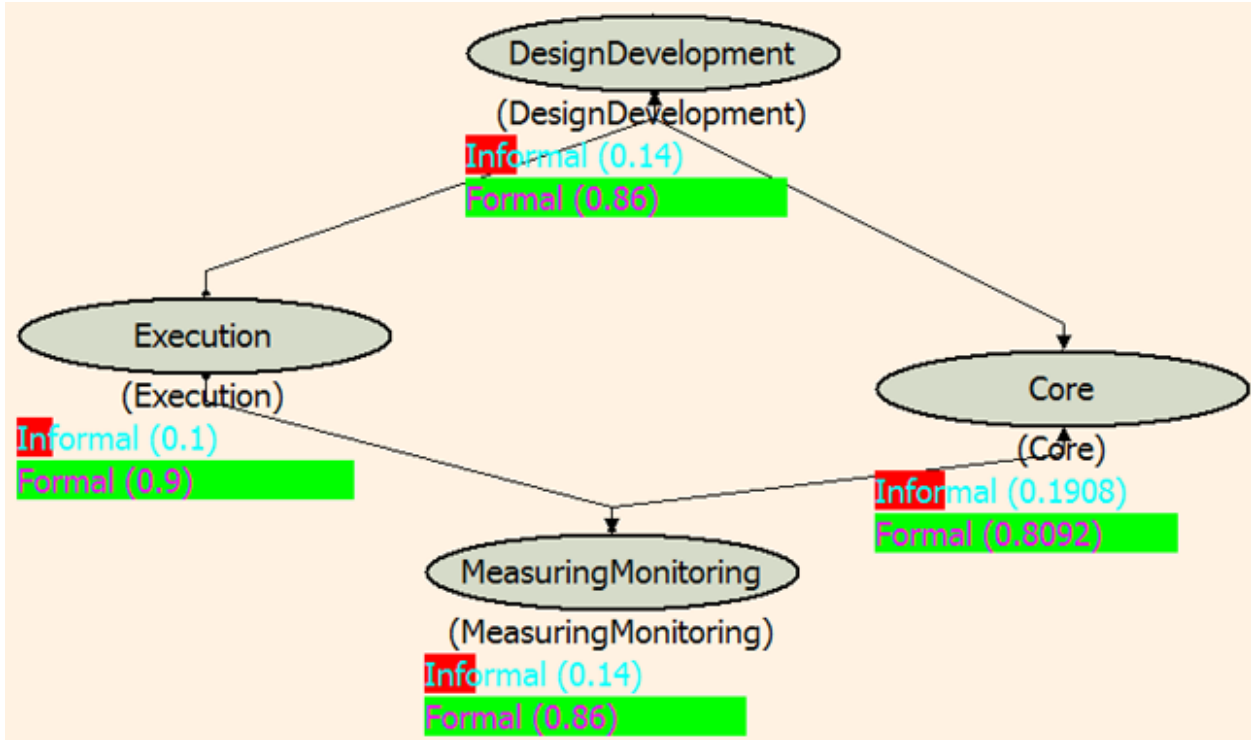
SME #4
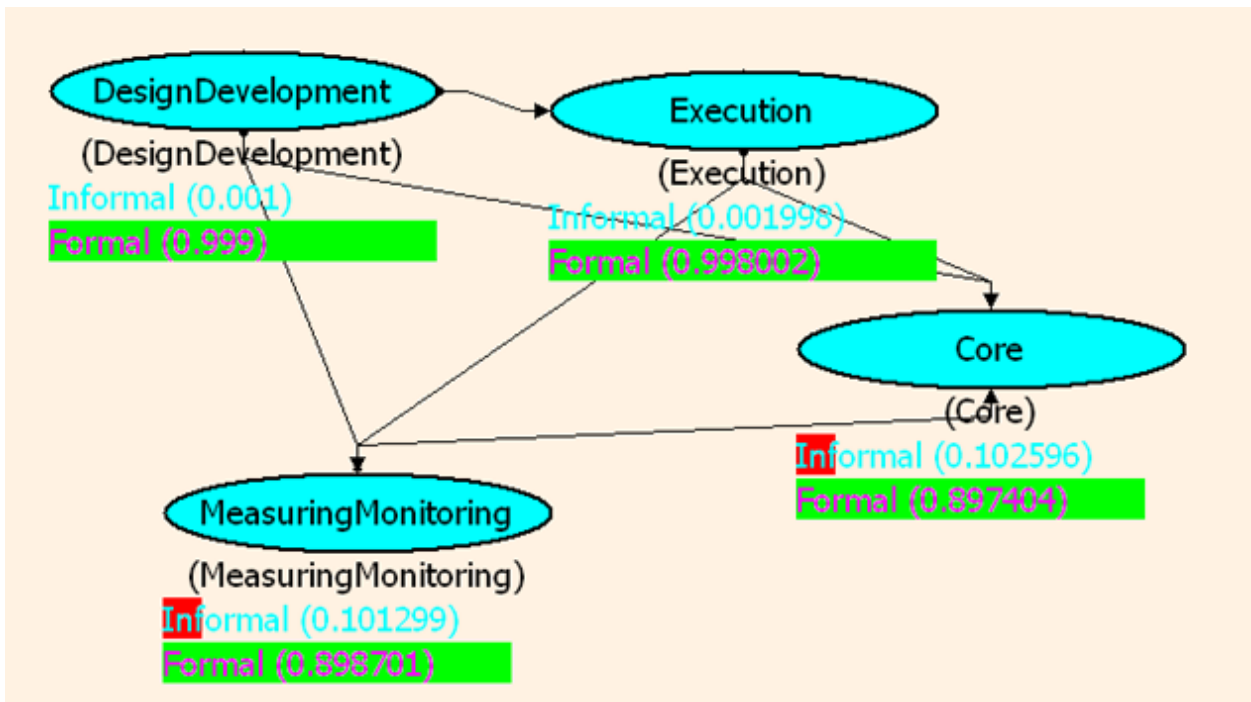
SME #5

SME #6

SME #7

SME #9

Appendix K: M-1 Abbreviated Output BBNs
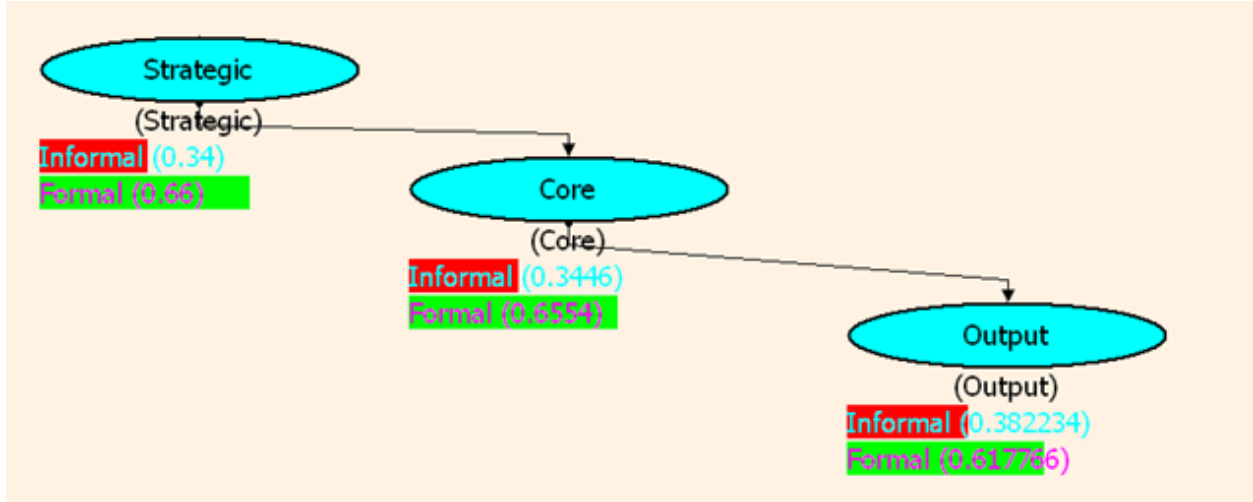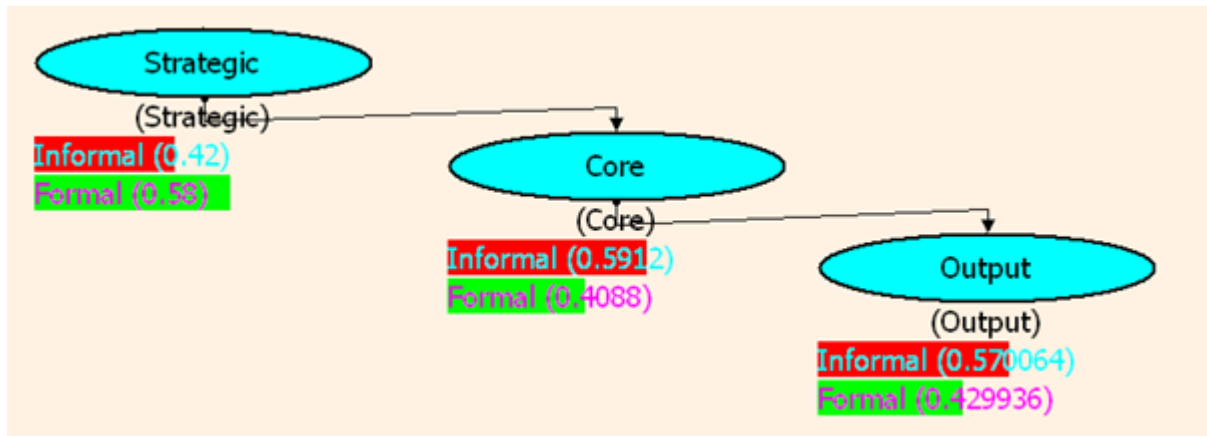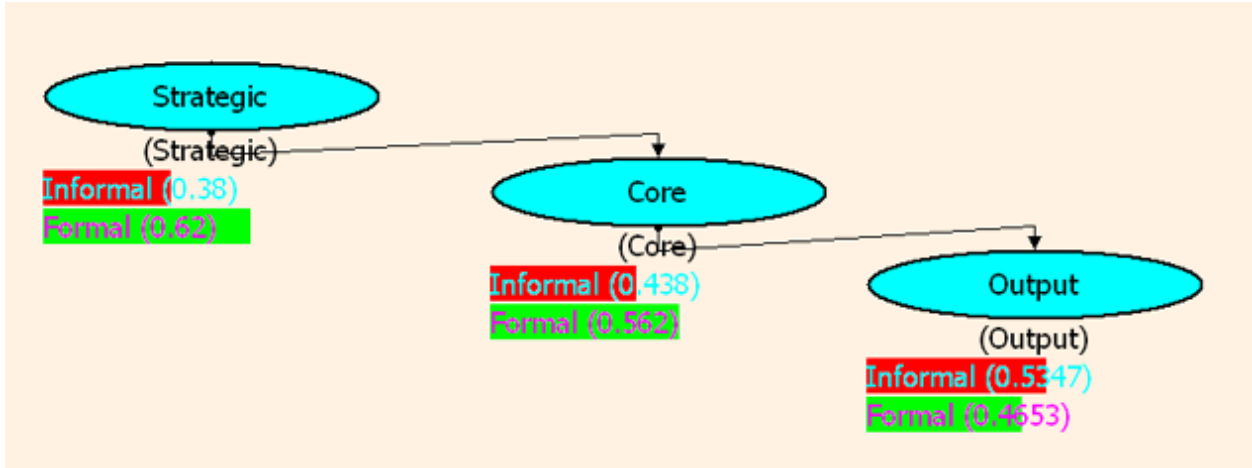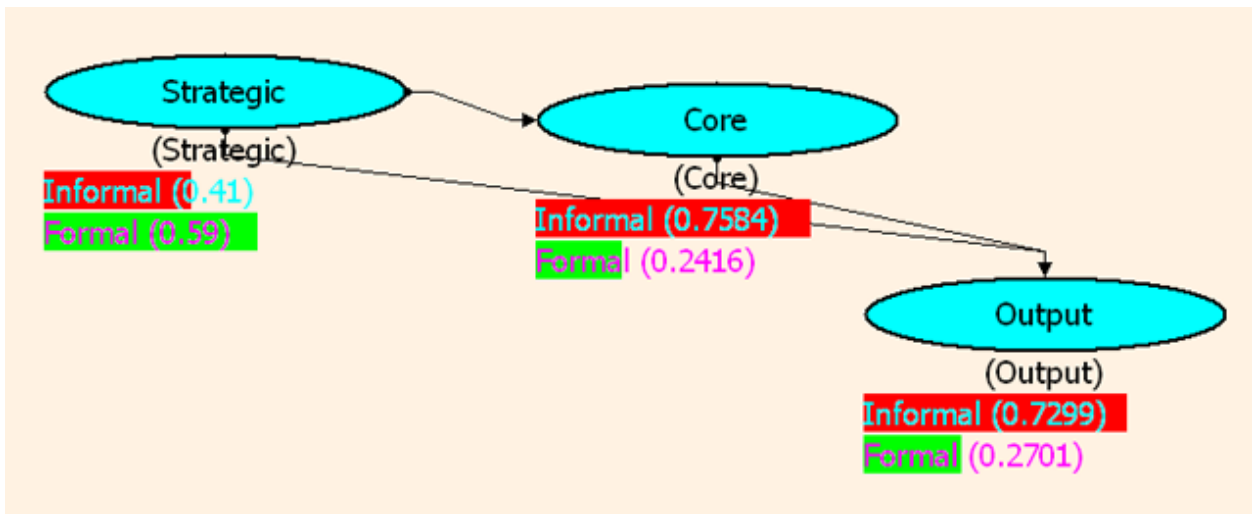
SME #1

SME #2

SME #3

SME #4

SME #5
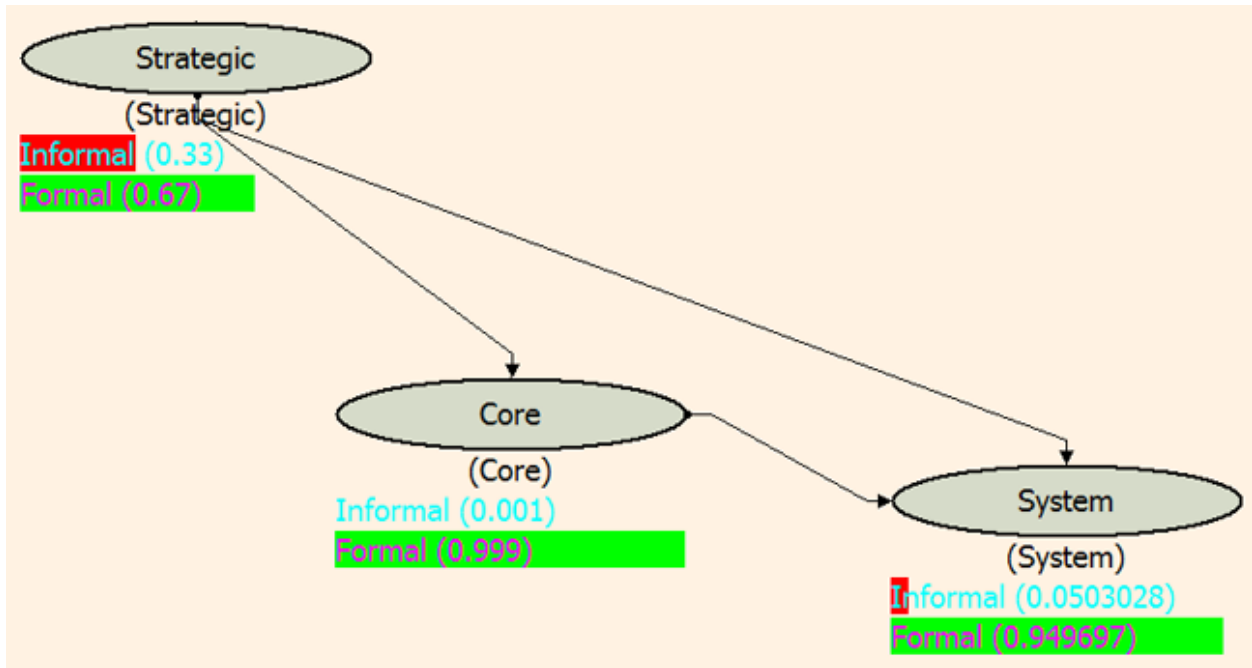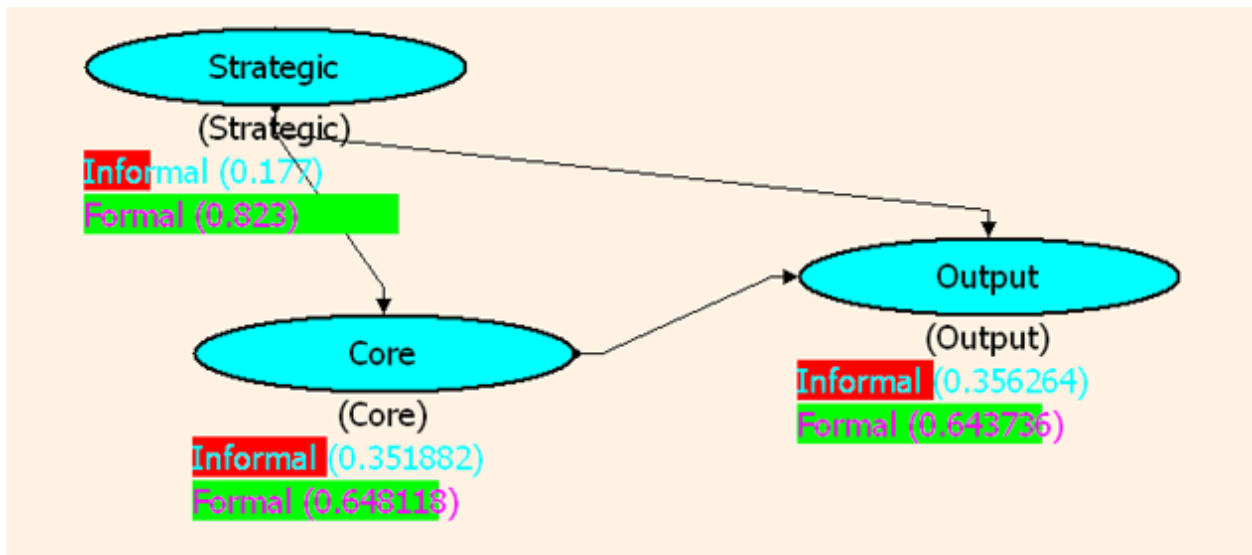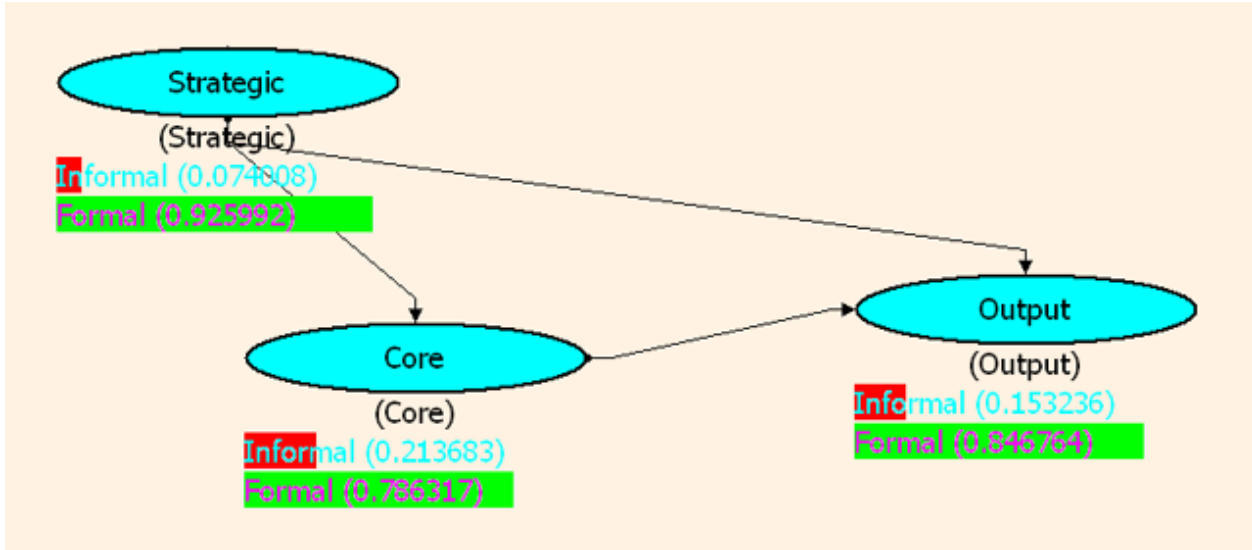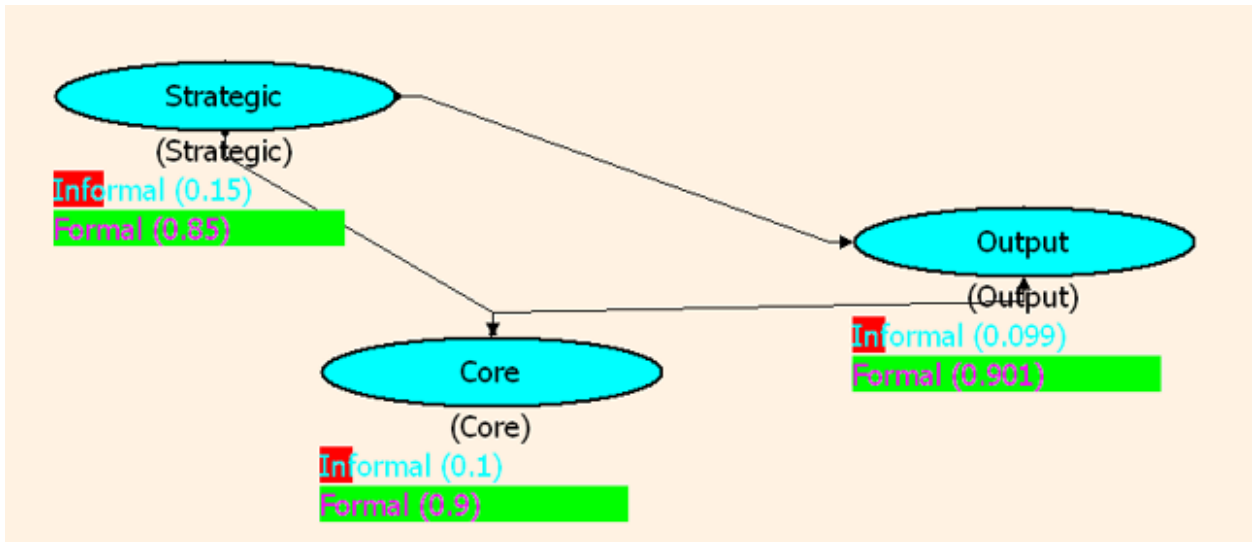
SME #6

SME #7

SME #9

Appendix L: M-2 Abbreviated Output BBNs
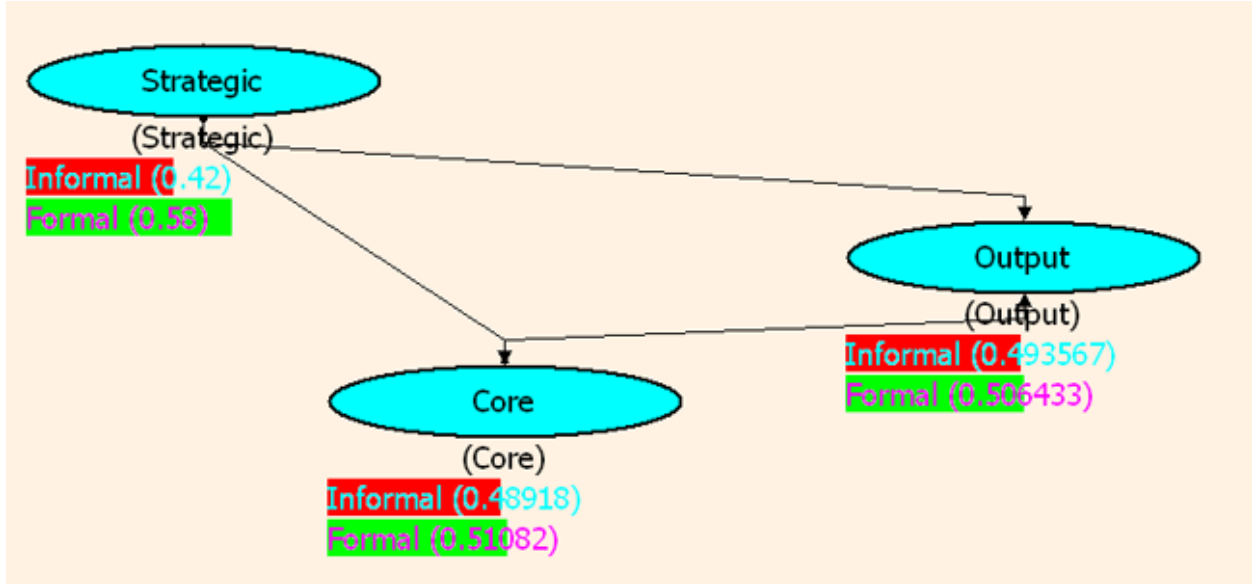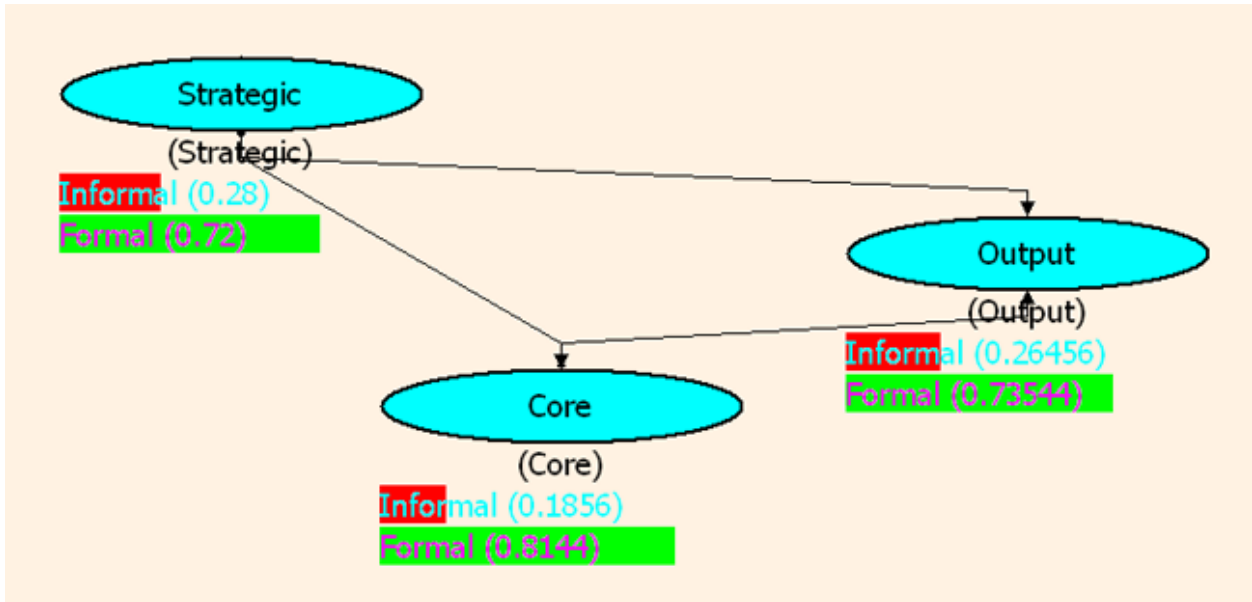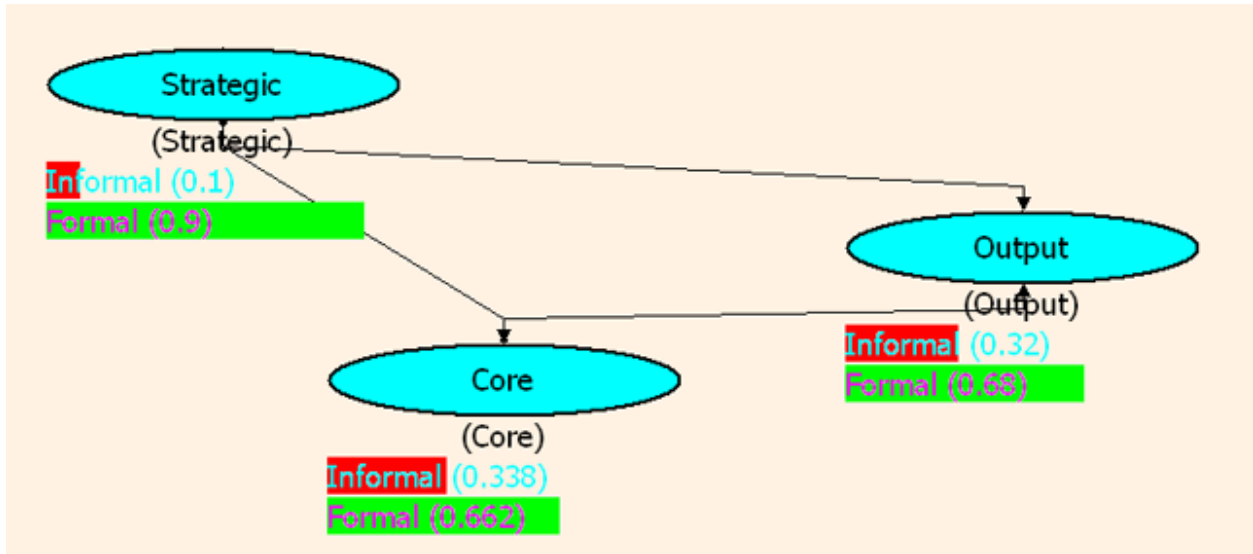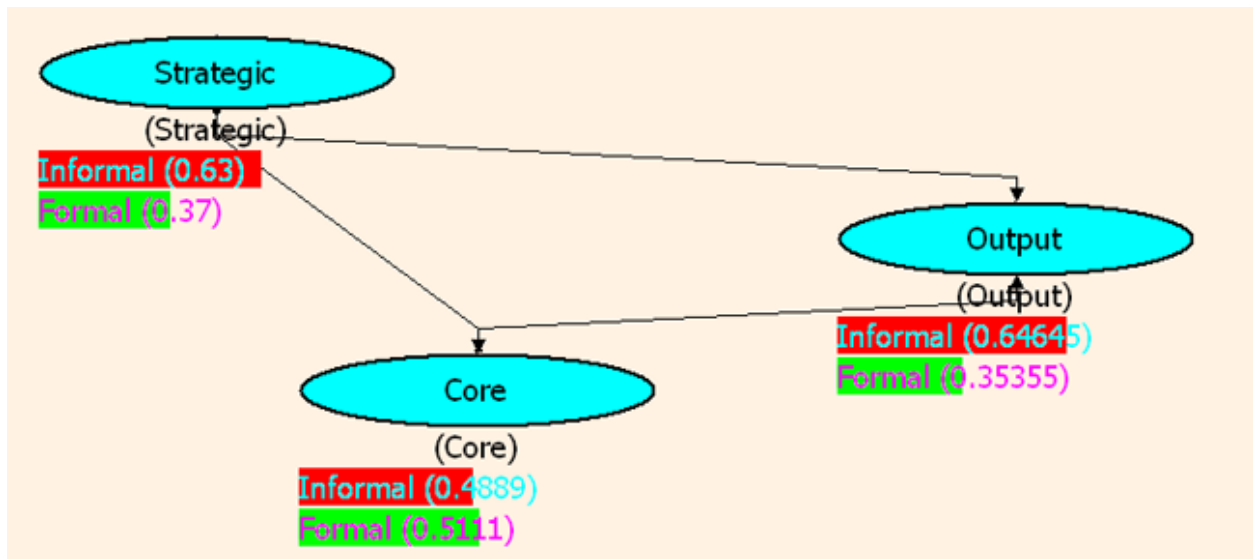
<u>SME #1</u>
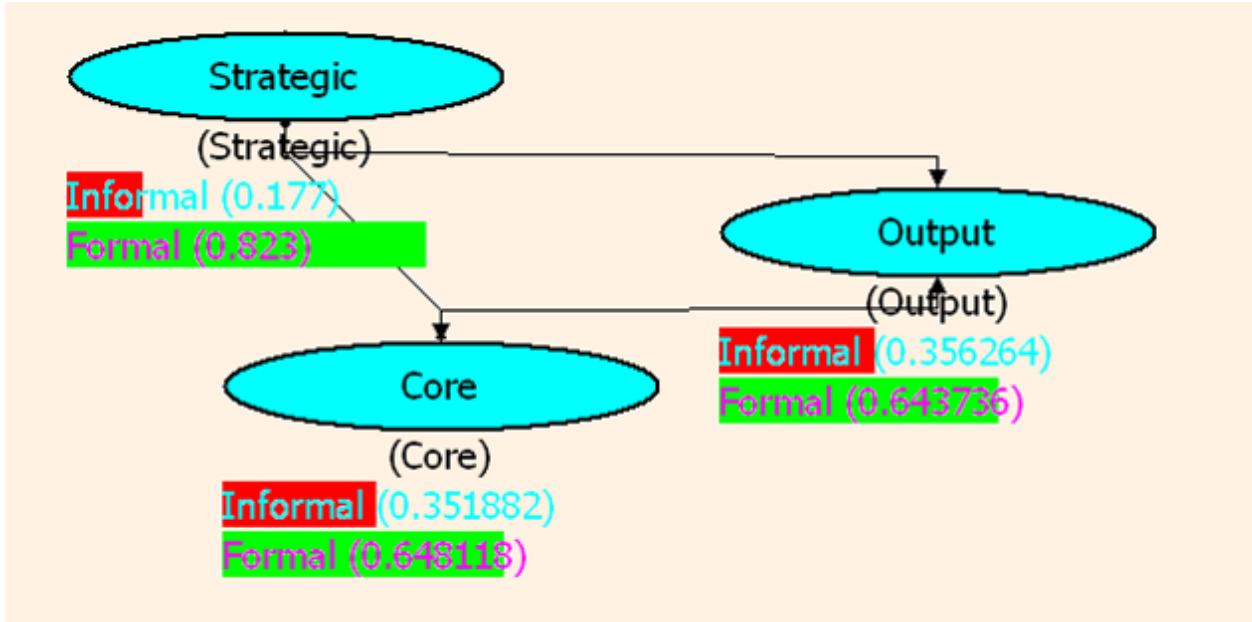
<u>SME #2</u>

SME #3

SME #4

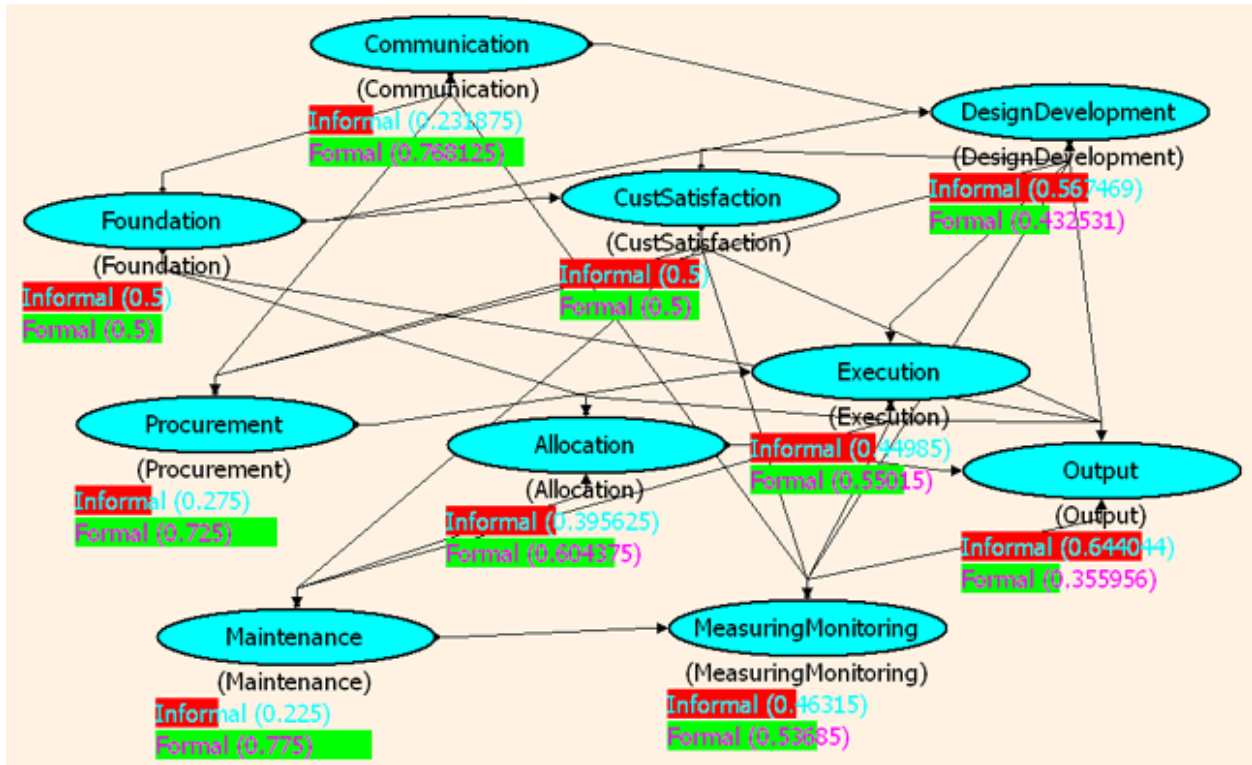**SME #6**

SME #7
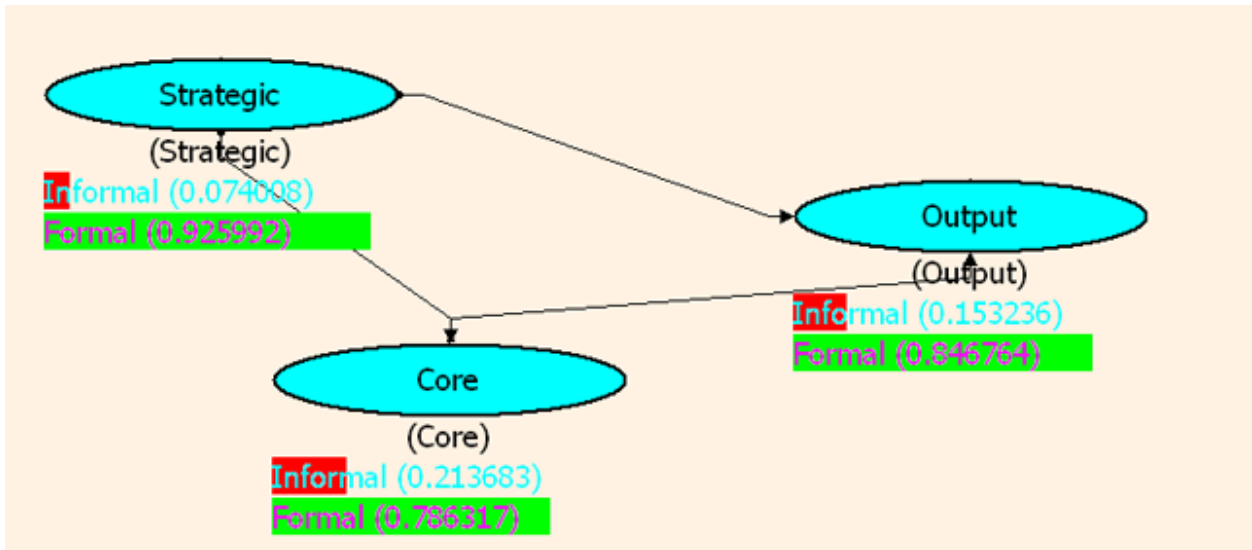
SME #9
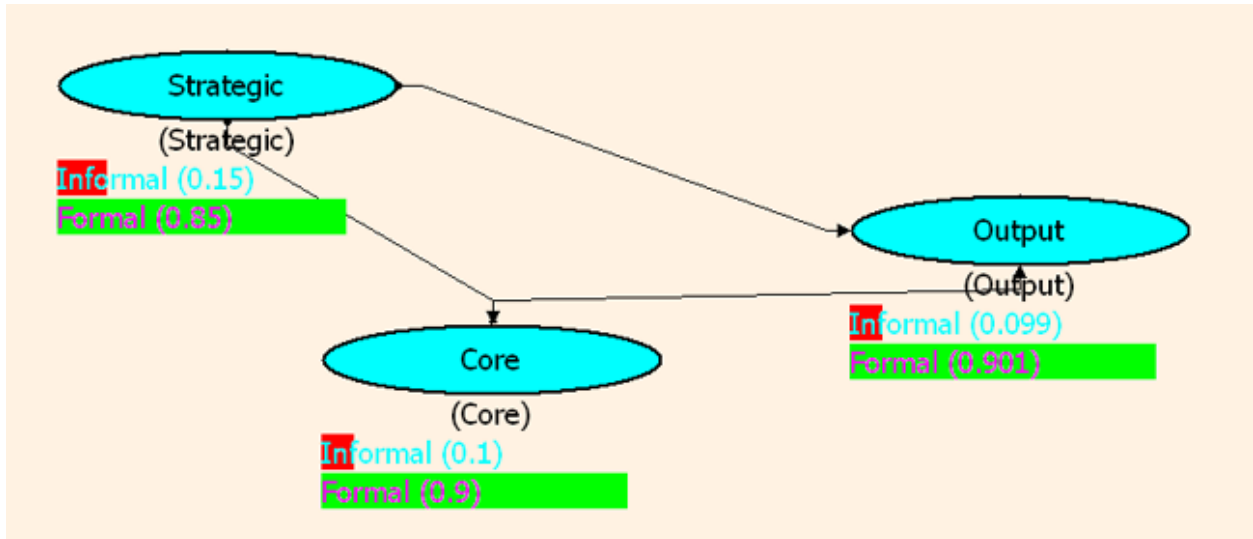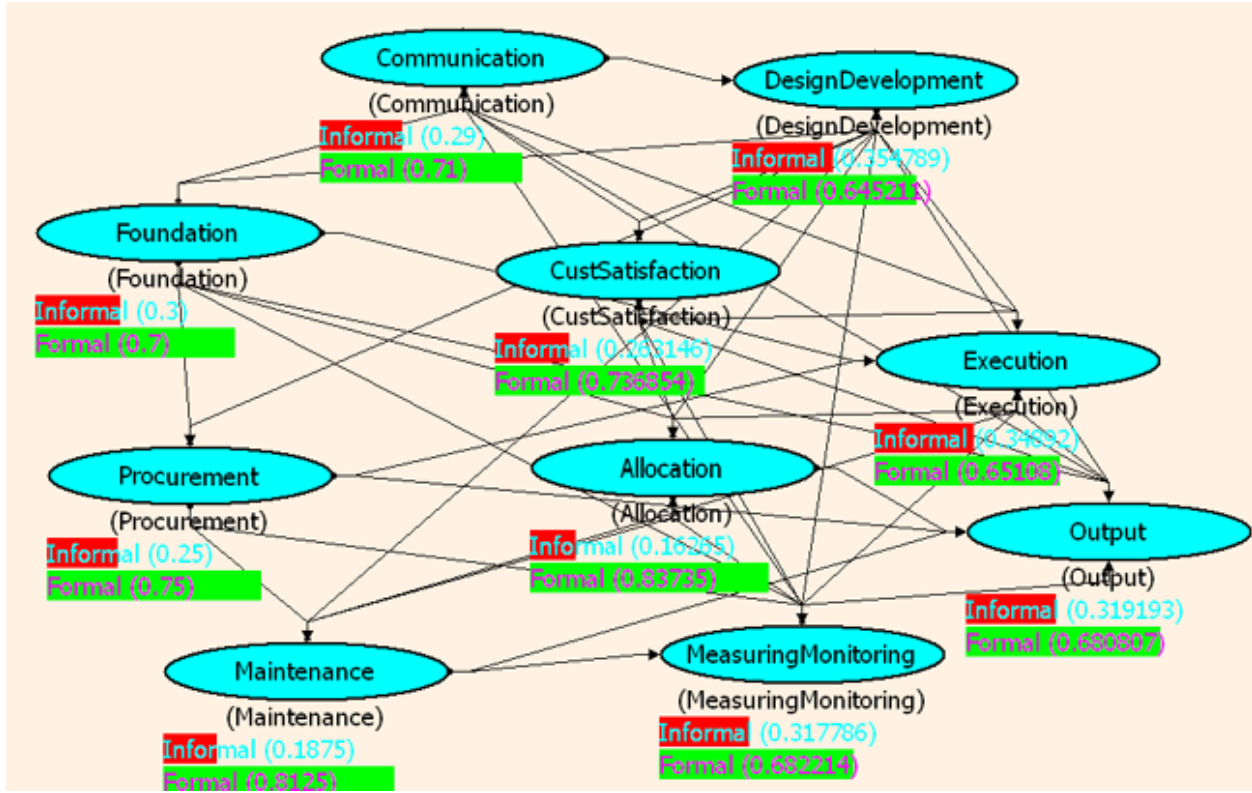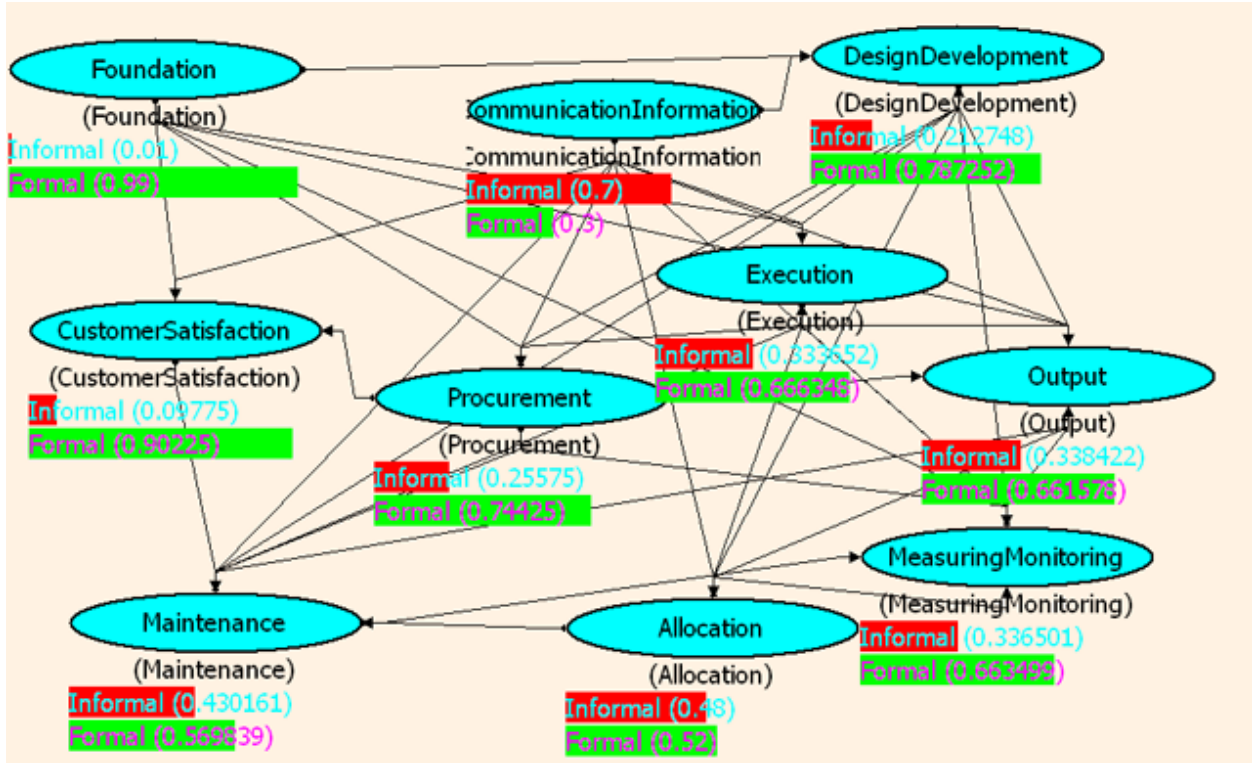
Appendix M: M-1 Expanded Output BBNs

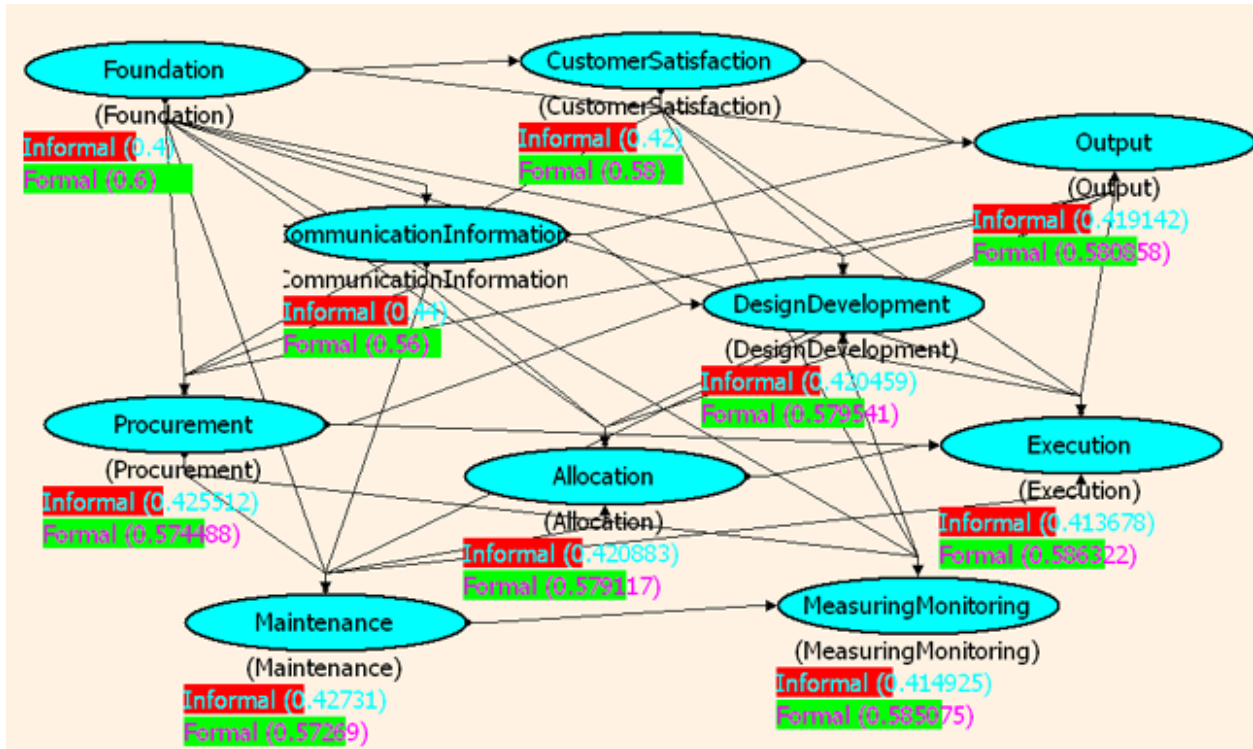**SME #1**

SME #2
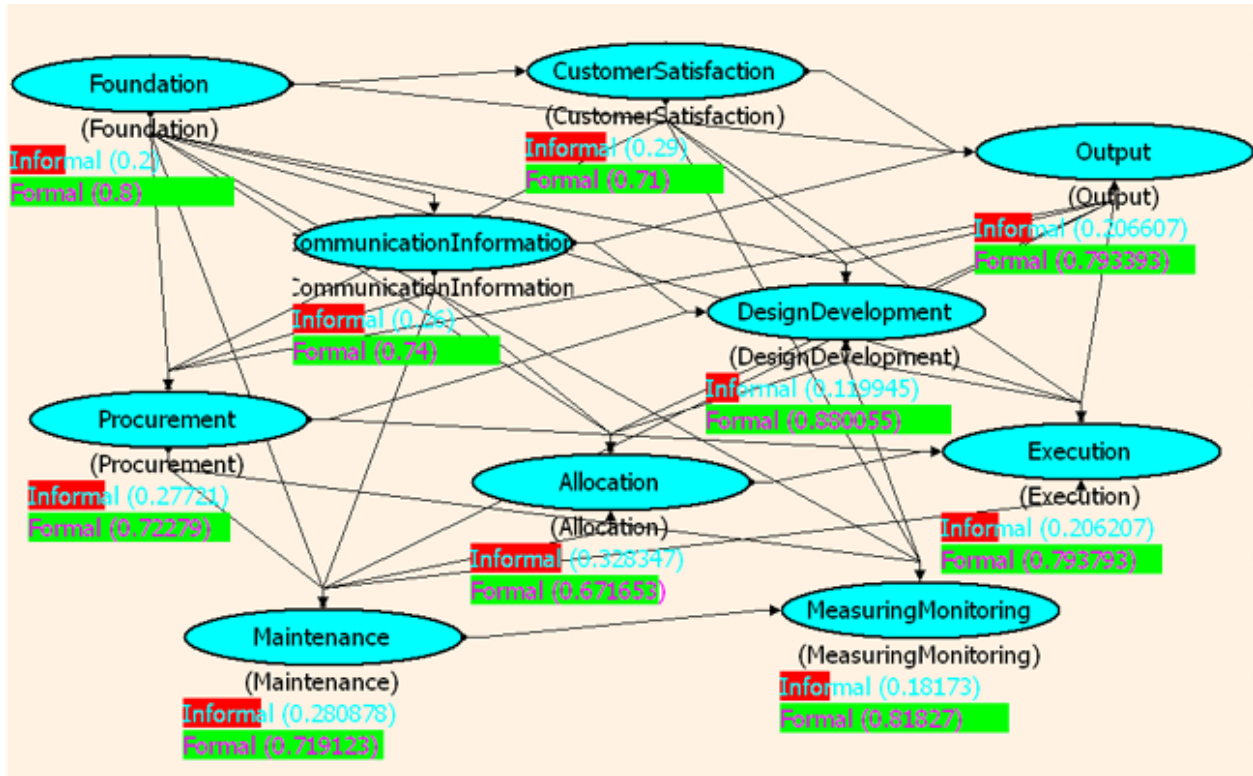

276

SME #4

278

SME #6

279
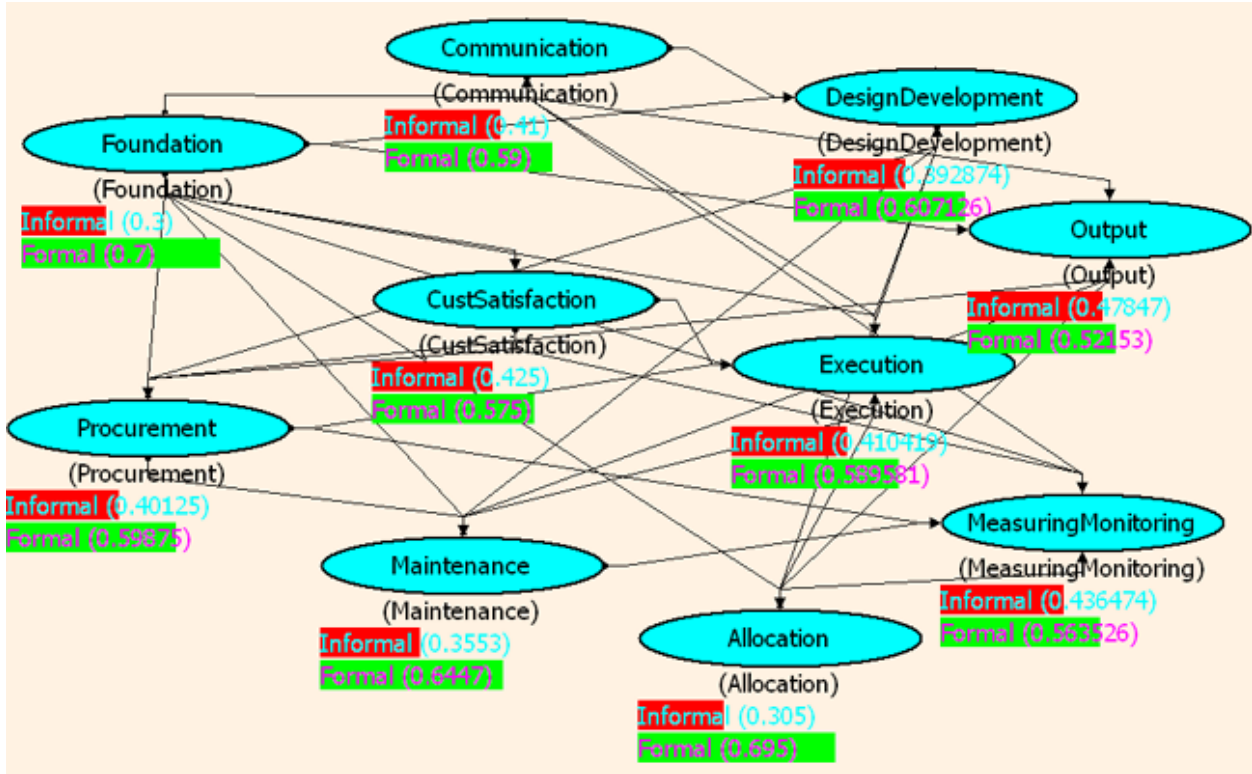
SME #9

Appendix N: M-2 Expanded Output BBNs

Group 1 – SME #1
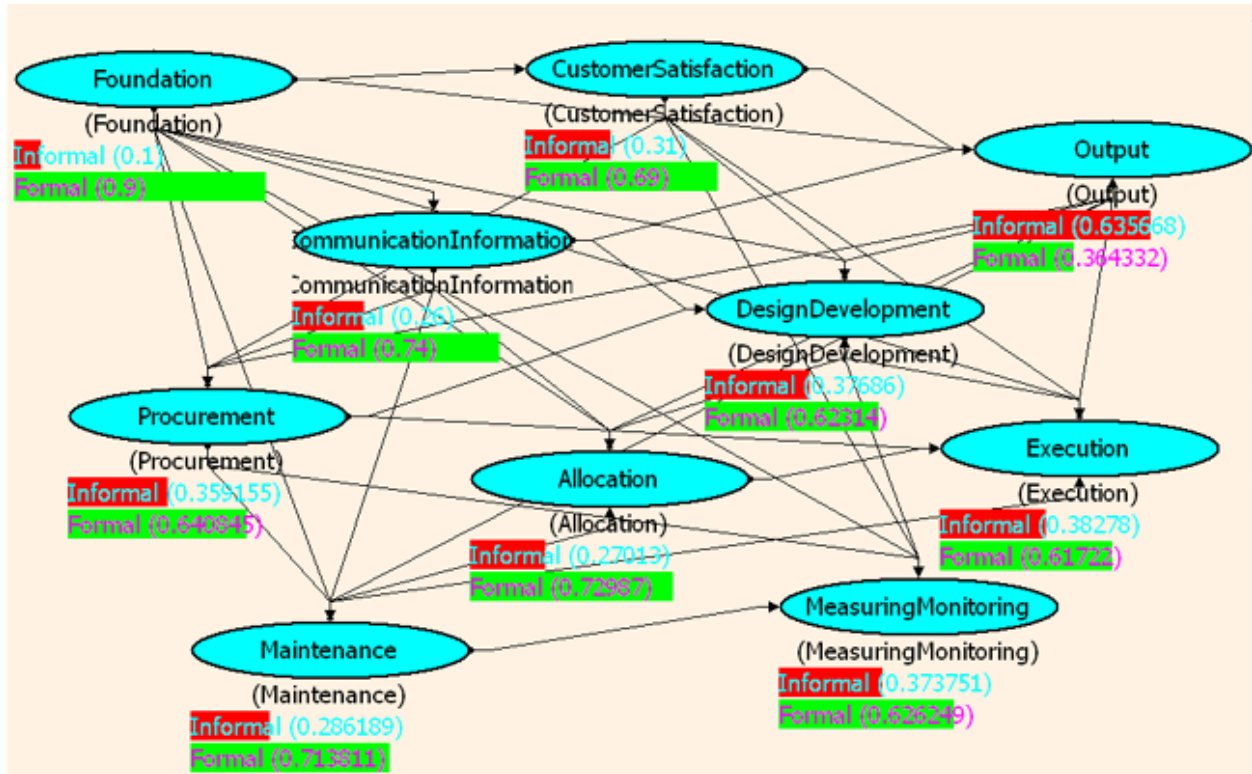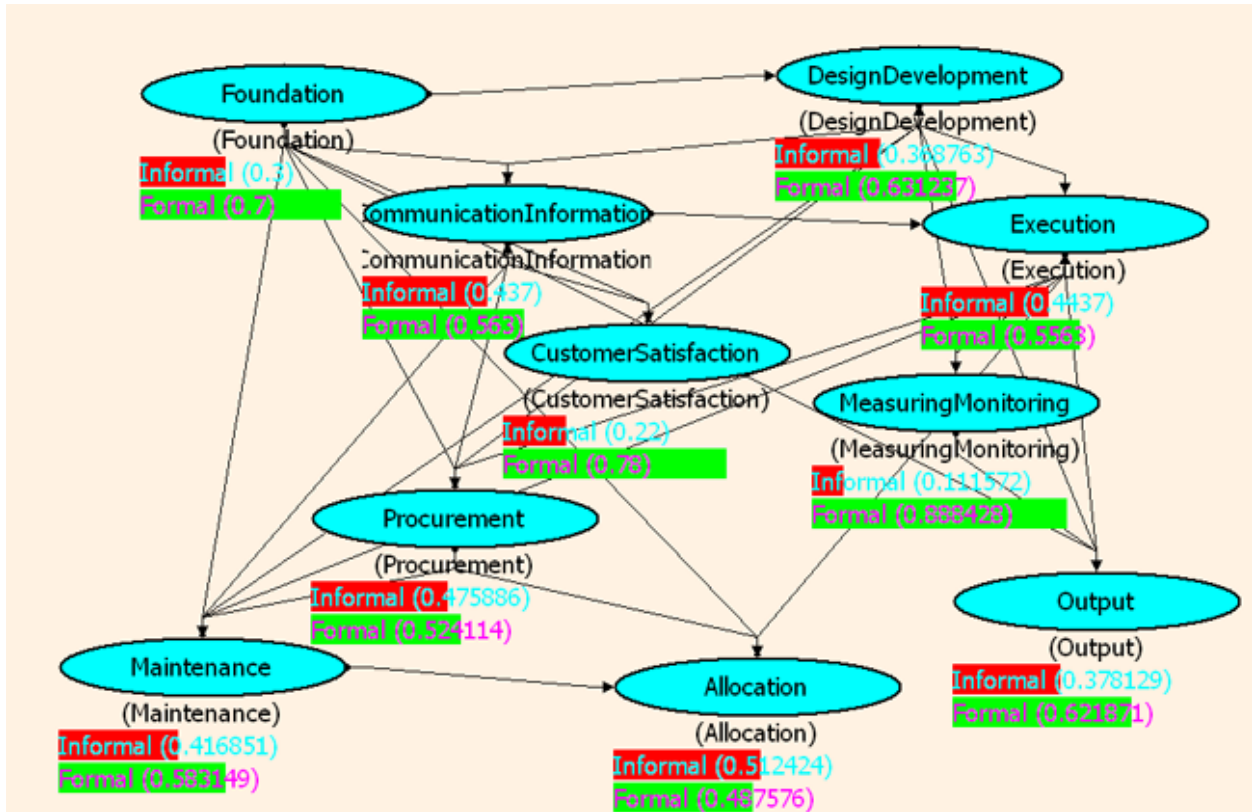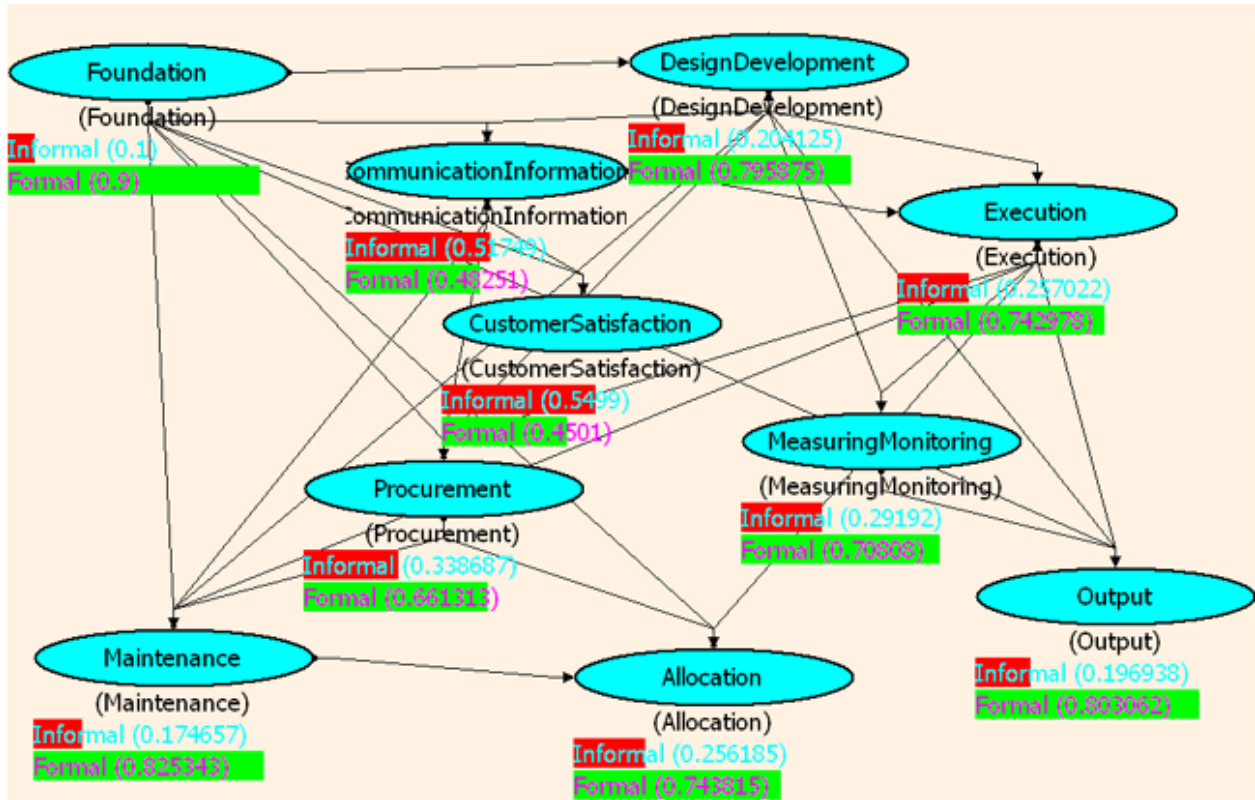
Group 1 – SME #3
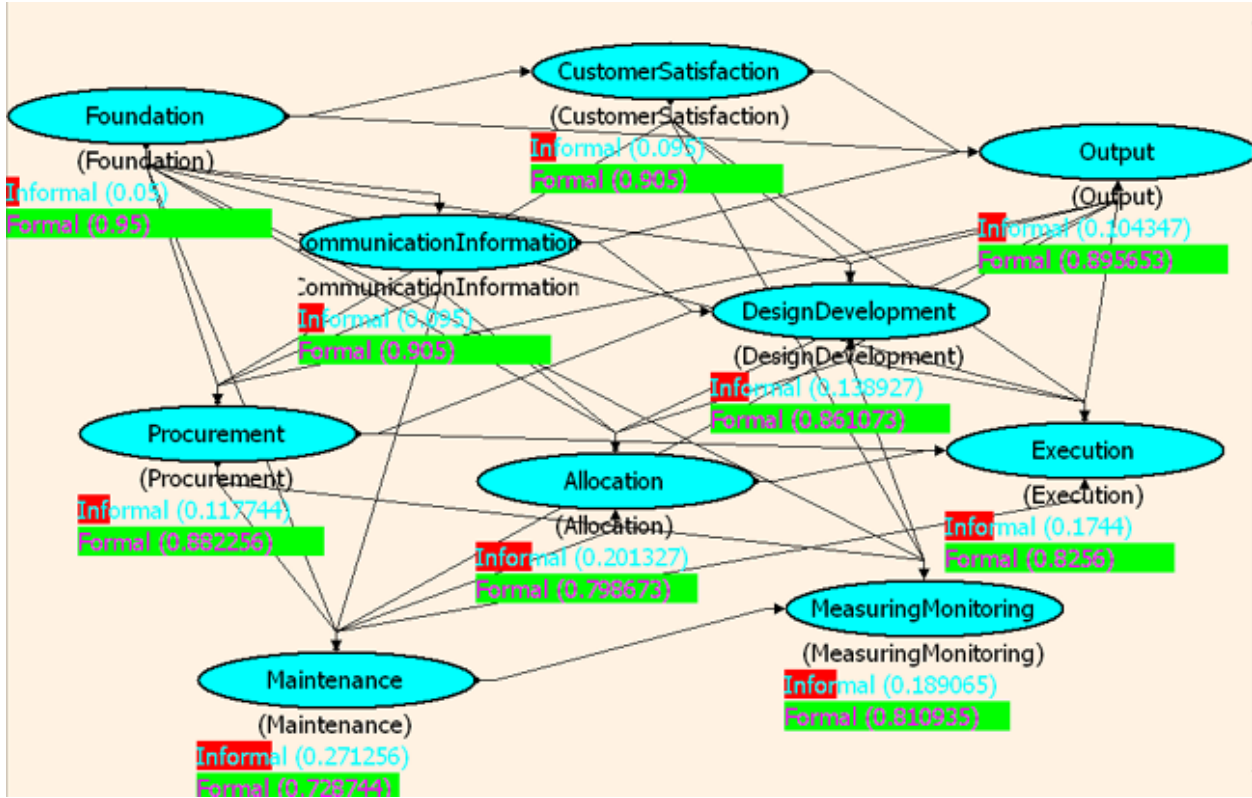
Group 2 – SME #6

Group 2 – SME #9

Glossary

Allocation – the act of distribution performed by apportioning items for a specific purpose.

Audit – an independent, objective evaluation of an entity's system's processes providing evidence of the effectiveness, efficiency, and compliance of the process as it relates to the entity's objectives.

Calibration – the act of checking or adjusting (by comparison with a standard) the accuracy of a measuring instrument.

Communication – the process of transferring information from a sender to a receiver with the use of a medium in which the communicated information is understood by both the sender and the receiver.

Control/Informational Informal Process – a process that supplements or deviates from the formal process in terms of the controls.

Controls – documented or oral information that establishes the method(s) required t achieve the output; all applicable internal and external regulations, standards, specifications, etc.

Core Processes – the realization processes (those that provide the intended output of the organization) and measuring and monitoring processes (those utilized in the measurement and gathering of data for performance analysis, effectiveness, and efficiency).

Customer Satisfaction – a measure of the degree to which a product, service, or information meets the customer's expectations

Data – a representation of facts, concepts, or instructions in a formalized manner.

Equipment – an item of tangible property that retains its original shape, appearance, and character with use; does not lose its identity through fabrication or incorporation into a different or more complex unit; is non-expendable.

External Customer – a person or organization that receives a product, service, or information, but is not part of the organization supplying it.

External Factor – any item that contributes logically or causally to a process or system, but that is not within the control of the organization.

Facilities – a building or place that provides a particular service or is used for a particular industry.

Formal Process – an accepted collection of activities which converts inputs into outputs, utilizing appropriate, consistent resources and directed by controls. Formal processes may be documented or undocumented.

Foundation – the fundamental assumptions from which something is developed.

Foundation Processes – those processes that determine the fundamental framework from which the goals of an organization are attained.

Functional Informal Process – is an informal process that occurs when there is no defined formal process by which to achieve an objective.

Human Resources – the function of the organization that is responsible for the recruitment, administration, management, and training of employees.

Humans – personnel.

Informal Process – an activity that is not formalized with respect to inputs, resources, and/or controls.

Information – organized data that has been arranged for better comprehension, understanding, and/or retrieval.

Input – an event or circumstance that initiates activity required to achieve an objective.

Inspection – a formal or official examination that determines if the output is of sufficient quality based on the examination of a predetermined number of samples from a given population.

Internal Customer – the recipient (person or department) of another person's or department's output (product, service, or information) within an organization.

Logistics – management of the flow of materials, equipment, and tools as required.

Maintenance – the care and work put into an asset to keep that asset operable and productive.

Management – the concepts, techniques, and processes that enable goals to be achieved efficiently and effectively.

Material – tangible substance that may lose its original shape, appearance, and character when incorporated into a different item.

Metrics – the various parameters of a process that are to be measured to assess the performance in any given area.

Objective – the goal intended to be attained (and which is believed to be attainable).

Operational Informal Process – a process that supplements or deviates from the formal process in the areas of equipment, tools, material, environment, humans, and/or inputs.

Oral – using speech.

Organization – a collection of people working together in a planned deliberate social structure to achieve a common goal.

Organizational Management Processes – those processes that enable goals to be achieved efficiently and effectively with a collection of people working together in a planned deliberate social structure to achieve a common goal.

Output – the completed objective.

Planning – the act of formulating a program for a definitive course of action.

Policy – a deliberate plan of action to guide decisions and achieve rational outcomes.

Preventive Maintenance – essential care and fixed time maintenance of an item regardless of its condition.

Process – a systematic sequence of activities which converts inputs into outputs utilizing resources and influenced by controls.

Procurement – the acquisition of goods and/or services at the best possible total cost of ownership, in the correct quantity and quality, at the correct time, in the correct place for the direct benefit or use of a corporation.

Purchasing – the acquisition of something for payment (materials, equipment, tools)

Resource – any physical or virtual entity of limited ability.

Resource Management Processes – those processes that enable goals to be achieved efficiently and effectively utilizing any physical or virtual entity of limited availability.

Scheduling – setting an order and time for individuals to work.

Stock – a supply of items available for use.

Strategic Processes – those processes that include the organizational management processes (planning, policy establishment, determination of objectives, communication, and customer satisfaction).

System – a group of independent yet interrelated processes comprising a unified whole which serves a common objective.

Third-Party Customer – a person or organization that is independent of both supplier and customer organizations, but may become involved in an indirect way or is affected by it.

Tools – devices which provide an advantage in accomplishing a physical task, or provides an ability that is not naturally available to the user.

Training – teaching of knowledge, skills, and competencies to improve an individual's capability, capacity, and performance.

Tribal Knowledge – knowledge that is not commonly known by others within a company.

Written – set down utilizing letters or symbols to represent a language.

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