STAKEHOLDER ANALYSIS IN THE CONTEXT OF THE LEAN ENTERPRISE

by

Ignacio Grossi

Submitted to the System Design and Management Program in
partial fulfillment of the requirements for the degree of

Master of Science in Engineering and Management

at the

Massachusetts Institute of Technology

March 2003

Signature of Author ____

Ignacio Grossi
System Design and Management Program
March 2003

Certified By ____

Prof. Deborah J. Nightingale
Thesis Supervisor
Professor of Practice of Aeronautics and Astronautics and Engineering Systems

Accepted By ____

Prof. Steven D. Eppinger
Co-Director, LFM/SDM
GM LFM Professor of Management Science and Engineering Systems

Accepted By ____

Prof. Paul A. Lagace
Co-Director, LFM/SDM
Professor of Aeronautics & Astronautics and Engineering Systems

THIS PAGE INTENTIONALLY LEFT BLANK

STAKEHOLDER ANALYSIS IN THE CONTEXT OF THE LEAN ENTERPRISE

by

Ignacio Grossi

Submitted to the System Design and Management Program in partial fulfillment of the requirements for the degree of

Master of Science in Engineering and Management

ABSTRACT

This thesis combines three different areas of study that are very active nowadays: Lean Enterprises, Stakeholder Theory, and Social Networks. Elements from these three research areas have been articulated to produce a methodology that allows for the analysis of stakeholder systems. In order to successfully apply lean enterprise principles and practices the study of the way in which stakeholders are structured along the extended enterprise is an indispensable first step. In a similar manner, stakeholder management practices require the identification of the most salient stakeholders together with their motivations to participate in the enterprise's value creation efforts.

Original frameworks and methodologies for stakeholder systems analysis are presented in this thesis. Several qualitative, quantitative and systematic techniques have been developed that allow for the characterization and mapping of stakeholder networks. Among them are models for stakeholder systems representation, a process for the identification of stakeholders, a method to determine their salience and relationships relevance, and several stakeholder network metrics. Also is proposed and demonstrated the use of Dependency Structure Matrix technique for the analysis of stakeholder networks structural and functional characteristics. Some of these methodologies rely on known theories and practices such as social network analysis techniques and other graph theoretic concepts although their combination and further development provide an original set of tools for the analysis of stakeholder systems.

All these methodologies were applied to a real case enterprise scenario. The stakeholder system of a relatively small space application enterprise was analyzed and characterized. Several important conclusions were derived from this enterprise's stakeholder analysis, demonstrating the capabilities and adequacy of the methods and techniques proposed.

Thesis supervisor: Deborah J. Nightingale
Title: Professor of Practice of Aeronautics and Astronautics and Engineering Systems

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

TABLE OF CONTENTS .... - 5 -
LIST OF FIGURES .... - 7 -
LIST OF TABLES .... - 8 -
ACKNOWLEDGMENTS .... - 9 -
CHAPTER 1 .... - 11 -
INTRODUCTION .... - 11 -
  Context and Motivation .... - 11 -
  Thesis Objectives .... - 13 -
  Thesis Outline .... - 14 -
CHAPTER 2 .... - 15 -
LEAN ENTERPRISES .... - 15 -
  Lean Production .... - 15 -
  Lean Thinking .... - 16 -
  Lean Enterprise Value .... - 18 -
  Value Creation Framework .... - 19 -
  Stakeholders and the Lean Enterprise .... - 20 -
CHAPTER 3 .... - 23 -
STAKEHOLDER THEORY .... - 23 -
  Introduction .... - 23 -
  Stakeholders – A formal definition .... - 25 -
  Stakeholder Identification .... - 29 -
  Stakeholder Salience .... - 31 -
  Stakeholder Structure .... - 33 -
    Resource dependence analysis .... - 35 -
    Stakeholder networks .... - 35 -
  The Ladder of Stakeholder Loyalty .... - 36 -
CHAPTER 4 .... - 41 -
SUPPORTING THEORIES .... - 41 -
  Social Networks .... - 41 -
  Complexity Theory .... - 45 -
  Game Theory .... - 47 -
CHAPTER 5 .... - 51 -
STAKEHOLDER ANALYSIS MODELS .... - 51 -
  A Tale of Two Donkeys .... - 51 -
  The Dual View .... - 55 -
  Water-Drop Model .... - 56 -
    A generic example .... - 60 -
  Network Model .... - 64 -

Lean Enterprise Viewpoint - 67 -
CHAPTER 6 - 71 -
STAKEHOLDER NETWORK ANALYSIS - 71 -
Stakeholder Identification Methodology - 71 -
System Level Value Identification - 73 -
Initial Focal Organization - 74 -
Groups Identification - 75 -
The Litmus Test - 76 -
Registration Process - 76 -
Process Iterations - 77 -
Stakeholder Salience Methodology - 78 -
The Stakeholder Salience Index - 79 -
Relationship Salience Methodology - 86 -
The Relationship Salience Index - 86 -
Stakeholder System Structure - 89 -
Social Network Analysis - 90 -
Dependency Structure Matrix Methodology - 99 -
Measuring Functional Complexity - 102 -
CHAPTER 7 - 107 -
APPLICATION EXAMPLE - 107 -
Company Background - 107 -
Focus of the Stakeholder Analysis - 110 -
CCU Stakeholder Analysis - 113 -
CCU Stakeholders Identification - 113 -
CCU Stakeholders Saliencies - 120 -
CCU Stakeholders Relationship Saliencies - 122 -
CCU Stakeholders Network Structure - 126 -
CCU Stakeholders Network Functionality - 137 -
CCU enterprise qualitative models - 141 -
Water Drop Model - 141 -
Network Model - 142 -
CHAPTER 8 - 145 -
CONCLUSIONS AND FUTURE WORK - 145 -
REFERENCES - 149 -

LIST OF FIGURES

Number *Page*
Figure 1: Value Creation Framework .... - 20 -
Figure 2: Stakeholder identification and salience framework................ - 32 -
Figure 3: Stakeholder structure, "bicycle-wheel" model .... - 34 -
Figure 4: Network of Stakeholders .... - 36 -
Figure 5: Stakeholder system – Water drop model .... - 58 -
Figure 6: Stakeholder system - Network Model .... - 65 -
Figure 7: Stakeholder Identification Process Flow Diagram................ - 72 -
Figure 8: Radar plot of stakeholder attributes: Power, Legitimacy, and Criticality .... - 80 -
Figure 9: Stakeholder relationship intensity................ - 87 -
Figure 10: Stakeholder network density and its related functional Complexity................ - 92 -
Figure 11: Betweenness Centrality calculation example .... - 97 -
Figure 12: Stakeholder DSM Example – DSM setup................ - 100 -
Figure 13: Stakeholder DSM Example – Partitioning and Clustering................ - 101 -
Figure 14: Space Station Fundamental Biology Research Facility (SSFBRF) .... - 112 -
Figure 16: CCU Stakeholders – Water Drop Model representation................ - 142 -
Figure 17: CCU Stakeholders – Network Model representation .... - 143 -

LIST OF TABLES

Number *Page*
Table 1: Key differences between a Shareholder Firm and a Stakeholder Firm .... - 25 -
Table 2: Different definitions of the stakeholder term .... - 27 -
Table 3: Ladder of Stakeholder Loyalty .... - 40 -
Table 4: Relationships among stakeholders – Type and Characteristics................................. - 77 -
Table 5: Stakeholder's Criticality level determination.. - 83 -
Table 6: Stakeholders' Power level determination .... - 84 -
Table 7: Stakeholders' Legitimacy level determination... - 85 -
Table 8: Payload Systems – CCU project stakeholders.. - 117 -
Table 9: CCU enterprise – Other relevant stakeholders .... - 119 -
Table 10: CCU Stakeholder Salience Indices calculations .... - 121 -
Table 11: CCU Stakeholder Relationships – Adjacency Matrix .... - 123 -
Table 12: CCU Stakeholder's Relationship Salience Indices.. - 125 -
Table 13: CCU Stakeholders Centralities.. - 130 -
Table 15: CCU Stakeholders – Information Centralities .... - 139 -

ACKNOWLEDGMENTS

This thesis work has truly changed the way I perceive the world around me. It is all about connections. I am grateful to my advisor, Debbie Nightingale, for opening my eyes to these exciting and challenging topics that are the lean enterprise and its associated stakeholder network. She has also provided invaluable guidance and support during the whole thesis research and writing process. Jointly we have created value and no muda has been found in the process (except for my English writing style).

I wish to thank Payload Systems Inc., in particular its CEO, Dr. Javier de Luis. He has kindly opened the company's doors to provide access to all the data I needed to create the application example that is part of this thesis.

In times of severe economic and political difficulties in my home country, Argentina, my sponsoring company, INVAP, still insisted in giving me this wonderful opportunity that was studying at MIT. I am grateful to INVAP, not only for the essential financial support but also for having believed in me the way they did. I am ready to demonstrate what I have learned here and to apply this knowledge to help to the welfare of the company and my country.

In this breathtaking (literally) journey I was not alone, my fellow classmates were always there to offer me advise, expertise, and friendship. Thanks to you all for enhancing this learning adventure. Particular thanks go to Al, Javier, and Tom for so many hours shared together preparing homework, studying for exams, and delighting wonderful meals. My admiration goes to you fellows for your amazing professional abilities and humanity.

Last but not least, I am profoundly grateful for the indescribable support and infinite patience of my most relevant stakeholders: my beautiful family – Julián, Florencia, and Ana María. Without them this educational experience would, simply, have not been possible. No words can actually describe my gratitude to them; I can only make one sure statement: it is now my turn to devote time to each one of you, to our relationships, and to the wonderful family moments to come.

THIS PAGE INTENTIONALLY LEFT BLANK

C H A P T E R 1

INTRODUCTION

Context and Motivation

The lean enterprise model of the firm started empirically in Japan, with the efforts of the Toyota Motor Company to become leader in the automobile manufacturing business thus surpassing American companies like Ford or GM. The concepts and principles of what later was going to be known as the lean enterprise model, that had demonstrated their positive effect in the auto industry in Japan, were later researched and documented by members of the International Motor Vehicle Program at the Massachusetts Institute of Technology. Based on the results from that research the landmark book *The Machine that Changed the World* was published in 1990. The book extensively covered the principles and practices Toyota successfully applied to the production of cars, and compared those with the more traditional methods of American and European companies. Thus it was evident that a change in the occidental way of doing in that industry was necessary to regain competitiveness in the market. The lean production model and its subsequent lean enterprise model was the answer to that required change.

It was soon reasoned that the same methods were applicable to other industries and businesses as well. One of the most important movements towards lean implementations was done by the American aerospace industry, a highly competitive and complex business environment. MIT's Lean Aerospace Initiative, a joint effort of the industry, government and academia, was created almost a decade ago to respond to the lean implementation needs in the aerospace industry that was willing to project effectively to the 21st century. One of the maxims of the Lean Aerospace Initiative expresses that "a lean enterprise is an integrated entity which efficiently creates value for its multiple stakeholders by employing lean principles and practices."[1]

[1] Lean Aerospace Initiative website, http://lean.mit.edu

It is widely recognized within the lean enterprise body of research that stakeholders are essential to the successful implementation of lean principles and practices. In fact, the stakeholder viewpoint is of extreme importance when analyzing the value creation processes an enterprise must plan and implement in order to be competitive and survive in its market environment. Knowing who the receptors of the value creation processes will be is essential to define the direction the enterprise will take when considering its strategies, tactics, and operations.

Practically in every enterprise the stakeholders form a very complex system of relationships that needs to be well understood to properly implement lean principles and practices. Traditional stakeholders include *customers* (in their multiple forms of end users, acquirers, and/or distributors), *owners* (capitalists, shareholders, and corporations), *suppliers* (first-tier, second-tier, etc.), and *employee groups* (unions, minority groups, managers, blue collars, etc.) However, the list does not end there; many other secondary stakeholders may, at some point or another, acquire relevance and enhance or even interfere with an enterprise's value creation process. Consider, for example, the pressures of environmentalist groups over the nuclear power industry. The nuclear industry was developing at a regular and strong pace until the accidents first of Three Mile Island in the US in 1979 and later of Chernobyl in the former Soviet Union in 1986.[2] Environmentalist groups, acting as legitimate stakeholders since then, have used those two unfortunate examples as a claim to stop any further nuclear activity at many different local, national, and international forums. The effects of those pressures on the nuclear industry have been devastating. Not a single power plant has been ordered in the US since the Three Mile Island accident.

Moreover, the relationships among stakeholders are typically complex and dynamic. It is not unusual to find certain stakeholders exerting power by means of another stakeholder that has a stronger position with respect to the enterprise. The pressures of environmentalist groups on the nuclear industry were not applied directly to the nuclear companies but using instead the media and political lobby to strongly influence in the lack of support to the industry.

---

[2] Meltdown at Three Mile Island, http://www.pbs.org/wgbh/amex/three/index.html

The stakeholder view of the firm can be applied at many different levels in an enterprise whether that is the definition of the enterprise's growth strategies, the elaboration of operation plans, the analysis of the needs of different stakeholders and their influence on product architecture, design, and implementation, and so forth. It can also be applied to different enterprise scenarios, for example, the analysis of the value creation for just one of the products of the enterprise, a family of products, or multiple different products of the enterprise.

In summary, the analysis of stakeholders – who they are and how they are structured – is of fundamental importance when developing value creation opportunities within the lean enterprise model framework. The complexity of the stakeholder system requires the use of many system design and management methods and tools for its understanding.

Thesis Objectives

Every non-adventurous journey needs of a map to indicate how to get from here to there. That map can be as simple as verbal directions, or as sophisticated as a GPS-based electronic map, but needs to be there to conduct someone to a destination. Tracing a map involves careful observation and knowledge of the terrain's details; one needs to identify what the different referential elements are (mountains, valleys, rivers, and routes, among others), how are they contained in the mapping area of interest, and finally how those elements are interrelated (after a route intersection comes a bridge, after the bridge there is a winding road, and so forth). Only after this analytical process one is able to draw and eventually use the map. The final product will not tell which is the best strategy or the best route to go from point A to point B, but will be essential to plan and later to implement the journey. Using maps we humans, or more recently, intelligent computer applications, can design the most efficient way and even alternate routes to connect two points.

Implementing a lean enterprise initiative is a long journey – most likely a never-ending journey that must be carefully planned and frequently revised if one is willing to succeed. Thus any lean enterprise initiative will have need of many different level maps in order to achieve the initiative's partial or final goals. As we stated before, the practices associated with stakeholder analysis are crucial for the implementation of lean enterprise initiatives. The main objective of this thesis work is to develop qualitative and quantitative tools that aid us in constructing the maps needed to traverse the field of stakeholder analysis. We certainly are not looking for strategies or tactics to navigate stakeholder maps; the existent literature on the subject is plagued with should-do-this-or-that recommendations. We are looking for frameworks, methods, and tools that aid us in building and understanding such maps.

Stakeholders are the rivers, mountains, and valleys of stakeholder systems maps. We need to understand who they are, why are they interested in the enterprise, and how they are structured with respect to the enterprise. Consequently, the objectives of this thesis work are to provide tools and frameworks that can be applied by enterprises' managers to assist in the understanding of stakeholders systems. In particular, we will be looking for tools that allow for:

- The identification of the stakeholders of an enterprise, including the determination of the boundaries of its stakeholder system.
- The assessment of the salience or relevance of each stakeholder
- The discovery of the structure of the stakeholder system in order to assess its complexity and the actions derived from that.

Thesis Outline

Chapter 2 presents some of the history and fundamental principles of the lean enterprise model of the firm. It also covers the Value Creation framework that will be essential for the development of our stakeholder analysis tools. Chapter 3 presents some common definitions and practices found in stakeholder theory. Chapter 4 introduces some supporting theories, like social networks and complexity theory that will help us to develop our proposed stakeholder analysis tools. Chapter 5 presents qualitative frameworks for stakeholder analysis, and Chapter 6 elaborates on more quantitative or analytical tools. Chapter 7 develops an application example of those tools to a real case scenario. Finally, Chapter 8 presents the conclusions and possible future work related with the content of this thesis.

C H A P T E R 2

LEAN ENTERPRISES

This chapter presents some of the fundamental concepts, principles, and practices of what is known today as the Lean Enterprise model. Most importantly, the lean value creation framework is introduced, where the relevance of stakeholder analysis becomes evident.

Lean Production

It was in 1990 when James Womack, Daniel Jones, and Daniel Roos wrote the book *The Machine that Changed the World*.[3] In their book they established the basis for what today is known as the Lean Enterprise Paradigm. They explained, after many years of research in the automotive industry, how some Japanese companies had changed for good the mass-production concept developed by Henry Ford and widely used by North American and European companies. This new production paradigm was called Lean Production. Led by the Toyota company efforts, lean production was aimed at reducing – or more profoundly, eliminating any source of *waste* from the production system. The term 'lean' was used in this context because this production method utilized less of everything when compared to mass-production: less material inventories, less time to develop a new product, less time to produce a car, less space in the plant, and so on. In other words, it meant reducing any step or process that consumed some resource and did not add value to the final product.

The focus of *The Machine that Changed the World* was mainly on production, although it analyzed the upstream and downstream factors that affected it, such as product development and engineering, supply-chain coordination, and customer relationship management. In other terms, lean production focuses only on manufacturing efficiency, which typically is expressed as:

Manufacturing Efficiency = Product produced / Resources Consumed by Manufacturing

---

3 Womack J.P., Jones D.T., and Roos D., *The Machine That Changed The World: The Story of Lean Production* (New York: HarperPerennial, 1991)

Lean Thinking

Womack and Jones' second book, *Lean Thinking*,[4] expanded the concepts of lean production to cover other aspects of the lean enterprise model, providing a more holistic view of the firm. They stated in this book that *lean* is a way of thinking about an organization and its processes, and is the driving force behind the integration of the individual lean efforts carried out in each one of the activities or processes of the enterprise. They introduced the five basic principles of lean thinking: specify the *value* of specific products, identify the *value stream* for each product, make value *flow* without interruptions, let the customer *pull* value from the producer, and pursue *perfection*.

According to Womack and Jones *value* can only be defined by the ultimate customer of a product or service. A product shows value when it satisfies customer's needs at an acceptable price at a specific time. A product's value is created by the producer. Creating value is the ultimate reason of why an enterprise exists. We will see later that value must not only be created for end customers but also for all participants (stakeholders) involved with the enterprise.

The *value stream* is the process or set of activities required to bring a product or service from its conception to its final delivery form to the customer. Identifying the value stream for each product helps in discovering opportunities to apply lean practices. This analysis allows for mapping three types of activities that are typically present in every value stream of any enterprise: activities that unambiguously create or add value to the end product; activities that create no value but are necessary to support the value creation activities; and activities that add no value nor support any other activity. Making more efficient the type two activities and eliminating the type three activities contribute to the goal of achieving a lean enterprise. Value stream analysis should be performed for all the activities necessary to produce a product or service. This involves thinking beyond the boundaries of the firm and incorporating into the process other actors (stakeholders) that contribute to produce the final product.

4 Womack J.P., Jones D.T., *Lean Thinking* (New York: Simon & Schuster, 1996)

Value creation steps must *flow* through the enterprise. This means that the interfaces between any two activities in the value stream – whether they are internal or external to the firm, must be minimized and streamlined in such a way that the product does not encounter any resistance (non-value added activities) in moving to the next step in the process.

The end customer must *pull* the products from the producer rather than the producer to push products to the customers. Complying with this principle will ensure that no unwanted inventories will be waiting for customers to buy them. In the extreme application of this principle an enterprise should solely produce a unit of a product only when a real customer demands it. The same principle must be applied for every step in the value stream: no upstream activity must produce its goods unless a downstream step requires them.

The analysis of the above mentioned principles should be done continuously in order to pursue *perfection* in the goal of achieving a lean enterprise. An enterprise is not a static entity but rather it changes according to new opportunities in its environment and the actions of other parties. Pursuing those opportunities and constructing on the actions of others will inevitable generate different reactions among the internal and external constituents of the enterprise. Many of these reactions will certainly open new opportunities for improvement.

An overarching principle and practice of lean thinking is the implacable search and elimination of *muda* at every level in the enterprise. Muda is the Japanese word for useless or waste. It represents all the activities or processes that consume a resource of any nature but do not add value to the final product – the third type of activity in the description of the value stream above. The most common types of muda as defined by Taiichi Ohno, the creator of the Toyota Production System, are: mistakes in any step of the production process, overproduction of parts or final products, excessive inventory of raw materials, unnecessary processing, unnecessary motion of people, unnecessary transportation of goods, and waiting times. Although this list was originally applied to Toyota's manufacturing processes it well represents the sources of waste that are typically found in other levels or processes of any enterprise.

However, when considering enterprise level waste, it is important to add two important sources of waste to the ones described above: opportunity costs, and structural inefficiencies.[5] Opportunity Cost waste results, for example, from lost opportunities in the marketplace or ill-defined business strategies. Structural Inefficiency waste is produced, for example, by inappropriate organizational structures, or bad business model structures.

Lean Enterprise Value

A lean enterprise can be measured by its efficiency in creating value to all the stakeholders. In this case, we can express the efficiency of a lean enterprise by the following relation:

Lean Enterprise Efficiency = Value Created for All Stakeholders / All Contributions to the Enterprise

It is important to understand the components of this equation. In a recently published book, *Lean Enterprise Value*,[6] written by members of MIT's Lean Aerospace Initiative (LAI), the three concepts – lean, enterprise, and value are explained in great detail. An enterprise is the interconnected whole comprised of one or more organizations having related activities, unified operation, and a common business purpose. We will extend on this definition later but in essence an enterprise is formed by all the internal operative entities of a firm plus all the organizations that help in the process of value creation. All these different entities constitute what is known as the *stakeholders* of an enterprise: those entities that hold a 'stake' or a legitimate interest in the results of the operations and strategies of the enterprise. In order to survive, an enterprise must create value for each and every one of its stakeholders. Each stakeholder will essentially be looking for different gains, utilities or benefits in exchange for its contribution to an enterprise. Stakeholders' contributions can be of various forms ranging from different types of resources (financial, raw materials, plant capacity, work hours, etc.) to supporting activities (media coverage, government regulations, etc.) The value or benefit one stakeholder is looking for very often conflicts with that of many others as not all the stakeholders necessarily obtain value from the end products

[5] 'Enterprise Level Waste', lecture notes from MIT's graduate level course 16.852J "Integrating the Lean Enterprise"

[6] Murman E. et al., *Lean Enterprise Value* (New York: Palgrave, 2002)

delivered by the enterprise. A lean enterprise reaches its highest efficiency when *all* the stakeholders are satisfied by what they obtain from their contributions.

Value Creation Framework

The authors of *Lean Enterprise Value* suggest a value-creation framework that has three phases: value identification, value proposition, and value delivery (Figure 1). They define that value is created for each stakeholder when they find adequate worth, utility, benefit, or reward in exchange for their contributions to the enterprise. A necessary first step involves the identification of all the stakeholders that form the enterprise. Only then can the *value identification* analysis step be performed, which involves determining and understanding the needs, interests, and benefits each one of the stakeholders expects from contributing and participating in the enterprise. A first attempt to align portions of the entire value stream map to those needs must be done at this stage, determining which activities add value to which stakeholder.

During the *value proposition* phase a value trade off analysis must be performed to obtain a fair value offer for each stakeholder, one that reflects as much as possible its needs and interests. That trade off results from the differences in the values pursued by each one of the stakeholders. A lean enterprise should strive to provide a *balanced* and a *robust* value proposition. A balanced value proposition is one that is agreed and accepted by each and every one the stakeholders of the enterprise. While this agreement process is not easy it is essential for the survival of the enterprise. A robust value proposition allows for changes in the enterprise environment to occur without greatly affecting the balance of the value offer to the stakeholders.

The *value delivery* phase corresponds to what is typically known as the implementation phase. In many cases this phase takes the form of a manufacturing process but can also represent the delivery of a service, or any other process that actually embodies the exchange of value with stakeholders. Most of the realizations of lean we see today have focused on this last phase, and have applied lean principles only to 'do the job right' when producing products to end customers. The value-creation framework helps in ensuring that an enterprise is 'doing the right job'.

Source: Murman et al., Lean Enterprise Value

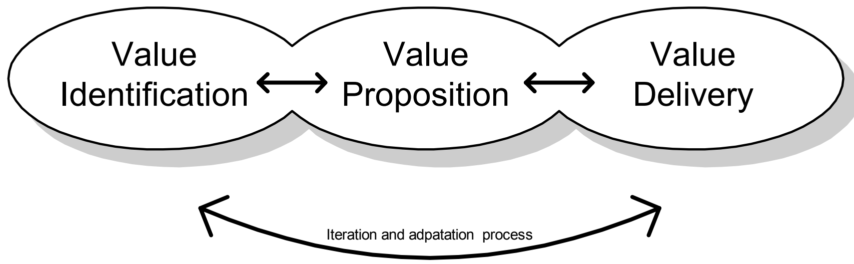


Figure 1: Value Creation Framework

The value-creation process is far from being static because value, stakeholders, and value propositions need to be frequently reevaluated in order to respond to each enterprise particular dynamic environment. In addition, the value-creation framework should be applied across all the relevant levels of an enterprise. This means analyzing the entire enterprise, paying attention to the different products, product lines, programs, and projects; and considering the local, national, and international impact of the enterprise actions.

Creating adequate value to all the stakeholders, providing balanced value propositions, and efficiently delivering value should be the ultimate objective of the waste elimination efforts that are carried out when implementing lean thinking practices. Waste elimination by itself does not help to achieve a better or a leaner enterprise. The goal of waste elimination must be directed by what the authors of *Lean Enterprise Value* call the 'true north' of any lean effort, which is precisely a value centered view of the entire enterprise. Becoming lean is a process of eliminating waste with the goal of creating value, not only for end users but also for all other stakeholders in an enterprise. A lean enterprise is an integrated entity that efficiently creates value for its multiple stakeholders by employing lean principles and practices.

Stakeholders and the Lean Enterprise

A lean enterprise consists of a set of more or less integrated entities such as owners, partners, suppliers, and customers, among others. These constitute, precisely, the stakeholders of the enterprise who together with it pursue and accomplish its value-creation processes. This enterprise of enterprises system is what the authors of *Lean Enterprise Value* have called the 'extended enterprise'. This system of interdependent entities is what will be referred throughout this thesis as the stakeholder system, whereas the extended enterprise will be referred simply as the enterprise.

One of the principles of lean enterprise value creation states that value must be delivered only after identifying stakeholder value and constructing robust value propositions. To this end stakeholders must be identified, their needs must be determined – find the reasons why they participate in the enterprise, their relative importance for the enterprise's processes must be evaluated, and the effect of stakeholder interdependencies and structure on the enterprise must be understood.

Any structural inefficiency that might be present at any level in the enterprise will create waste and will hinder the creation of value for some or all of the enterprise stakeholders. As stated before, structural inefficiencies may come from inappropriate organizational structures. This includes, but it is not limited to, poorly integrated stakeholders to the activities of the enterprise and the existence of unnecessary interfaces among stakeholders that impede collaboration and processes coordination. The lean enterprise paradigm calls for the rationalization of those interfaces – sources of waste – and the creation of a more cooperative environment among all stakeholders to efficiently achieve the goals of the enterprise.

We will see later in this thesis work that not only stakeholders' identification is necessary for guiding the value-creation processes of an enterprise. Knowing how stakeholders are structured and organized in relation with the enterprise, and what types of relationships exist among them is of great importance to the achievement of a lean enterprise. The complexity of the organizational relationships among different stakeholders and its consequences on the value creation processes represent both, a threat to the enterprise lean transformation, and a source of opportunities to successfully push the enterprise forward into the future.

THIS PAGE INTENTIONALLY LEFT BLANK

C H A P T E R 3

STAKEHOLDER THEORY

Knowing who the enterprise's stakeholders are, their relevance, how they are structured, and why do they participate in the efforts of an integrated enterprise are key factors to properly define and implement a value creation process that conducts to a better implementation of lean principles and practices. This chapter serves as an introduction to the stakeholder theory, which is precisely, aimed at answering the above-mentioned questions. The chapter will cover some common definitions necessary to frame the theory and then it will go to the details of the issues that form the theory as it is known today.

Introduction

The idea that enterprises have stakeholders is not new and has become commonplace in both academic and business thinking for the last 40 years. Stakeholder analysis has been applied to many diverse areas of study and applications such as economics, marketing, corporate governance, corporate social responsibility, business ethics, environmental issues, organizational studies, and so forth.

The stakeholder theory of the firm and its management implications contrasts with more traditional management control practices that are aimed exclusively at satisfying shareholder's (owners) interests. Some scholars (Donaldson and Preston, 1995) have focused on the problem of justifying the stakeholder theory as a valid alternative to those more 'conventional' practices. Although there is still not enough empirical evidence or analytical arguments that the enterprise efficiency is enhanced by practicing stakeholder management, there exist normative assumptions that allows for its justification. In particular, Donaldson and Preston argue that the stakeholder theory can be justified based on the "evolving theory of property". This theory's traditional view has been that a focus on property rights justifies the dominance of shareowners' interests. However, property rights are typically limited, i.e. the right of ownership is applicable up to the point where, for example, harmful uses of the property are exerted. These restrictions on property rights immediately bring in the concept of the existence of 'others' whose own interests (stakes) impose and exercise those limitations. Consequently, managers must focus their efforts not only shareholders but on many other stakeholders as well if they want to adequately defend property rights.

Supporters of stakeholder theory believe it key to more effective management and to a more useful, comprehensive theory of the role of the enterprise in society.[7] Kochan and Rubinstein (2000) present an excellent historical perspective of why the shareholder-centric view of the corporation and its correspondent management practices gained momentum in the past centuries, particularly within the American context. They also explain from historical facts why the stakeholders' viewpoint of the corporation is acquiring relevance since a few decades ago. They argue that the debate on which of these two points of view must prevail is going to continue as long as the question of how to obtain a more balanced and equitable distribution of social benefits and risks among multiple stakeholders remains unanswered. In order to bring some light to this argument they present the key distinctions between a shareholder-wealth-maximizing firm and a stakeholder firm. A summary of those key differences is presented in Table 1. In between these two extreme 'pure' models of the firm there exists a continuum of approaches where some characteristics of both models are present at the same time. For example, for some corporations the development of strategic alliances can satisfy attributes of both the shareholder and the stakeholder model of the firm. An alliance can be pursued in order to neutralize a competitor (co-option), to combine different set of resources and capabilities (cospecialization), and/or to learn and internalize new skills.[8] A stakeholder orientation of an alliance will indicate that a win-win type of relationship between the parties must be established. On the contrary, a shareholder orientation will view an alliance as a means for achieving higher returns (profits) to the owners or as a way of perpetuating the power position of the firm. Of course, the other party will be looking for the same goals thus generating the tensions we commonly observe in this type of alliances.

---

[7] See, for example, Mitchell, Agle, and Wood (1997)

[8] The terms co-option and cospecialization and their related concepts are from Doz Y.L. and Hamel G. (1998)

Table 1: Key differences between a Shareholder Firm and a Stakeholder Firm

Attribute	Shareholder Firm	Stakeholder Firm
Goal(s)	Maximize shareholder wealth	Pursue multiple objectives of parties with different interests
Governance Structure and Key Processes	Principal-Agent Model: Managers are agents of shareholders. Control is the key task	Team Production Model: Coordination, cooperation, and conflict resolution are the key tasks
Performance Metrics	Shareholder value sufficient to maintain investor commitment	Fair distribution of value created to maintain commitment of multiple stakeholders
Residual Risk Holders	Shareholders	All Stakeholders
Stakeholder Salience/Influence	Finance/investor/owners only stakeholder with sufficient power and legitimacy to achieve "definitive" status in governance processes	More than one stakeholder with sufficient power and/or legitimacy to achieve "definitive" status in governance processes

Source: Kochan & Rubinstein, 2000

What is clear is that the stakeholder firm constructs a multi-objective optimization function in order to achieve better efficiency by coordinating its actions among all the stakeholders. This is analogous to what we have expressed about lean enterprises in the previous chapter. There we stated that an integrated stakeholder viewpoint is of fundamental importance to the analysis of a lean enterprise.

Two questions are of great significance in stakeholder theory: who are the stakeholders (how to identify them), and how to define the boundaries of the enterprise in terms of which are the relevant stakeholders to consider (who are the most salient stakeholders).

Stakeholders – A formal definition

The term 'stakeholder' is inevitably associated with the idea of stockholder – the investors in or owners of a business. Stockholders are very important for financially and economically supporting a company's activities, but they are not the only ones who provide some kind of support. Stakeholder is a more comprehensive term involving other relevant actors that are essential for the life and continuity of an enterprise. The Shorter Oxford English Dictionary defines a stake as "that which is placed at hazard, esp. a sum of money, etc. deposited or guaranteed, to be taken by the winner of a game, race, contest, etc." It also defines '*To have a stake in (an event, concern, etc.)'* as "to have something to gain or lose by the turn of events." A stake then is an interest or a share in an undertaking. A stake is also a claim (tacit, or legal), a demand for something due or believed to be due. In between these two extremes of a simple interest and a legal claim is a 'right' for something, which can be either legal or moral (Carroll and Buchholtz, 2002).

In order to be able to precisely identify an enterprise's stakeholders we have to have a formal and complete definition of what constitutes one. Many scholars have provided different definitions, usually tailored to their particular area of study. Mitchell, Agle, and Wood (1997) present a chronology that shows how the definition of the term stakeholder evolved over the years. A summary of that chronology is shown in Table 2.

Probably the most widely accepted definition of what constitutes a stakeholder is given by R. Edward Freeman in his landmark book, *Strategic Management: A Stakeholder Approach*,[9] where he states that "**stakeholder is any group or individual who can affect or is affected by the achievement of the firm's objectives**"

To put this definition in the terms of this thesis work we need to say that 'the firm' should be actually what we have defined as 'enterprise' in the previous chapter. It is the whole enterprise system, and most likely some components more than others, that is affected by the achievement of the objectives of the firm. Reciprocally, the actions or inactions of each and every element of the enterprise (stakeholders) affect the attainment of those objectives. This talks about the complexity of the stakeholder system where strong and weak interdependencies alike can destabilize the enterprise system.

---

[9] See Freeman R.E., 1984

Table 2: Different definitions of the stakeholder term

Date	Author(s)	Definition
1963	Stanford memo	"those groups without whose support the organization would cease to exist"
1964	Rhenman	"are depending on the firm in order to achieve their personal goals and on whom the firm is depending for its existence"
1971	Ahlstedt & Jahnukainen	"driven by their own interests and goals are participants in a firm, and thus depending on it and whom for its sake the firm is depending
1983	Freeman & Reed	Wide: "can affect the achievement of an organization's objectives or who is affected by the achievement of an organization's objectives" Narrow: "on which the organization is dependent for its continued survival"
1984	Freeman	"can affect or is affected by the achievement of the organization's objectives"
1987	Freeman&Gilbert	"can affect or is affected by a business"
1987	Cornell & Shapiro	"claimants" who have "contracts"
1988	Evan & Freeman	"have a stake in or claim on the firm"
1988	Evan & Freeman	"benefit from or are harmed by, and whose rights are violated or respected by, corporate actions"
1988	Bowie	"without whose support the organization would cease to exist"
1989	Alkhafaji	"groups to whom the corporation is responsible"
1989	Carroll	"asserts to have one or more of these kinds of stakes" – "ranging from an interest to a right (legal or moral) to ownership or legal title to the company's assets or property"
1990	Freeman & Evan	Contract holders
1991	Thompson et al.	In "relationship with an organization"
1991	Savage et al.	"have an interest in the actions of an organization and… the ability to influence it"
1992	Hill & Jones	"constituents who have a legitimate claim on the firm… established through the existence of an exchange relationship" who supply "the firm with critical resources (contributions) and in exchange each expects its interests to be satisfied (by inducements)"
1993	Brenner	"having some legitimate, non-trivial relationship with an organization [such as] exchange transactions, action impacts, and moral responsibilities"
1993	Carroll	"asserts to have one or more of the kinds of stakes in business" – may be affected or affect…
1994	Freeman	Participants in "the human process of joint value creation"
1994	Wicks et al.	"interact with and give meaning and definition to the corporation"
1994	Langtry	The firm is significantly responsible for their well-being, or they hold a moral or legal claim on the firm
1994	Starik	"can and are making their actual stakes known" – "are or might be influenced by , or are or potentially are influencers of, some organization"
1994	Clarkson	"bear some form of risk as a result of having invested some form of capital, human or financial, something of value, in a firm" or "are placed at risk as a result of a firm's activities"
1995	Clarkson	"have, or claim, ownership, rights, or interests in a corporation and its activities"
1995	Näsi	"interact with the firm and thus make its operation possible"
1995	Brenner	"are or which could impact or be impacted by the firm/organization"
1995	Donaldson & Preston	"persons or groups with legitimate interests in procedural and/or substantive aspects of corporate activity"

Source: Mitchell, Agle, and Wood, 1997

Another obvious addition to Freeman's definition is the consideration of the possibility of an enterprise to fail in attaining its objectives, i.e. the objectives of a firm are not always achieved as planned. If this were the case, some or all the stakeholders and most likely the whole enterprise system will be negatively affected.

In terms of the objectives, if they are not properly defined using either the previously described value creation framework or any other method that takes into account the benefits to all stakeholders, a sub-optimization of the integrated value creation process will be obtained. Therefore, we assert that the objectives do not belong to a particular firm but must be defined for all the stakeholders – those who define the entire enterprise, which also includes the firm under study. This is not more than the construction of balanced and robust value proposition we mentioned in the previous chapter. Furthermore, the objectives can be partially attained and still be delivering some value to some of the stakeholders in the enterprise system. Each of the actions and results of the value creation processes can potentially benefit some stakeholders and even the entire enterprise.

There are other factors other than the achievement of objectives that can influence as well the stakeholder system. For example, the effects of an energy regulation policy implemented by a local government (a typical stakeholder of any enterprise) can impact on the results of the entire enterprise. This can constitute the root cause by which the income objectives for the year will not be met, thus affecting all the enterprise financial or economical structure. Because the goal of every enterprise is the creation of value (not only monetary value but also societal values) we will use this concept to define the level of achievement of the enterprise.

The 'affect or is affected by' portion of Freeman's definition also needs to be interpreted. The use of the verb 'affect' here implies the existence of levels or grades in the consequences derived from the actions of the enterprise. It also suggests that there is some relationship element connecting the parties being it an exchange mechanism (e.g., commercial contract, financial transaction), some type of influence relationship (e.g. political or media pressures), or any other kind of interaction (e.g. environmental issues), in which those consequences are reflected. Freeman's definition allows for both unidirectional and bi-directional type of relationships. The consequences of the achievement of an objective can be direct or indirect depending on how the stakeholder is related to the enterprise. If the stakeholder in question is of less relevance to the enterprise (meaning his/her stake has less relative value or is less risky than those of other stakeholders) then the consequences or impacts on him/her will be less important. Also, the consequences can be of many different types: economical, environmental, political, and social, just to mention some of the most important.

Although it is difficult to formulate a thorough explanation of what constitutes a stakeholder, one that includes all the elements presented above, we will provide here the following broad definition: **stakeholder is any group or individual who directly or indirectly affects or is affected by the level of achievement of an enterprise's value creation processes**. This extensive definition allows us not to arbitrarily exclude any stakeholder from our lean enterprise analysis. Also, by including the value creation framework, this definition ties some of the stakeholder theory concepts with the lean enterprise model we described in the previous chapter.

Stakeholder Identification

The above adopted broad definition of what constitute a stakeholder still leaves us with the problem of the identification of those stakeholders that really count for the creation of value. According to that definition virtually any entity can affect or be affected by an enterprise's actions. Because an enterprise, as we briefly stated in the previous chapter, is a complex system of organizational (stakeholder) relationships, determining which stakeholder is relevant and which is not is normally a difficult task. Like in any complex system, even a negligible contribution by an insignificant stakeholder can potentially produce a strong impact on the whole enterprise system. As the butterfly effect (frequently used by complexity theorists) explains it: "a butterfly flapping its wings in China can cause a severe storm in New England." Consequently, the stakeholder theory needs a reliable mechanism to identify which are the relevant stakeholders and to define clear boundaries of the stakeholders system.

Mitchell, Agle, and Wood (1997) propose a way of classifying stakeholders by their possession of one or more of the following attributes: the stakeholder *power* to influence the firm; the *legitimacy* of the stakeholder relationship with the firm under study; and the *urgency* of the stakeholder claim on the firm.

A stakeholder demonstrates *power* in its relationship with an enterprise when it has or can gain access to coercive, utilitarian, or symbolic means to impose its will (or the will of others) in the relationship. Coercive power is that related with the use of physical resources of force, violence, or restraint. Utilitarian power is that based on the exchange of material or financial resources. Symbolic power is that based on symbolic resources – normative symbols, like prestige and esteem; and social symbols, like love and acceptance.

Legitimacy is defined as "a generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions" (Mitchell, Agle, and Wood, 1997; cf. Suchman, 1995). Legitimacy and power can exist independently or can be combined to create authority (power that is attached to a position that others perceive as legitimate)

Urgency, according to Mitchell, Agle, and Wood, is the necessary attribute to provide their stakeholder identification model with dynamic characteristics. Urgency exists when two conditions are met: (1) when a relationship or claim is of a time-sensitive nature and (2) when that relationship or claim is important or critical to the stakeholder operations and/or strategies. Instead, we prefer to identify this urgency attribute as *criticality* since this term involves both urgency (time sensitivity) and importance sub-attributes. In this way, some claim that is perceived as important but still not urgent can be considered as relevant, and vice versa. This distinction will allow us, for example, to identify and incorporate stakeholders with whom an enterprise defines long-term strategic issues (e.g. strategic alliances) that are of keen importance to the entire enterprise system.

Any of the attributes of power, legitimacy, and criticality are dynamic in nature, each one constituting a variable that can adopt different values according to the environment and the particular circumstances an enterprise is traversing. Also, all these attributes are socially constructed, not objective reality – meaning that they are subject to multiple and different perceptions. Moreover, the actual presence of one or more of the attributes does not mean either that the stakeholder or the managers are conscious of the level of those attributes, or that they are willing to act on the inferences that are possibly made from them.

Also, it is interesting to note that this identification methodology allows for the possession of more than one attribute of the same type. For example, a stakeholder relationship with an enterprise can be legitimate because both a legal contract and a moral right are recognized as valid between the parties.

Stakeholder Salience

Once stakeholders are identified a mechanism for prioritizing stakeholders is crucial to determine to whom and to what managers must actually pay attention. In the work by Mitchell, Agle, and Wood (1997) they propose a theory of stakeholder *salience* that helps in determining the priority managers should assign to dynamically changing stakeholder relationships. Stakeholder salience derives from manager's perception about stakeholder's control of some of the attributes of power, legitimacy, and criticality. Various stakeholder types emerge from the possession of one or more of the three attributes and the different possible combinations of them.

Building on the propositions of Mitchell, Agle, and Wood we assert that the salience of a stakeholder is determined by both the cumulative number of attributes (of same or different type) *and* the relative strength or intensity of each one of those attributes. This latter property will help us later in defining a quantifiable way of determining the salience of each stakeholder participating in the enterprise.

Latent stakeholders are those possessing only one of the attributes of power, legitimacy, or criticality, and include dormant, discretionary, and demanding stakeholders (Figure 2) Expectant stakeholders are those possessing two different attributes, and include dominant, dependent, and dangerous stakeholders. Definitive stakeholders are those possessing all three attributes. By exclusion, individuals or groups possessing none of the attributes are either nonstakeholders or potential stakeholders.

Any stakeholder in any of the described categories can change its condition by acquiring or losing one or more of three types of attributes. Managers should be aware of the fact that any stakeholder can suddenly change (increase or decrease) its salience property, which will demand a proper adjustment to the attention to stakeholder's claims.

Source: Mitchell, Agle, and Wood (1997)

Figure 2: Stakeholder identification and salience framework

We recognize that the presence of one or more stakeholder legitimacy attributes, as defined by Mitchell et al., depends on some kind of contribution from either the stakeholder or the firm side. Kochan and Rubinstein (2000) propose that salience or the level of stakeholder influence on the firm is a function of (1) the number or quantity of valued resources contributed by potential stakeholders, (2) the level of risk and failure costs associated with the relationship between stakeholders and the firm, and (3) the power they have or exert in or over the firm. They go further in the definitions by explaining that the contribution of valued resources "creates incentives for others to recognize a potential stakeholder" while having those resources compromised at risk in the relationship give stakeholders a moral claim or right. Both of these characteristics give legitimacy rights to potential or actual stakeholders. As we have expressed before, combining legitimacy with stakeholders' power position and the urgency or importance of their stakes gives stakeholders a definitive salience.

Stakeholder Structure

Having described the theory behind stakeholder definition, identification, and salience, we still need to make a description of the issue of stakeholder structure. A comprehensive stakeholder theory of the firm requires an explanation of how stakeholders influence the firm and how the firm responds to those influences (Rowley, 1997)

A first attempt to explain stakeholder structure was done by Freeman when he depicted a stakeholder map in which the firm was the hub of a wheel and stakeholders were at the ends of spokes around the wheel (Frooman, 1999). A graphical representation of that type of structure is shown in Figure 3.

However, in this conceptualization relationships are dyadic, i.e. only between an individual stakeholder and a firm. Also, the firm is positioned in the center of the figure concentrating the links and relationships with each and every stakeholder. However, in reality the set of relationships are hardly independent from one another and the position of the firm is not typically central. Moreover, the focus of most stakeholder analysis theories is on the actor's attributes and not in the relationships' attributes. These relationship attributes may tell a lot about how stakeholders interact and potentate in order to exert power or to claim rights on the firm results. Thus, the analysis of the relationships and its attributes constitute an essential viewpoint to understand the way stakeholders influence on the enterprise decisions and actions. Frooman states that relationships among stakeholders and the firm are the elements that actually exhibit the power attribute. This contrasts with our previous descriptions, where one of the main attributes of stakeholders was precisely the power characteristic (Mitchell et al., 1997) In consequence, it is the stakeholder structure together with stakeholder attributes that provides the power or influence characteristics of the integral enterprise. We will propose later in this thesis work mechanism to evaluate the stakeholder structure.

Figure 3: Stakeholder structure, “bicycle-wheel” model

Resource dependence analysis

Frooman goes on and proposes a theory to determine the type of influence strategies stakeholders use based on resource dependence theory. A resource is essentially something an actor perceives as valuable, whereas dependence is a state in which one actor relies on the actions of another to achieve particular outcomes. This theory states that because organizations are not self-contained or self-sufficient they must rely on others (stakeholders) to gain access to the resources necessary to perform the firm activities. In return for the contribution of those resources stakeholders typically will demand certain actions from the organization. This mutual resource dependence provides actors in a relationship with a power attribute that can be used to measure the influence of one actor over the other. If actor A depends on actor B for the contribution of a resource more than B depends on A for the retributions, then actor B has more power or the ability to influence over the A. Then, power or influence is defined in relative terms.

Actors providing resources to a firm have two ways of influencing it: (1) determining whether the firm gets the resources it needs and (2) controlling the quantity of that resource the actor is willing to provide to the firm. Also, the pathway of influence can be direct or indirect, depending on whether the resource provision is managed with the firm in a straightforward manner or it is controlled via third parties.

Stakeholder networks

The recognition of the fact that stakeholders can indirectly exert elements of power over an organization talks about the existence of interdependence among certain or even all the firm's stakeholders.

Rowley (1997) goes beyond the analysis of dyadic relationships between individual stakeholders and firms and analyzes the impact on firms' behavior of multiple and interdependent stakeholder interactions using a social network approach that allows studying the characteristics of stakeholder systems' structures. According to Rowley, "firms do not simply respond to each stakeholder individually; they respond, rather, to the interaction of multiple influences from the entire stakeholder set." Also, he recognizes that the firm under analysis (focal organization) can also be a stakeholder of other firms; hence, the firm is not necessarily at the center of the network. The same is true for each one of the stakeholders; each one having its own set of relationships with other stakeholders. It is evident then that whenever we analyze the stakeholders' structure we typically find a complex system of relationships organized in the form of a network. Figure 4 depicts an example of such a network where circles are drawn representing different organizations, which are connected by arcs representing some form of relationship.

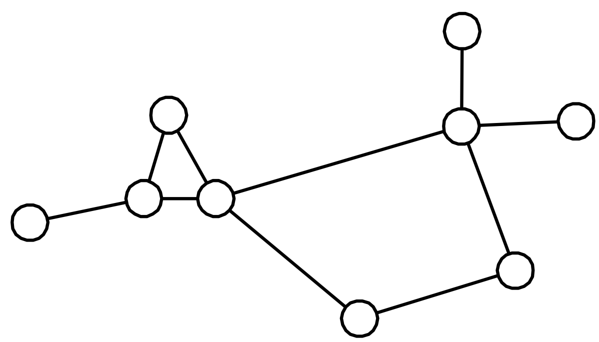


Figure 4: Network of Stakeholders

The power and influence characteristics of the stakeholders system reside in the network of relationships rather than in individual actors on that network. By analyzing a stakeholder's network structure we will be able to determine how the nature and attributes of the relationships impacts on the behavior of each one of the actors and the network as a whole system.

The Ladder of Stakeholder Loyalty

Polonsky, Schuppisser, and Beldona (2002) studied the different types of relationships that may exist between stakeholders. According to their view there exists a range of possibilities in the type of relationships stakeholders maintain, from very negative to very positive type of relationships. Based on the work by Tuominen they state that firms attempt to classify relationships with their stakeholders in a "ladder of stakeholder loyalty". In this ladder model stakeholders are classified according to the level of support each one provides to the firm. For instance, we find, in decreasing order of support, advocating, supporting, regular, new, and potential stakeholders.

Relying on the complexity of relationships among stakeholders, Polonsky, Schuppisser, and Beldona go on to expand this ladder of stakeholder loyalty to consider negative type of relationships, like the ones typically maintained with competitor groups. Competitors need to be considered as since they typically have legitimate interests in the results of an enterprise's value creation processes. Competitors are also affected by the actions the enterprise develops in the marketplace where they also have established their operations.

In addition, Polonsky et al. list and explain the factors that normally influence in firm-stakeholder relationships and how those factors determine the position of each stakeholder in the ladder of loyalty. Among those factors we find:

Relationship orientation. This factor refers to the motivation each party in a relationship has to be willing to be involved with the other party. It also considers how each party evaluates the relationship. The motivation can be a cooperative, individualistic, or competitive relationship orientation. In a cooperative relationship orientation the stakeholder considers both its own interests and those of the other party in the relationship. An individualistic orientation means that the stakeholder is only interested in obtaining the best value from the relationship for itself, not considering the gains or loses of the other party. A competitive orientation is similar to an individualistic one but in this case the stakeholder is also willing to defeat the other party.

In terms of the evaluation of the relationship a stakeholder can either consider it strategic or operational. A strategic relationship is one that potentially produces long-term benefits whereas an operational relationship is one in which the parties pursue more short-term type of objectives.

Trust. This factor affecting stakeholder relationships is defined by Polonsky et al. as "the willingness of one party to be vulnerable to the actions of another party" They distinguish three forms of trust: calculus-based, knowledge-based, and identification-based. In calculus-based trust the parties are able to measure and control the costs and benefits associated with the relationship (e.g. contractual relationships) hence both parties can rely on that controllability. In knowledge-based trust the parties have got to know each other in such a way that both can discern and predict the actions of the other. Identification-based trust exists when the parties thoroughly understand, agree with and endorse each other's intentions and goals. Each party can act as if it where the other.

Communication. The communication factor is essential for establishing any kind of relationship between stakeholders and is characterized by its frequency, direction, modality, and content. A more collaborative type of relationship will be defined by a higher communication frequency, bi-directionality, informality, and indirect content. On the other hand, more autonomous stakeholders will communicate less frequently, using more unidirectional information flows, more formally, and using direct requests.

Learning. This relational factor accounts for the learning opportunity the relationship offers to the parties in terms of how actions affect one, both, or the relationship between them. There typically exists a learning cycle where goals are conceived, actions to achieve them are planned, then carried out, outcomes are experienced, and finally results are evaluated. The results of these often repeated learning cycles usually produce errors hence create learning opportunities. Depending on the level with which the parties are willing to change and correct their actions so does it is the level of learning. These levels can be defined as single-loop, double-loop, and triple-loop action-learning. In single-loop action-learning only the actions to achieve the goals are revised. In double-loop action-learning also the goals are revised. And in triple-loop action-learning each party is also willing to change some organizational objectives in order to attain the revised goals.

Power. This factor is equivalent to that defined by Mitchell et al. (1997) as we have already described in previous sections.

Reciprocity and Commitment. A party commits itself to a relationship when it demonstrates interest in the relationship and also consistent future behavior. Reciprocity involves the type of reactions of one party to the actions of the other. Positive reciprocity is found when good actions are repaid with good actions, and negative reciprocity is found when bad actions are repaid with bad actions.

Based on all the above-defined attributes Polonsky et al. define the ladder of stakeholder loyalty as it is presented in Table 3. These definitions will be used later on in this thesis to conceptualize a qualitative model for representing stakeholder systems.

Table 3: Ladder of Stakeholder Loyalty

Relationship Type	Relationship Orientation and Evaluation Mode	Trust	Communication	Learning	Power	Reciprocity and commitment
Allied	Cooperative Strategic	Identification-based trust	Hi frequency Bi-directional Informal Indirect content	Single-loop Double-loop Triple-loop	Very low	Positive and weak High commitments
Cooperative	Cooperative Strategic	Knowledge-based trust	Hi frequency Bi-directional Informal In-/direct content	Single-loop Double-loop	Higher Normative	Positive and weak/ Strong Limited commitments
Neutral	Individualistic Operative	Calculus-based trust	Low frequency Bi-directional Formal Direct content	Single-loop	High Normative/ Utilitarian	Positive/Negative and strong Low/no commitments
Competitive	Individualistic/ Competitive Operative	Calculus-based trust	Low frequency Unidirectional Formal Direct content	Single-loop	High Utilitarian/ Normative	Negative and strong Low commitments
Threatening	Competitive Operative	Distrust	Low/high freq. Uni-/Bidirectional In-/Formal Direct content	Single-loop	Very High Utilitarian/ Normative/ Coercive	Negative and strong Low/High commitments

C H A P T E R 4

SUPPORTING THEORIES

This chapter presents elements of different supporting theories and practices that will help in setting the basis of our stakeholder analysis frameworks and methodologies.

Social Networks

From the descriptions and definitions given in the previous chapters it can be easily interpreted that stakeholders and firms form a social structure where the set of relationships define a network of ties among them. Hence the concepts behind Social Networks are appealing to be applied to the study of stakeholder systems. Social networks theory provides a set of definitions and quantitative measures that will aid in recognizing the structure of stakeholder networks.

Relations or ties among actors are the fundamental components and object of study of social networks theories and practices. Social networks allows for the application of a systemic view to the problem of stakeholder analysis. Some of the principles guiding social network analysis are the following: [10]

- Actors and their actions are interdependent rather than independent units
- Links between actors are channels for the flow of resources of any type
- Network models visualize the network structural environment as providing opportunities or constraints for the actions of each one of the actors in the network
- Network models conceptualize structure (social, economic, political, and so forth) as lasting patterns of relations among actors

[10] see Wasserman and Faust, 1994

These social networks characteristics match perfectly with the type of analysis we like to perform as part of this thesis work. Fundamental to this appropriateness is the focus of social network analysis on the relationships between the constituents of the network. The behavior of each component of the network will surely affect the behavior of many other actors in the network and most likely the behavior of the entire network structure. Stakeholder structures, as a social structure they are, are not different from this description; the actions of one stakeholder may very well influence on the reactions of many other stakeholders in the system. In short, one needs a network viewpoint to fully understand the behavior of the stakeholder system.

A social network is defined as a set of actors and the links or relationships among them. Relational links among actors are the primary set of data whereas the attributes of actors are secondary. Some of the key concepts of social network analysis are: actors, relational ties, dyads, triads, subgroups, groups, relations, and social network.

Actors are the social entities that form the structure of relationships in a social network. They can be discrete individual, corporate, or collective social units. Examples of actors are people in a working group, functional departments, communities, companies, or national/international organizations.

Relational ties are the elements linking any pair of actors. The type of ties can be quite extensive being the most common in network analysis the following:

- Individual evaluations (for example expressed friendship, liking or respect)
- Transaction or transfer of material resources (for example buyer-seller or supplier-producer relationships)
- Transfer of non-material resources (for example communications, sending/receiving information)
- Association or affiliation (for example belonging to an industry working group)

- Behavioral interaction – physical presence of two actors in the same place at the same time (for example actors attending to the same social events)
- Physical connection (sharing of an office space or recreation areas)
- Formal roles (for example authority or hierarchies)
- Kinship relationship (marriage, descent)

A *dyad* is the most basic level of relationship that can be established between two actors. The link is a property of both actors and hence it cannot be thought as pertaining to one individual actor, it is something that is recognized by both parties. The link between two actors can be multiple, meaning that there can be more than one type of relational tie relating those two actors.

A *triad* is a connection among three actors, although not necessarily complete (each actor linked with the other two) and it basically inherits the basic properties of dyad except in this case there are three actors involved in the relationship. The study of triads allows for analyzing transitive relationships of the type "if actor A influences on actor B, and actor B influences actor C, then actor A will also influence actor C".

Any subset of actors and their relationships – dyads and triads – can be defined as a *subgroup*. Locating subgroups or clusters of actors and the influence they exert on the social network of actors is a key property that allows discovering behavioral patterns in that network.

A *group* of actors is defined as a finite set of actors on which the network analysis is going to be performed. A group defines the boundaries of the network system. A method to determine the boundaries of the actors set – being it theoretical, empirical, or conceptual is necessary to properly define a group on which to perform network measurements.

A *relation* is the collection of ties of specific kind among the members of a group. For the same group of actors we can measure the network through many different relations. A relation refers to the collection of ties of a certain type among the actors of a group. The ties themselves always belong to a pair of actors.

With all the above definitions we can provide a more formal statement for what constitute a social network. A *social network* consists of a finite set or sets of actors and the relation or relations defined among them. The existence of relational information is the defining feature of a social network.

The analysis of a social network requires the study of the ties among the actors. However, the attributes of the actors themselves may also be considered into the analysis. Measurements on actors' attributes are referred to as network composition. For example, for stakeholder analysis we might want to measure profitability, revenues, geographical location, interests, prominence, and so forth.

Network analyses can be performed at different levels of aggregation: individual actors, dyads, triads, subgroups, and groups (whole network). This is a distinctive property of social network analysis that fits perfectly with stakeholder systems because in enterprise settings one might want to concentrate the analysis only in specific aspects of the value creation processes. For example, we might want to analyze how a particular group of suppliers of a firm affects the behavior of the rest of the enterprise system.

There exist a myriad of metrics and methods associated with social networks analysis. The majority of them allows for discovering structural patterns, i.e. how actors are organized in a social network. It is the belief of social network theorists that structure informs about the potential behavior of the network. Most of the methods provided by social network analysis are based on graph theory that, in turn, relies in matrix operation techniques.

Among the most important measurements of social networks are different ways of determining the centrality of actors in the network. Centrality measures inform about the relative structural position or importance of each actor in the network. The idea is that more central actors maintain more relationships, or control the relationships of other actors in the network. Less central or peripheral actors need other actors to access different parts of the network. Hence more central actors are more relevant for the functionality of the whole social network while less central actors are less important or secondary for the behavior of the network. We will cover the specifics of centrality metrics in our chapter on stakeholder network analysis.

Complexity Theory

We have stated before that stakeholders form a complex system of relationships. It is then useful to introduce some elements of complexity theory that will help in describing some of the attributes of stakeholder networks. The field of complexity theory is still under development but there exist a number of properties that are common to every complex system. We will shortly describe some of these properties and will relate each one of them to stakeholder analysis.

Bar-Yam (1997) defines a complex system as a system formed out of many elements whose function or behavior is *emergent* in the sense that function cannot be interpreted from the simple analysis of the behavior of its elements. Then, in every complex system it is important to study how parts of a system affect the collective behavior of the system, and how the system interacts with its surrounding environment. The field of complex systems focuses on certain questions about parts, wholes and relationships. These characteristics are important to many areas of study and so they are for stakeholder systems.

We can mention here several properties common to all complex systems that can be particularly interpreted for stakeholder systems:[11]

Interactions in complex systems are typically nonlinear. Nonlinearities in complex systems are responsible for chaotic behavior. The number of attributes types and forms defining relationships between the stakeholders of any enterprise produces a combined effect that cannot be interpreted simply by studying the characteristics of individual relationships. It is the combination of relationships and their dynamics that will define the response of the stakeholder system to internal or external forces.

[11] see Baranger M., no date

Constituents of complex systems are interdependent. In every complex system there exists a sort of symbiosis among its elements. Separating one or several of those elements from the system will normally produce a strong impact on the whole system. This is particularly true for stakeholder systems where the removal of some key stakeholder (e.g. an allied supplier) may profoundly affect the ability of the enterprise system to deliver value to other stakeholders in the network.

Structure in complex systems is found at several different scales. This property is indicative of some sort of granularity in every complex system. When delving into the details of the components of a complex system it is common to find elements of structure inside them. In other words, zooming into each component reveals the existence of a lower level of interrelated elements. For stakeholders systems this property is represented by the fact that, when zooming inside a particular stakeholder, we will typically find organizational structures (business units, teams, working groups). Inside those organizational structures, and zooming one more level down, we will find smaller teams or individuals that interrelate to produce some sort of value for the level above. This is an important property for stakeholder systems because it allows for understanding the different levels at which the analysis of stakeholders can be done. For example, the analysis can focus exclusively on the value created by some specific product of an enterprise, or more broadly, on the integrated enterprise and its whole line of products and services.

Complex systems are capable of emergent behavior. We have stated before that the behavior of a complex system is the result of the interactions among the elements of the system. Behavior or functionality typically emerges at a particular system scale from the interactions of elements at the scale below that. Interactions among stakeholders in different subgroups produce results for other subgroups belonging to the enterprise. For example, supply chains organized in n-tiers schemes produce physical parts or components that another stakeholder in the enterprise will later integrate into a final product. By considering the stakeholder system as a whole we can infer which is the emergent value pursued by the whole enterprise, not just the value pursued by individual or subgroups of stakeholders. This emergent system level value will help us determining the boundaries of the enterprise system and identifying potential stakeholders within those boundaries.

Complexity involves interplay between cooperation and competition. This phenomenon usually occurs because of interacting system scales. Competition at certain scale is fed by cooperation at a scale below that. This can be exemplified in stakeholder systems by the typical stakeholder coalitions formed against competitors entering or pressuring in the market place where the enterprise operates. Stakeholders align themselves cooperatively in order to compete in a shared market environment with similar enterprises.

Game Theory

Like many other managerial strategic, tactical, and operational practices Game Theory origins and ideas come from a war setting. It was during World War II when the British discovered an analytical rather than an intuitive way of moving their war resources in the battlefields, although the theory itself came as such later when John von Neumann and Oskar Morgenstern developed and documented it thoroughly. Game Theory proved to transform many fields of study like economics, politics, social studies, and even evolutionary biology.

Originally game theory dealt with zero-sum games where there is always an actor that wins and an actor that loses – the typical desired situation in a war scenario. Later on the theory developed fully to cover positive-sum games best known as win-win situations.

Game theory is useful for the analysis of stakeholder management practices because "[it] is particularly effective when there are many interdependent factors and no decision can be made in isolation from a host of other decisions."[12] It is particularly useful in such complex scenarios because it allows for decomposing the problem into its key components.

Game theory in the context of stakeholder analysis allows for determining where the power resides in the stakeholders' structure. It permits determining which components of the stakeholder structure have the most bargaining power that allows them to control the use of resources in the enterprise system. Game theory is all about determining which player posses the most powerful position that allows him or her to control the game.

Game theory is appealing to apply to stakeholder analysis because it explicitly considers the values added and obtained by each player in a game. As we have mentioned before, when analyzing stakeholders we have to consider how they affect or how they are affected by the value creation actions and decisions implemented by the whole enterprise system. Thus the concepts behind game theory fit naturally for value creation analysis in complex stakeholders' settings.

Developed from game theory, the now popular Nash Equilibrium theory roughly states that, no matter how complex the economic or social scenario is, in a game-like situation involving many participants there is always a set of negotiation states and strategies where everyone involved in the game is satisfied with the payoffs obtained from it.[13] In other words, there always exists a set of mixed strategies for each player in the game that maximizes the payoffs each one can obtain from the game.[14]

In an enterprise scenario, which can be associated with a game scenario, stakeholders are the players. Each one of them will typically devise its business strategies in order to obtain the maximum benefits from the enterprise independently of the degree of collaboration and cooperation they offer to the other participants in the enterprise. But according to Nash's equilibrium theory they will obtain a maximum payoff from the execution of those strategies. This is equivalent to say that at certain steady state the value each stakeholder will obtain from the enterprise will be maximal. Consequently, if we assume that what flows in the relationship between any two stakeholders is value (payoffs from stakeholders' contributions to the enterprise) then these values will be in equilibrium. This means that their relationship is balanced in the sense that the value flowing in one direction is compensated by the value flowing in the other direction, i.e. no "value tensions" exists in the relationship. For example, in a supplier-producer relationship the supplier provides goods to the producer and in return he obtains a fair monetary payoff. Value for the supplier is the benefit obtained from revenues coming from the producer once the

---

12 see Brandenburger and Nalebuff, 1998

13 John Nash proved this theory in a 27 pages Ph.D. thesis masterpiece in 1950. Later, in 1994, this work allowed him to win the Nobel Prize in Economics.

14 Nash J., 'Non-Cooperative Games' paper in Kuhn H.W. and Nasar S., 2002

cost of the manufactured goods and other associated costs have been discounted. Value for the producer is represented by the proportional monetary benefits obtained from the final product due to the supplied component once the cost of that component has been deducted. If the negotiation process resulted in a fair value for both parties then the relationship is in equilibrium. The assumption that stakeholders maintain balanced valued relationships will be one of our strongest assumptions throughout the rest of this thesis.

THIS PAGE INTENTIONALLY LEFT BLANK

C H A P T E R 5

STAKEHOLDER ANALYSIS MODELS

This chapter presents qualitative frameworks to analyze relationships and structures in stakeholder systems. Two different frameworks are introduced: a firm-centric model, and a network model of stakeholder systems. In Chapter 7 we will present an example using both models.

A Tale of Two Donkeys

The well-known children's story *The Tale of Two Donkeys* will help us in illustrating the fundamentals of our stakeholder analysis frameworks.[15]

> Two hungry donkeys are tied together when suddenly they both see some food. One sees a bundle of hay at the bottom of the field and the other sees a bundle of hay at the top.

> They both begin to walk in opposite directions towards the food they have seen. Slowly the rope that ties them together unwinds and becomes tighter and tighter until they cannot move towards the sweet smelling hay any more. Each donkey begins to pull as hard as she can towards the hay. The more they pull, the angrier and angrier they become.

> Eventually, they are so tired that they sit down in the middle of the field in despair. Suddenly, one of the donkeys has an idea — she knows how they can both eat. All they need to do is work together.

[15] Text and pictures obtained from http://www.hwdsb.on.ca/

First, they go to one bundle of hay and share it....

...then they walk to the other bundle and they are both well fed.

As one can easily imagine the fundamental lesson behind this story is the advantage of a cooperative relationship. Cooperation means two or more parties working together to find the solution to a problem.[16] The problem for the donkeys is how to eat all the hay they can even when restricted by the length of the rope. To obtain the most value (hay) out of a constraining relationship (rope) the donkeys must think of ways of working around that constraint. They can do that unilaterally, but most likely this approach will end in competitive efforts to obtain the desired value. This is donkeys' first attempt. Alternatively, both can think together of a way to solve the problem, which they nicely do in this case.

Very much like these two starving donkeys the relationships between stakeholders many times results in competition for the use of some resource or the extraction of value from the business. In many of these cases maintaining cooperative relationships possibly signify a more efficient

[16] The Shorter Oxford English Dictionary defines cooperation as "the combination of a number of persons, or of a community, for purposes of economic production or distribution"

utilization of resources or an increased value (a win-win type of relationship) obtained from the system. Consider, for instance, a constrained relationship between a producer and a key supplier where a binding contract specify the quantities of certain parts to be monthly delivered by the latter. If the producer wants to buy less of those parts in a certain month due to a reduction in the demand of the final product the contract will limit that transaction. The supplier will want to stay on the safe side and deliver the quantities stipulated in the contract. In this case the contract is the limiting factor in the relationship making both parties to work inefficiently. If a cooperative type of relationship would exist instead then more predictable demand from the producer and better lead times from the supplier can be accomplished.

Naturally, if the rope in the two donkeys' tale is of such a length that both donkeys can eat from both bundles of hay simultaneously then the limiting relationship disappears, and so does the need for cooperation. These are the cases where the amount of resources or the value obtained from the relationship is enough to amply satisfy both parties. Following on with our example, if the component a producer requires from the supplier is a commodity (e.g. nuts and bolts) then the producer may well buy from different suppliers in the case, for example, of a positive variation in demand of the final product. Similarly, the supplier is free to sell the same type of components to many different customers so does diversifying the risks of a single commercial relationship. In this case supply contracts or even simple opportunistic transactions are enough to guarantee a good relationship between the parties and the creation of value for the enterprise. There is no need for collaboration schemes between the parties.

An intermediate case in the tale would be one in which the rope is of just the right length to allow each donkey to barely reach one of the bundles of hay. In this case both will be able to eat some food at the same time but soon they will start to compete to eat the rest of their corresponding heap. Although they will eat some food they can do better if they think in a semi-cooperative/competitive alternative to solve the problem. For example, they can agree to eat in turns from their corresponding bundle of hay. In our producer-supplier example a relationship of this type might be one in which the market conditions are just enough to guarantee adequate demand of parts to sustain the supplier business. The supplier can work in cooperation with the producer to promote the sales of the end product or the producer can help the supplier to find alternative applications for his products in order to expand the business opportunities for both parties.

Another possible scenario in the donkey's tale is that of a totally competitive relationship. This would be the case, for instance, of another animal (e.g. a bull) tied to the other end of the rope. It is unlikely that these two animals will be willing to cooperate. Nevertheless, even in this case each party needs to understand the needs and motivations of the other in order to be able to think of creative solutions to solve the problem. They need to understand that the interests of each one are tied to the interests of the other. In a stakeholder environment there are plenty of cases similar to this example. For example, consider the role of a competitor of the producer, one that produces similar products for the same market. Eventually, both parties will be sharing a portion of the market but it is the responsibility of both parties together to make that market grow in order to obtain further gains from the business.

Like in the tale, the relationships between any two stakeholders in an enterprise may tighten because both parties compete while trying to use resources more efficiently or to create more value from the relationship. Stakeholders must be aware of the needs of other actors in the system promoting collaborative relationships that would enhance the value they can obtain from the enterprise efforts. It is hardly the case that collaborative relationships are needed with every stakeholder in the enterprise system, but more typical with some selected actors that demonstrate a win-win or strategic attitude towards the enterprise.

In summary, a system of stakeholder relationships needs to be evaluated in cooperative terms in order to relax the tensions produced in the whole system by scarce resources and limited value creation opportunities. A cooperative vision of the enterprise will help producing better results from the value creation strategies.

The Dual View

The donkey's situation can be analyzed from two distinct points of view. On the one hand, the problem can be visualized from the perspective of any one of the two donkeys, in an egocentric manner. This viewpoint will allow any of the donkeys to think primarily in terms of her needs – how fast can she reach and eat her bundle of hay. Although "donkey-centered" this view does not ignore the fact of the existence of another donkey, the rope that ties them together, and the other bundle of hay. Each donkey needs to consider those elements in order to solve her problem, but under this viewpoint they do that to evaluate the consequences on her particular needs. On the other hand, the problem can be analyzed from a more systemic perspective, considering all the different elements in the context and analyzing their interdependence. This rather external view would allow for a more balanced analysis of the possible outcomes, one that evaluates which are the gains and loses of each particular solution strategy from a more cooperative perspective.

Similarly, the analysis of stakeholder systems requires, like every other complex system, the use of many different views and their related models in order to attain a complete description of the system attributes and characteristics.[17] We propose here two different models, both aimed at slightly different managerial objectives. Both models are complementary in nature hence defining a duality concept: each one of the models informs on some of the characteristics of the other, both are necessary to obtain a complete picture of the system. Managerial actions need from both models to come up with solutions that produce better results by considering stakeholders from the firm vantage point, and at the same time, assure that all the stakeholders get adequate payoffs (value) from their contributions to the enterprise system.

The first model is a firm-centric model that can be used to qualitatively measure the consequences on a firm's performance objectives coming from the relationship with its stakeholders. For example, this model would allow identifying which stakeholders need to be closer to the firm to

---

[17] Maier and Rechtin (2002) define a model as "an approximation, representation, or idealization of selected aspects of the structure, behavior, operation, or other characteristics of a real-world process, concept, or system.", and a view as "a representation of a system from the perspective of related concerns or issues."

increase opportunities of successfully entering in a new market or to implement distinctive growth strategies.

The second qualitative model we propose in this thesis is a network or system model, which involves the analysis of the detailed relationships among all stakeholders. This model can be used, for instance, to balance the needs and value propositions offered to all or some particular group of stakeholders, and to predict system's behavior when implementing policies that affect part or the whole stakeholder system.

Water-Drop Model

A stakeholder system's water-drop model represents a way of depicting different type of relationships among stakeholders and a focal firm in an enterprise. This model is based on some of the characteristics of stakeholder theory presented in Chapter 3, particularly in the concepts presented in "the ladder of stakeholder loyalty". It also relies on the descriptions and examples presented in the previous section title. Figure 5 presents an example of a water-drop model. We will use this figure to explain the details of the model.

The water-drop model represents a stakeholder system as a firm-centric view of an enterprise where a focal organization assumes the role of concentrator of all the constituents of that enterprise. Because typically the initial efforts to map out a stakeholder system will come from a particular organization in the system it is interesting to present a model that depicts how stakeholders are organized around that organization. This model will be useful for that organization to determine, for instance, which stakeholders (once they are identified) maintain a cooperative relationship with the firm.

Another characteristic of this model is that it allows for representing both internal and external stakeholders. Different groups, divisions, and business units within a company are also stakeholders of the firm, ones very close to it, and as such they are represented in the center of the figure. The model as it is presented in the figure is merely an example of the type of stakeholders that can exist around a firm, and or the relationships that the firm maintains with them. It does not pretend to represent a full picture of the universe of possible stakeholders neither of all the possible type of relationships among them.

Highly collaborative relationships are depicted as overlapping 'drops' (ellipses) that mean to indicate that the relationship is very cooperative in nature and based on trust between the parties. The overlapping degree intends to represent the level of cooperation and collaboration between the parties. Communications between the parties serve the purpose of coordinating the activities and strategies to achieve common goals and are typically frequent and informal. The relationship is evaluated as strategic by both parties, which means that the ultimate purpose of the relationship is the achievement of long-term goals. The level of commitment in the relationship is high due to its strategic importance for both parties. The actions and attitudes of one party are reciprocated with similar or enhanced actions and are always aiming at win-win type of relationship. None of the parties need to exert power over the other to perform value creation actions or to achieve enterprise's objectives. The relationship allows for cultivating learning opportunities for both the firm and the stakeholder. This situation in the water-drop model corresponds to the allied stakeholder type we have described in the ladder of stakeholder loyalty section in Chapter 3.

A relationship where collaboration is present but with less degree or intensity than in the previously described type is represented in the water-drop model with two drops connected with a 'water neck'. In this case there exist some degree of coordination and communication but the relationship is evaluated by both parties more as a short-term or operative type of relationship. The length of the water-neck represent degrees or levels in those collaboration and coordination efforts – a longer water-neck (analogous to two water drops that are about to split) is indicative of a less cooperative relationship. This is cases are equivalent to the cooperative or even neutral stakeholders we have described in Chapter 3.

Figure 5: Stakeholder system – Water drop model

Relationships that involve more formal transactions or exchanges are represented by double or simple arrows depending on whether the relationship is bidirectional or unidirectional. In a formal transaction it is unusual to evaluate the relationship in terms of strategic or long-term visions. Instead, a cost-benefit case-by-case type of analysis is performed every time a relationship of this kind is established or reevaluated. This analysis helps each party in assessing the convenience of the relationship in terms of the cost and risk associated with the relationship and the benefits that can be obtained from it. If the balance is positive for both parties then the relationship is established but it will always be measured from an individualistic point of view. No further gains or long-term opportunities are expected from the relationship. Relationship commitment in these cases is guided by some type of contract or agreement, which, once completed, can be reestablished if the relationship still shows to be convenient for both parties. When the contract is finished there will be typically an evaluation process where past performances and new objectives are considered in order to assess the convenience of continuing with the relationship.

Disconnected drops in the water-drop model represent dormant, latent, or competitive stakeholders. Competitive stakeholders are those that pursue an individualistic type of relationship and at the same time try to undermine the objectives of the firm influencing the stakeholder system by applying different power exertion schemes. In essence, a competitive stakeholder builds its own set of relationships (water-drop system) to outperform the firm under analysis. A competitor then is graphically represented as a 'water bubble' indicating the existence of another stakeholder system that influence on the firm under analysis.

Dormant or latent stakeholders are those that were identified as potential influencers in the enterprise, those that have some claim or an interest at stake, but that for some reason – usually low power, legitimacy, and/or criticality – they stay expectant but observant of the enterprise actions and evolution. These type of stakeholders need to be represented in the model because, potentially, they can become active stakeholders if their stakes or interests get compromised by the actions of the firm or other stakeholders in the enterprise system.

The water-drop model also intends to represent the fact that primary stakeholders also have a set of stakeholders linked to them that can potentially influence on the firm under analysis. We say that the model is recursive or fractal in the sense that for each of the firm's primary stakeholder the types of relationships they maintain with their own stakeholders are of the same nature as those found at the first level of analysis. Hence we depict these secondary relationships as mini water-drop systems connected to the main firm representation.

Lastly, the water drop analogy gives the model certain sense of dynamism. In fact, relationships and stakeholders are usually in constant evolution hence the necessity to constantly reevaluate who the firm's stakeholders are and what type of relationship they maintain with the focal organization.

A generic example

The example presented in the water-drop model of Figure 5 represents an investor-based type of company where certain production process requires of a set of different suppliers and the products produced are sold to different types of customers. Other relevant stakeholders in this enterprise include shareholders (private and public), unions, partner companies and funding organizations. Secondary or less relevant stakeholders include the news media, society in general, different governmental levels, end users, and consumers. Competitors operating in the same marketplace are also represented as stakeholders as they can affect or be affected by the value creation processes of the company under analysis.

Allied suppliers are those that maintain a highly collaborative relationship with the enterprise as described above thus represented as an overlapping water-drop with that of the focal firm. These allied suppliers in turn have their own set of relationships with second-tier suppliers and many other stakeholders. The type of relationships they maintain with them can be any of the different types described above in terms of levels of collaboration and cooperation. Allied suppliers maintain a symbiotic type of relationship with the producer where the actions of any of the actors complement those of the other both benefiting from that dependency. This is the case, for example, of a first-tier automobile parts supplier where the timeliness and quality of the parts affect the final product's market success. In turn all marketing actions for the end product are carried out by the focal firm where their success will certainly affect the outputs and the survivability of those first-tier suppliers. Both parties define a win-win type of relationship one that requires high commitment for its proper maintenance and evolution.

Cooperative suppliers, while still close to the focal firm, view the relationship as less strategic but still perform collaborative and coordinated actions together with the focal firm. They are represented as a separate drop linked to the firm by a water-neck. Also here second-tier suppliers are accommodated according to the type of relationships they maintain with these suppliers. Commitment to the relationship is limited as a result of more near-term objectives. Cooperative suppliers understand the business the enterprise is in but they are not essential to its performance, they do not completely depend on the enterprise to survive and the enterprise can count on alternate suppliers to obtain the goods or services they supply. Communications tend to be more formal, and although frequent, they are limited to specific supply issues and do not include strategic or business development topics.

Neutral suppliers are those that maintain a contractual or transactional relationship with the enterprise. They act individually and independently of the actions of the focal firm and are typically tied to it by means supply contracts. Commodity parts suppliers are characteristic of this group where the firm can choose from several different suppliers depending on the cost-benefit convenience of the transaction. Neutral suppliers have much less influence on the enterprise that allied or cooperative suppliers but they can still form a cluster with enough power to affect the firm results and objectives.

Several types of customer stakeholders are represented in the water-drop model example of Figure 5. The types of relationship that loyal, regular, and occasional customers maintain with the focal firm are parallel to those of allied, cooperative, and neutral suppliers respectively. Loyal customers are those that obtain further gains by establishing highly collaborative relationship agreements with the focal firm. They both know for sure that a long-term buyer-seller relationship is convenient because of, for instance, an increasing demand or technological dependency. For example, car dealers in the automobile industry and DOD in the defense aerospace industry are both loyal customers of an auto producer and an aerospace company respectively.

Regular customers are those that buy the firm's products on a regular basis but they also have other sources to obtain identical or similar products. While purchases in this case may still require some coordination due the importance of the transaction, mutual dependence of both customer and firm is not that high as for the loyal customers.

Occasional customers are those that buy the enterprise's products every once in a while either because they do not need to replace products so often or because they can buy similar products from other producers. They evaluate the relationship with the enterprise as opportunistic hence they measure the convenience of the relationship strictly from a cost-benefit point of view. Then, the type of relationship they maintain is of transactional or contractual nature. However, a large base of occasional customers can make for a big market opportunity that the enterprise may want to exploit in order, for instance, to leverage product development and/or marketing investments. Considering the needs and value proposition for this group of customers can be of vital importance for the viability of the enterprise hence the necessity to represent them in the model.

Partner companies, unions, and corporate shareholders typically maintain a highly collaborative relationship with the enterprise as their respective goals are tightly coupled with those of the focal firm, and vice versa. While it may appear that unions always are in a position of confrontation with the firm they also understand that the results of the enterprise affect them directly hence at some point in the relationship they need to closely collaborate with the firm to achieve mutual gains and objectives.

This generic example also depicts different type of competitors participating in the enterprise. Among them we have industry, substitute, and disruptive competitors. They can affect the enterprise value creation processes in many different ways. Industry competitors are those that belong to the same industry environment as the focal firm. They offer the same kind of products to the same market. Substitute competitors are those that offer alternate products to satisfy customers' needs in the same market hence competing with the focal firm to gain more market share. Disruptive competitors are those that offer disruptive products; those that redefine the performance trajectory of established products and that typically are produced by an outsider (entrant firms not belonging to the same industry)[18] These three competitor types will capture the attention of many of the other stakeholders participating in the enterprise; particularly regular, occasional or even loyal customer stakeholders. Hence, it is important to monitor and be aware of competitors' actions in order to be able to neutralize them by means of more profound consideration of the relationships with actual and potential stakeholders of the enterprise.

Last but not least are the media, society, and governmental stakeholders. They are represented as separate 'drops' because they tend to behave more as secondary stakeholders; their presence is most of the times of second order relevance with respect of that of primary stakeholders described above. Media and society typically trigger their demands towards the enterprise when some business ethics principle is violated. Nurturing the relationships with them can help in future ventures or when the actions of more powerful stakeholders compromise the image or viability of the enterprise. Governmental stakeholders typically have more relevance for the strategies of the enterprise as they can be sources of resources through funding organizations. They can also provide support for the enterprise actions through the provision of protecting laws or regulations. Their presence is of such an importance that it is common to find many important lobbying organizations representing the interests (stakes) of different enterprises influencing in the decisions of governmental stakeholders at many different levels.

As for internal stakeholders one may want to zoom into those to obtain similar representation as to those of external stakeholders. The focus in this case is to obtain more details about the type of relationships that exist among different groups inside the focal firm. This model example presents all the relationships among internal stakeholders as highly collaborative – each group's 'drop' is overlapped with that of the others. This should represent the 'leaner' way of operating the firm; one in which internal organizational boundaries are resolved based on lean principles and

[18] See Christensen C.M,. 2000.

practices. However, it can result from an internal analysis of the firm that certain groups within it are not properly integrated thus impeding appropriate cooperation schemes to prosper. It is also assumed in the model that one of the most important stakeholders of any firm – the employees – constitute the support base for all the enterprise. While they do not explicitly appear in the water-drop model representation they are thought as being present 'behind' each of the stakeholder drops, at a lower complexity scale (see complexity theory section in Chapter 4).

Another important role in the model is that of focal firm's managers and leaders. They must provide a challenging vision for the firm and the necessary impulse to adequately nurture the relationships with each and every stakeholder in the enterprise system.

Network Model

The water-drop model provides a firm-centric viewpoint of the enterprise system. This model is useful to managers for them to recognize stakeholders and to analyze their level of integration with the firm. However, the complexity of the relationships among stakeholders calls for a more system-level representation of the enterprise system; one in which stakeholders and their specific relationships can be explicitly shown. This is the intent of our second qualitative model: the Network Model.

In this model stakeholders are represented as a set of actors and their relationships in a social network type of diagram. A hypothetical example of a network model is depicted in Figure 6. This representation allows for a qualitative visual analysis of the relative positions of each stakeholder (including the focal firm) and the power each one can exert on the whole enterprise system. It also lets us analyze stakeholder's clusters: groups of stakeholders that in combination can influence other stakeholders and the whole enterprise to perform to their convenience. In short, with a network model representation the structure of the stakeholder system can be easily visualized an interpreted.

Figure 6: Stakeholder system - Network Model

In the network model (see Figure 6) stakeholders are represented by circles and relationships between stakeholders by lines connecting those circles. Whenever two stakeholders are recognized as maintaining a relationship relevant to the enterprise they are connected by a line. The size (diameter) of circles representing stakeholders is indicative of their salience as it is perceived by managers or the person in charge of the analysis. In the next chapter we will develop a methodology for measuring stakeholders' saliencies based on the attributes of power, legitimacy, and criticality we have described in Chapter 3. The result of those measures can be used to determine the relative size of the circles, but it is also useful to depict them using qualitative or approximate salience estimation.

The width of the lines (relationships) connecting circles (stakeholders) is representative of the importance or relevance of those links to the value creation processes of the whole enterprise. This relationship relevance has to be somehow normalized for each link, i.e. a particular line width should be representative of the relative importance of the link it represents when compared to the importance of every other link in the network. Similarly to stakeholder's salience, in this qualitative model the relevance of the relationship can be an estimation or perception of the analyst coming from the observation of the system as a whole. The next chapter will also present a methodology for measuring relationships' relevancies that can be used to construct better or more representative network models.

Different type of relations can be represented by different line patterns. For instance, an information flow relationship between any two stakeholders can be depicted using dotted lines while material, goods, or services transactions and exchanges can be represented with solid lines. Another possibility is to consider relationships where balanced values are considered to be flowing between any two stakeholders as we explained in the game theory section in Chapter 5. This is the case we have chosen to represent in Figure 6. In this case there is only one type of relation that can exist in the network, which is defined by the value exchanges between stakeholders. Then, line patterns representing relationships are all alike.

Instead of representing each stakeholder in arbitrary positions in the diagram we can exploit the two dimensional space to represent some characteristic of the stakeholder network structure. For instance, we might want to represent stakeholders that belong to a certain affinity group as a cluster of circles in a particular region of the diagram. Or we might want to represent in the center of the figure those stakeholders that are more relevant for the enterprise value creation processes and in the periphery those stakeholders whose influence abilities are not that important. There exist in the social network research literature many methods to represent actors in two or even three dimensional spatial depictions. One of the most widely used techniques is called *Multidimensional Scaling* (MDS) (Wassermanm and Faust, 1994; Freeman L., 2000) MDS allows for displaying the proximities among stakeholders groups in the network. MDS can be used to study cohesive subgroups showing which subsets of stakeholders are relatively close to each other in an enterprise network.

While there exist several ways of performing MDS on a relational data set the most common one is MDS based on geodesic distances (Wasserman and Faust, 1994). Using this alternative, proximities among stakeholders are defined as the geodesic distances among stakeholders. Geodesics are the shortest paths linking any two stakeholders in the network as measured by the minimum number of links that need to be traversed to reach one stakeholder starting from one another. The input to the MDS process is a squared matrix of the geodesics between stakeholders, row and columns of the matrix corresponding to the stakeholders in the system. Then, the process iterates trying to arrange stakeholders in such a way that the distances between pairs of stakeholders in a two dimensional space correspond to the distances between stakeholders in the input matrix. The resulting spatial distribution should display the structure of stakeholders in the system.

Although the details of MDS process and calculations are beyond the scope of this thesis we can mention here that there exist several software packages that are able to perform multidimensional scaling on a set of dichotomous or valued relationships (see Wasserman & Faust, 1994, Freeman L., 2000). We will use one of such software packages when we develop our application example's models in Chapter 7.

In summary, the network model allows focusing not only on the constituents of the enterprise – its stakeholders, but also on the relationships among them. Using this model the relative salience of each stakeholder can be easily analyzed when visually compared to that of others. Also, structural patterns, stakeholder clusters, network connectivity, and other network characteristics can be assessed by visually inspecting this kind of model.

Lean Enterprise Viewpoint

One problem that appears when building both type of models is defining the boundaries of the system, i.e. which stakeholders to include in the network model. Rowley (1997) defines three different ways of determining which actors to include in a network representation. Citing the work by Knoke, Rowley states that analysts can focus on (1) actor attributes, (2) types of relations under analysis, or (3) a central issue or event providing that motivates the analysis. For stakeholder systems an actor attribute corresponds, for example, to the size of organizations in terms of annual income and/or number of employees. A relation type can be exemplified by the information or communication flow across the stakeholder network, or the exchange of goods and services among stakeholders. As for central issues in stakeholder networks we find that, for the case of the analysis presented in this thesis, a value creation process of the enterprise under analysis constitutes the most relevant issue to consider when analyzing the implementation of lean enterprise initiatives.

Another question that typically arises when analyzing stakeholder representation models and its associated data is whether the structure of the stakeholder system is adequate for accomplishing the objectives of the enterprise, i.e. implementing its value creation processes. A lean enterprise viewpoint of both models will indicate whether a stakeholder system is more or less lean depending on the existence of tensions between any pair of stakeholders in the network. Tensions or frictions are sources of waste in the enterprise; they need to be resolved in order to achieve lean enterprise performance. In water-drop models these tensions are characterized by the lack of collaboration or cooperation among stakeholders and the focal firm. In network models tensions and inefficiencies correspond to the presence or absence of relationships among the most relevant stakeholders in the network. Also, clusters of stakeholders and their associated power may constitute an object of analysis since they can influence in the behavior of the network.

In any case, and for each particular enterprise, the set of relationships and stakeholder interdependencies must be carefully analyzed to detect inefficiencies that produce waste and hinder the implementation of lean practices. Each enterprise must assess which relationships need to be highly collaborative and which ones can be considered as more formal but still influencing transactions. Also, establishing integrative relationships with distant subgroups in the network may help achieving leaner implementations. For each relationship present in the stakeholder network its content in terms of the value exchanged between any two stakeholders must be evaluated. A value analysis of each relationship will allow for detecting unbalances in the coordination activities between those stakeholders and opportunities to implement lean principles and practices aimed at resolving value exchange inefficiencies.

THIS PAGE INTENTIONALLY LEFT BLANK

C H A P T E R 6

STAKEHOLDER NETWORK ANALYSIS

This chapter presents the development of quantitative and formal methods for stakeholder's identification, salience calculation, and relationship and structure mapping.

Stakeholder Identification Methodology

The first step in building any representation of a stakeholder system is to identify which are the stakeholders that should be considered for the analysis. This involves two basic steps:

- Identify potential stakeholders
- Determine the salience of those stakeholders to evaluate whether it is reasonable to consider them for the analysis

This section covers the first question: who are the potential stakeholders of the enterprise system? The second question will be the subject of analysis of subsequent sections in this chapter.

We propose here a methodology for potential stakeholder identification that allows determining the boundaries of the stakeholder system. The method is based on the value generated by the stakeholder system (the enterprise) hence it is compatible with our broad definition of stakeholders (see Chapter 3) and with the lean enterprise model described in Chapter 2.

Figure 7 depicts the proposed stakeholder identification process and the following section titles describe it. The process is based on the 'snowball sampling' methodology described by Wasserman and Faust (1994: 30-35), which is specially suited for social networks where the boundaries of the system are unknown a priori. We have particularized this technique for the case of stakeholder identification and added lean enterprise and complex system theory elements to it to complete the methodology.

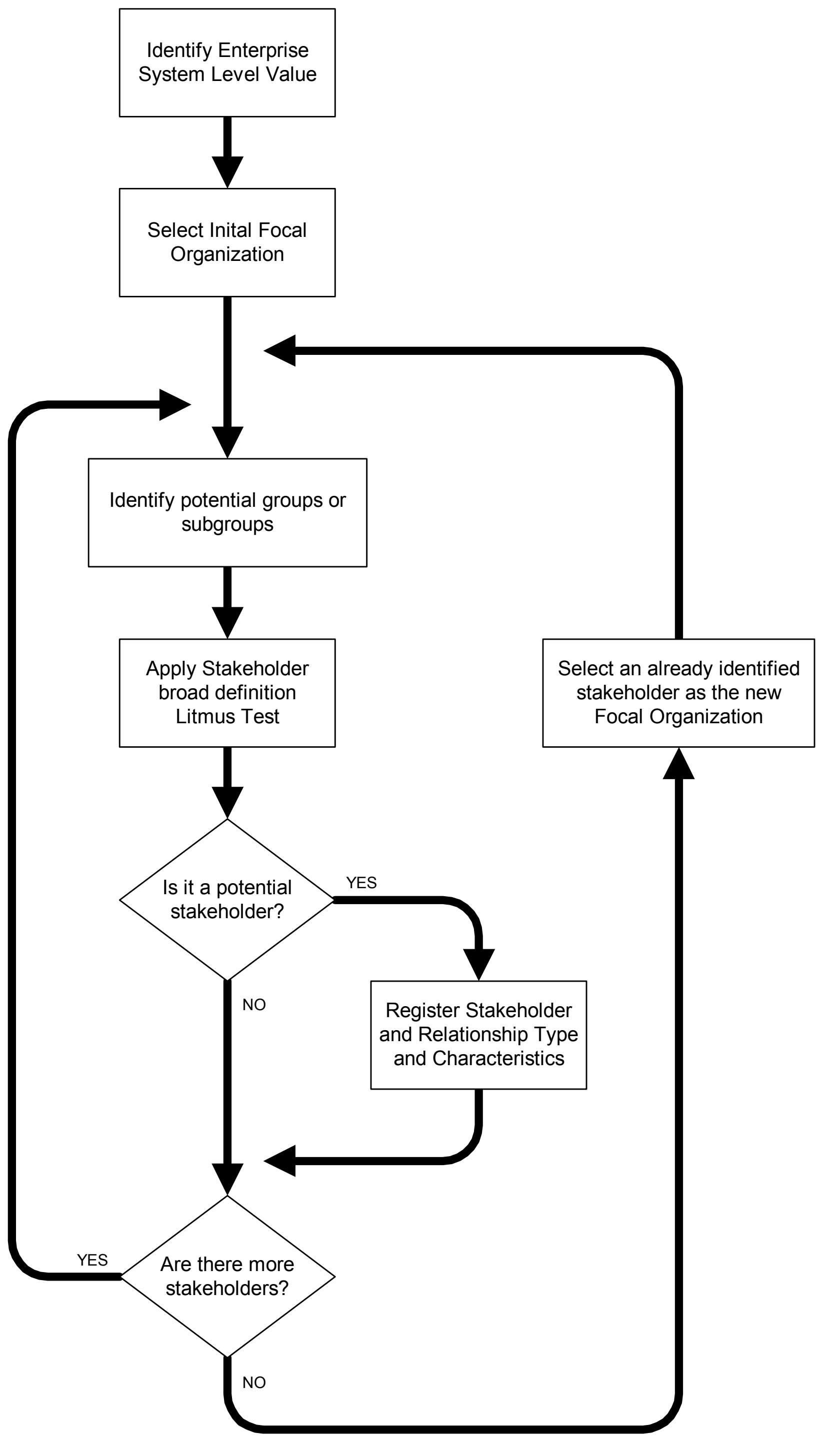


Figure 7: Stakeholder Identification Process Flow Diagram

System Level Value Identification

The stakeholder identification process starts with the definition of the value pursued by the enterprise system. This is not the value each particular stakeholder obtains or is willing to obtain as a payoff from its contribution to the enterprise. More transcendental than that, this is the *system level value* derived from the ultimate objectives of the enterprise system as a whole, and measured at the level of analysis we are interested in to study. This system level value can be either subjective, like in the proposition 'promote community welfare', or a more objective one, like 'put a man on the moon's surface by 1969', but certainly represents the intent of the integrated enterprise.

While particular stakeholder's values and stakes will be important in subsequent phases of the stakeholder analysis process system level value will help in the analysis of who must be considered as a potential stakeholder. In other words, determining the system level value will facilitate defining the boundaries of the enterprise system. In fact, the system level value usually constitutes the driving force for each and every stakeholder participating in the enterprise system, the reason why they contribute with their efforts in the enterprise.

The questions the analyst might want to ask to determine system level value are of the type: what is the ultimate intent of the integrated enterprise? What is the reason for being of the enterprise system? What are the mission and/or vision that define the objectives of enterprise? For the reason that this system level value represents the intent of the integrated enterprise it can be represented by grammatical constructions of the form "To… by…"[19] An example of this type of construction is "TO provide product X in marketplace Y BY implementing process Z." The general structure is "To [statement of overall intent] by [statement of process or behavior]"

The system level value can be defined at many different levels of analysis. Each of these levels will account for different sets of stakeholders and different boundaries of the enterprise system. For instance, one can focus on the value created by a particular program, project, or product of an

[19] 'Ambiguity', lecture notes from MIT's graduate level course ESD.34J "System Architecture"

enterprise; or one can focus on more aggregated levels and account for the value delivered by multiple programs that span across different organizations of the enterprise. In any case, the value object of the analysis must be unambiguously specified in order to proceed with the next steps in the process.[20]

In addition, the value pursued by the integrated enterprise can be made up of several different sub-values or multiple objectives. The analyst should be aware of these type of multiple goals as they can bring into the enterprise system stakeholders that otherwise would not have been considered as relevant for the enterprise. For example, a multiple system level value can be to provide certain products for a defined marketplace AND to create employment opportunities in the local community where the enterprise develops its activities. This value statement would allow incorporating as stakeholders of the enterprise different NGOs and many governmental entities that are interested in promoting employment in the region.

Initial Focal Organization

After the system level value has been identified the next step in the process asks for the selection of an initial focal organization to start with the identification process. This initial focal organization is some recognizable entity within the enterprise system that will serve as the starting point for the identification of stakeholders. This entity is the focal point in which the analyst wants to concentrate in each cycle of the stakeholder identification process. The initial focal organization can be selected using different criteria such as the size (income, number of employees) of different entities that explicitly participate in the enterprise, their presence or relevance in a particular marketplace, the time they have been participating in the business or industry, or simply because the analyst is interested in a firm-centric type of study. This latter case would be the situation, for instance, of the managers of a firm trying to analyze the relationships with its own particular set of stakeholders.

[20] ibid.

Groups Identification

This step of the identification process requires the detection of groups, or subgroups that can potentially constitute stakeholders of the enterprise system. Here the focus must be put on any group or subgroup inside or outside any of the organizations that the analyst think can constitute a potential stakeholder. These groups will be inevitable associated with the system level value pursued by the enterprise that was identified in the first step of the process. The obvious starting point are known types or categories of stakeholders; primary stakeholders, such as suppliers, owners, customers, employees, and competitors; and secondary stakeholders, like government agencies, political parties, media, environmental groups, communities, and so forth. Particular attention must be put on subgroups that may splinter from those original larger groups as they can constitute independent potential stakeholders.

Finding relationships of the focal organization with known or explicit types of potential stakeholders groups is not a difficult task, but discovering tacit relationships with unperceived groups can be a daunting one. To aid in the process of group identification several methods can be applied. Wasserman and Faust (1997) summarize several of these methods for collecting relationship data. Among them they list questionnaires, interviews, observation, and the study of archival records. Submitting questionnaires and conducting interviews with key people inside the focal organization and other external organizations are two of the most used techniques for collecting relationships data and they might help revealing groups that otherwise will remain hidden to the analyst knowledge. Observation of the business and enterprise context and environment is also a method that can lead to better group identification. In this case, the analysis of external forces acting on the enterprise may provide relevant information on the relationships with potential stakeholders. Another method is the study of historical data on the business and industry evolution. Historical data typically contains systematic analysis of different performance measures (e.g. business growth, revenues, market share) that can be correlated with the actions of the focal organization but also with particular phenomena occurring in the environment of that firm that can expose potential stakeholder groups.

The Litmus Test

The next step in the identification process is to apply our stakeholder broad definition presented in Chapter 3:

> **A stakeholder is any group or individual who directly or indirectly affects or is affected by the level of achievement of an enterprise's value creation processes**.

Although this is a broad definition of what constitutes a stakeholder it helps testing whether the groups identified in the previous step may affect or be affected by the enterprise system actions while it is pursuing the creation of the system level value. Submitting each potential group or subgroup to this litmus test will allow the analyst subjectively considering the potentiality of each of those groups to act as a relevant stakeholder. At this stage of the process no ruling out of any potential group should occur. The intention of the process is to obtain a comprehensive list of all the groups that can potentially act as stakeholders of the enterprise system. Thus, even if the relationship with a particular group appears to be weak we still want to be able to detect it and eventually filter that group out in a subsequent stage of the process. If the group under consideration passes this litmus test it will be a qualitative indication that a relationship with the focal organization exists. Consequently, the group under analysis constitutes a potential stakeholder of the enterprise system.

Registration Process

If the litmus test results positive we have identified a potential stakeholder and consequently it should be registered as such together with the analysis of the type and characteristics of the relationship between that group and the focal organization. This will constitute the basis data for building the stakeholders' social network in the following phases of the analysis methodology we will develop later in this thesis.

In a relationship between two stakeholders there is always some resource that is transferred from one stakeholder to the other, and vice versa. As we described in Chapter 4, there are many different types of relational ties that may exist between any two actors in a social network. Table 4 presents some examples of the type and characteristics of possible relationships among stakeholders.

Table 4: Relationships among stakeholders – Type and Characteristics

Relationship Type	Relationship Characteristics	Examples
Material Resources	Volume, Quantity, Frequency	Supplies, Raw Materials, Parts, Components, End Products
Financial Resources	Amount per unit of time	Funding, Loans, Credits, Stock offerings, Payments
Support Resources	Quality of service	Computing Services, Telephony Services, Cleaning Service
Information Resources	Frequency, relevance, quality	Design blueprints, Requirements, Specifications, Social Communications

Process Iterations

Stakeholder identification is far from being a one shot process, on the contrary, it is and needs to be an iterative process in which more and more potential stakeholders are identified in each round. The first round involves the identification of all the groups that can constitute stakeholders of the initially selected focal organization. This phase is iterative, as it needs to proceed group by group until no further entities are detected. This is represented by the process flow lines going back to the beginning of the process in Figure 7.

After this first round of stakeholder identification the next step in this snowball like process is to consider each stakeholder's stakeholders. The same methodology used in the first identification round is applied to that end. At this stage the process asks for the selection of an already identified stakeholder as the new focal organization with which to continue the identification of potential groups. The process then repeats itself iteratively applying the litmus test and registering newly identified potential stakeholders. This sort of stepwise refinement in the stakeholder identification process allows for a thorough review of the relationships among the different actors in the enterprise social network.

While considering the relationships of the new focal organization particular attention must be given to the possible recurrent appearance of the already identified stakeholders. This is an opportunity to discover cross-links or interdependencies among different sets of stakeholders other than the typical hub-and-spokes network configuration.

The identification process continues until every identified stakeholder has been selected as the focal organization with which to conduct the analysis. As we have mentioned before, the identification process must not be conditioned by any filtering mechanism, i.e. all potential stakeholders should be included as relevant to the system level value pursued by the enterprise. Later in the stakeholder analysis process stakeholders that are not relevant to the enterprise's value creation process will be filtered out, and those that are most salient will be prioritized.

Stakeholder Salience Methodology

Once we have exhaustively identified all potential stakeholders related to a particular value creation process of the enterprise under analysis we need to prioritize those stakeholders according to their relevance or salience. The greater the stakeholder salience the more powerful position it will embody, allowing this stakeholder to modify the behavior of the integrated enterprise according to its or some other entity will. However, not only the salience of each stakeholder is important to discover influence mechanisms and behavior in stakeholder networks. As we have mentioned before in this thesis the quality and characteristics of the relationships among stakeholders are determinants of the ability of any salient stakeholder to exert influence on the rest of the components of the integrated enterprise. In fact, no matter how powerful a certain stakeholder can be as defined by its attributes, if it does not have the means of influencing others then its position in the stakeholder network will be rather unfruitful. Those influence mechanisms are precisely provided by the relationships – their attributes, quality, and dynamics – that each stakeholder maintains with others in the enterprise system.

In this section we develop a methodology for the quantification of stakeholder salience that later in the chapter will be used to assess the relevance of the relationships between pairs of stakeholders.

The Stakeholder Salience Index

In Chapter 3, where we presented some stakeholder theory concepts, we described a way of analyzing stakeholder salience proposed by Mitchell et al. (1997). We will build on that model adding a methodology that allows for effectively measuring stakeholder salience.

Although Mitchell et al. adequately consider the possession of the attributes of power, legitimacy, and urgency (that we have replaced for criticality) as determinant of stakeholder salience; they fail to show in their propositions elements of a complete methodology to actually measure stakeholder salience. Moreover, they assume that the sole presence of a certain number of attributes is sufficient to define the salience of a particular stakeholder. Depending on how many of those attributes each stakeholder shows so does its importance increase. Thus, for example, stakeholders showing all three attributes are more relevant that stakeholders showing only one. While they recognize that the salience attributes should be regarded as continuous rather than dichotomous variables, i.e. the attribute is either present or absent, they do not use that characteristic to evaluate stakeholder salience.

While the presence of many of the attributes indeed determines salience, we argue that it is the level of each attribute what actually defines stakeholder salience. If stakeholders have been identified as such, then at least some degree of each of the three attributes will be present. The intensity of each attribute will ultimately define the importance of the stakes at risk and consequently the relevance, salience, or importance of the stakeholder. Consequently, we propose measuring stakeholder salience by a combination of the relative values assigned to each one of the attributes of power, legitimacy, and criticality.

If we represent the three variables – power, legitimacy, and criticality in a radar-plot chart we will obtain a representation similar to the one depicted in Figure 8. Intensity values has been assigned to each one of the attributes, in this case a number greater than zero and lower than ten, which has been used as ordinate values for the corresponding attribute axis in the chart. Logically, the greater an attribute value the more importance that attribute has in defining stakeholder salience. For instance, a power value of ten would indicate that the stakeholder has maximum power to make his claims to prosper, whereas a power value of 1 would signify a low ability to influence on the stakeholder system by means of power methods.

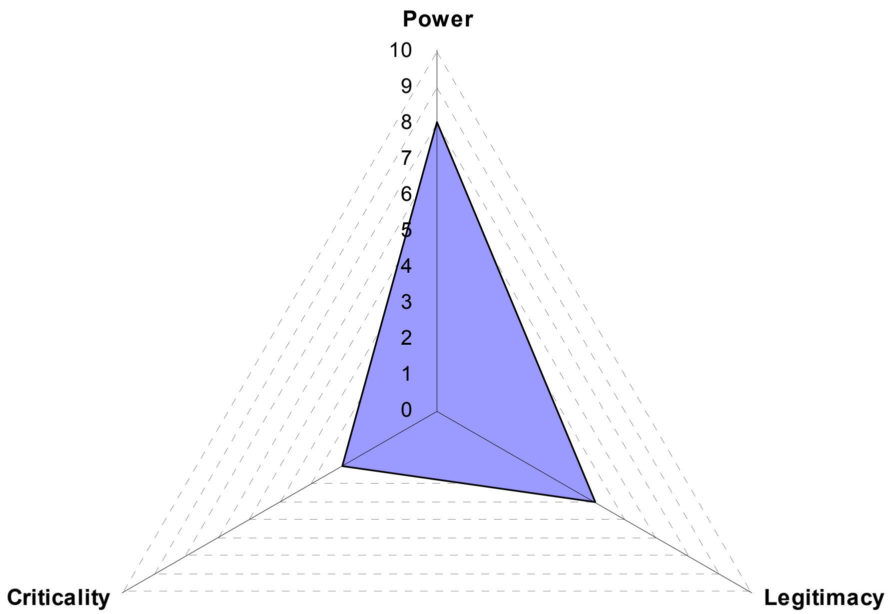


Figure 8: Radar plot of stakeholder attributes: Power, Legitimacy, and Criticality

It is fairly evident by observing the radar plot of Figure 8 that the area of the triangle resultant from joining the vertices defined by the values of the attributes of power, legitimacy, and criticality is representative of stakeholder salience. A greater area would indicate that the attributes' values are larger, which means that the stakeholder has more control to claim its stakes at risk than any other stakeholder with less of any or all of the attributes. Consistently with this description we propose the calculation of a Stakeholder Salience Index (SSI) that is representative of the relative importance of the stakeholder in the enterprise network. The SSI is simply equal to the area of the triangle defined by the level of each of three attributes. This area can be calculated as follows:[21]

$$SSI = \frac{\sqrt{3}}{4}\left(Power \times Legitimacy + Power \times Criticality + Legitimacy \times Criticality\right) \qquad \text{(Eq. 1)}$$

If we choose to define the possible range of the stakeholder's attributes as belonging to the interval [0,10] then a value of zero for all three attributes will be representative of a non-stakeholder and a value of 10 for all of the three attributes will be representative of a stakeholder with maximum salience. Correspondingly, the minimum value that SSI can take will be 0 for non-stakeholders, whereas the maximum value will be 130, or more precisely $\sqrt{3}/4 \times 300$ ($\sqrt{3}/4 \times (10 \times 10 + 10 \times 10 + 10 \times 10)$).

A normalized version that accounts for this maximum stakeholder salience value can then be calculated as:

$$NSSI = \frac{1}{3}\left(Power \times Legitimacy + Power \times Criticality + Legitimacy \times Criticality\right) \qquad \text{(Eq. 2)}$$

Using this latter equation, the minimum value will still be zero, but the maximum value of the salience index will now be 100, which is more convenient for comparing different stakeholder saliencies.

Measuring Power, Legitimacy, and Criticality

In order to apply our proposed Stakeholder Salience Index metric we need to somehow assign values to the each one of the attributes of power, legitimacy, and criticality. The values assigned to each one of those variables for a particular stakeholder must be relative to those assigned to any other stakeholder in the enterprise. This is to say that a scaling system must be devised in order to

---

[21] The area of the triangle can be calculated as the sum of the areas of the three sub-triangles defined by each pair of attribute axes. Sub-triangles areas in turn can be calculated as half the value of one of the attributes defining the sub-triangle times the value of the other attribute times sin(60) or, equivalently, $\sqrt{3}/2$. Factoring common terms produces the equation presented.

account for different interpretations of the attribute values for dissimilar stakeholders. Ultimately, the levels for each one of the attributes will be social constructions of the reality, i.e. they are not objective, as Mitchell et al. (1997: 868) adequately state.

Accordingly, we propose a qualitative assessment questionnaire to define the value for each one of the attributes of power, legitimacy, and criticality. This assessment questionnaire is based on the attributes definitions by Mitchell et al. and is presented in Table 5, Table 6, and Table 7; each table corresponding to each one of the three attributes. The assessment questionnaire maps different attribute factors into numeric values. We have developed guideline propositions for the evaluation of each factor each one corresponding to different value ranges. For each factor a numeric level is assigned depending on its strength or intensity as it is evaluated by the analyst. Ultimately, each attribute level is obtained by averaging the numeric values assigned to each one of the factors that defines the attribute. It is also possible to apply weighted averages for the calculation of each attribute depending on the relative importance that each one of the factors has for each particular enterprise environment. For example, in highly cooperative enterprise settings it will be difficult to find stakeholders that are willing to use coercive type of power in order to obtain value from the system. In this case the coercive power factor of the power attribute might be averaged with a much lower weight than the utilitarian or symbolic types of power. This weighted average will prevent the dilution of the attribute value when some low level characteristics are averaged together with high level ones.

It is important to note that in the descriptions we propose for each level we have replaced the rather firm-centric definitions provided by Mitchell et al. with more integrative or holistic definitions. These definitions take into account the fact that the focus of the analysis is the integrated enterprise, not just a particular firm or organization within the system. Whenever Mitchell et al. mention the firm as the provider or receptor of the stakeholder demands or contributions we have replaced that with similar concepts but operating at the level of the whole enterprise system. This makes for a more systemic evaluation of the power, legitimacy, and criticality attributes instead of their particular evaluation in relation to a unique focal firm. The reader should be warned that some of the definitions had to be recast in order to account for this different perspective, and to adapt the definitions to the lean enterprise context in which this thesis work is framed.

In addition, and particularly for the legitimacy attribute, we have condensed the guideline proposition descriptions corresponding to its different factors due to their extension in number and types. The different subtypes for this attributes are interpretations from the work of Suchman (1995) as cited in Mitchell et al. We leave to the reader the appropriate definitions for the value levels of the factors corresponding to this attribute. Also, we have provided a short version definition of legitimacy (also from Suchman, 1995) which can be used as a more subjective but quite direct way of evaluating the intensity level of this attribute.

Table 5: Stakeholder's Criticality level determination

Criticality Factor	Level Description	Level range
Urgency	The stakeholder is time insensible or has very low demands for a timely response to its claims at risk in the enterprise	0-2
	The stakeholder asks for its stakes or values with enough anticipation allowing the enterprise to attend them in a timely manner	2-4
	The stakeholder requires attention to its stakes in plausible or reasonable times	4-6
	The stakeholder calls for a prompt attention to the stakes at risk in the enterprise	6-8
	The stakeholder demands immediate attention to the stakes it compromise in the enterprise and their associated payoffs	8-10
	Urgency Level	
Importance	The stakeholder has null or very low dependency on the stakes it puts at risk in the enterprise	0-2
	The stakeholder shows low dependency on the values obtained from the enterprise	2-4
	The stakeholder relies on the values obtained from the enterprise for its future actions or operations	4-6
	The stakeholder shows high dependency on the stakes it contributes at risk in the enterprise	6-8
	The stakeholder demonstrates very high dependency on the stakes it puts at risk in the enterprise and on the values obtained from it	8-10
	Importance Level	
	Criticality Attribute (Weighted) Average	

Table 6: Stakeholders' Power level determination

Power Factor	Level Description	Level Range
Coercive	The stakeholder threatening position to obtain the outcomes desired from the integrated enterprise is null or very low	0-2
	The stakeholder uses threatening arguments to obtain the outcomes it desires from the enterprise	2-4
	The stakeholder is able to pose real threats regarding his claims on the enterprise	4-6
	The stakeholder is capable of using some elements of force, violence, or restraint to obtain benefits from the enterprise	6-8
	The stakeholder is determined and totally capable of using force, violence, or any other restrain resource to obtain desired outcomes from the enterprise	8-10
	Coercive Power Level	
Utilitarian	The stakeholder has null or very low control over the resources (material, financial, services, or information) used by the enterprise	0-2
	The stakeholder has some control over some of the resources used by the enterprise	2-4
	The stakeholder controls the use of some of the resources used by the integrated enterprise	4-6
	The stakeholder heavily administers significant number of the resources used by the enterprise	6-8
	The stakeholder extensively administers most of the resources used by the enterprise	8-10
	Utilitarian Power Level	
Symbolic	The stakeholder does not use or barely uses normative symbols (prestige, esteem) or social symbols (love, friendship, acceptance) to influence on the enterprise system	0-2
	The stakeholder uses some level of normative symbols or social symbols to influence on the enterprise system	2-4
	The stakeholder uses moderate levels of normative symbols or social symbols to influence on the enterprise system	4-6
	The stakeholder relies on normative symbols and/or social symbols to claim his stakes from the enterprise system	6-8
	The stakeholder extensively uses normative symbols and social symbols in order to obtain value from the enterprise system	8-10
	Symbolic Power Level	
	Power Attribute (Weighted) Average	

Table 7: Stakeholders' Legitimacy level determination

Legitimacy Factor	Subtypes	Level Description	Level
Broad definition		Generalized perception or assumption that the actions of a stakeholder are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions.	0-10
Pragmatic	Exchange Legitimacy	Extent to which the stakeholder maintains a materialistic (based on goods, services, or any other type of exchange) relationship with the enterprise, and the importance of those exchanges to the welfare of the enterprise system	0-10
	Influence Legitimacy	Extent to which the stakeholder helps in defining the strategic or long-term interests of the whole enterprise and its submission to those interests before its own welfare.	0-10
	Dispositional Legitimacy	Degree to which the stakeholder is predisposed to share or adopt the enterprise values demonstrating honesty, decency, and trustworthiness in the relationship	0-10
		Pragmatic Legitimacy Average Level	
Moral	Consequential Legitimacy	Degree to which the accomplishments of the stakeholder are perceived by the whole enterprise system as "the right thing to do"	0-10
	Procedural Legitimacy	Extent by which the stakeholder's value creation *processes* are perceived as sound and good efforts to achieve some, albeit invisible, ends as valued by the enterprise system	0-10
	Structural Legitimacy	The degree by which the stakeholder is perceived as having the right internal organizational structure to perform its assigned role in the enterprise system	0-10
	Personal Legitimacy	Extent by which the leaders of the stakeholder organization are perceived as having the adequate charismas, personalities, and authority to perform the job the stakeholder is supposed to do for the enterprise system	0-10
		Moral Legitimacy Average Level	
Cognitive	Comprehensibility Legitimacy	Degree of existence of cultural models that provide plausible explanations for the stakeholder participation in an enterprise and its related endeavors	0-10
	Taken-for-grantedness Legitimacy	Degree to which the legitimacy of the stakeholder is taken for granted without an explicit evaluative support	0-10
		Cognitive Legitimacy Average Level	
		Legitimacy Attribute (Weighted) Average	

Relationship Salience Methodology

While the stakeholder salience index defines the relative importance each identified stakeholder has in relation to the value creation processes of the enterprise, we need to provide a mechanism to measure the level of interaction and interdependency among stakeholders. Assessing the importance of the relationships among stakeholders will allow determining which are the most relevant links (and their associated stakeholders) affecting the behavior of the enterprise.

The Relationship Salience Index

One way of describing the relationship between any pair of stakeholders is by the intensity of their interaction. We want to be able to describe the value contained in every relationship present in the enterprise. We assert that the intensity of the interactions and the value associated with them is related with the salience of each one of the stakeholders participating in each particular relationship. When we introduced our definition of what constitutes a stakeholder we stated that that the expression "…affects or is affected by…" was indicative of the relationship among stakeholders. In any relationship each party always has the opportunity to affect the other, and at the same time be affected by the actions of that other party. Depending on the relative importance each stakeholder has for the value creation processes of the enterprise its influence abilities on other stakeholders in the system (the level with which it can affect others) will increase accordingly. Consequently, the intensity with which a stakeholder can affect another in a relationship is directly related with the salience of that stakeholder. Similarly, the salience of the stakeholder at the other end the relationship will affect the former.

If we assume that the value exchanged in any relationship is in equilibrium as we have stated in Chapter 4, then the strength of a relationship will be a direct function of the saliencies of each of the stakeholders involved in it. If we were to plot the level by which a stakeholder affects one another in a relationship against the level by which that stakeholder is affected by that other we will obtain a 2x2 matrix of the type represented in Figure 9.

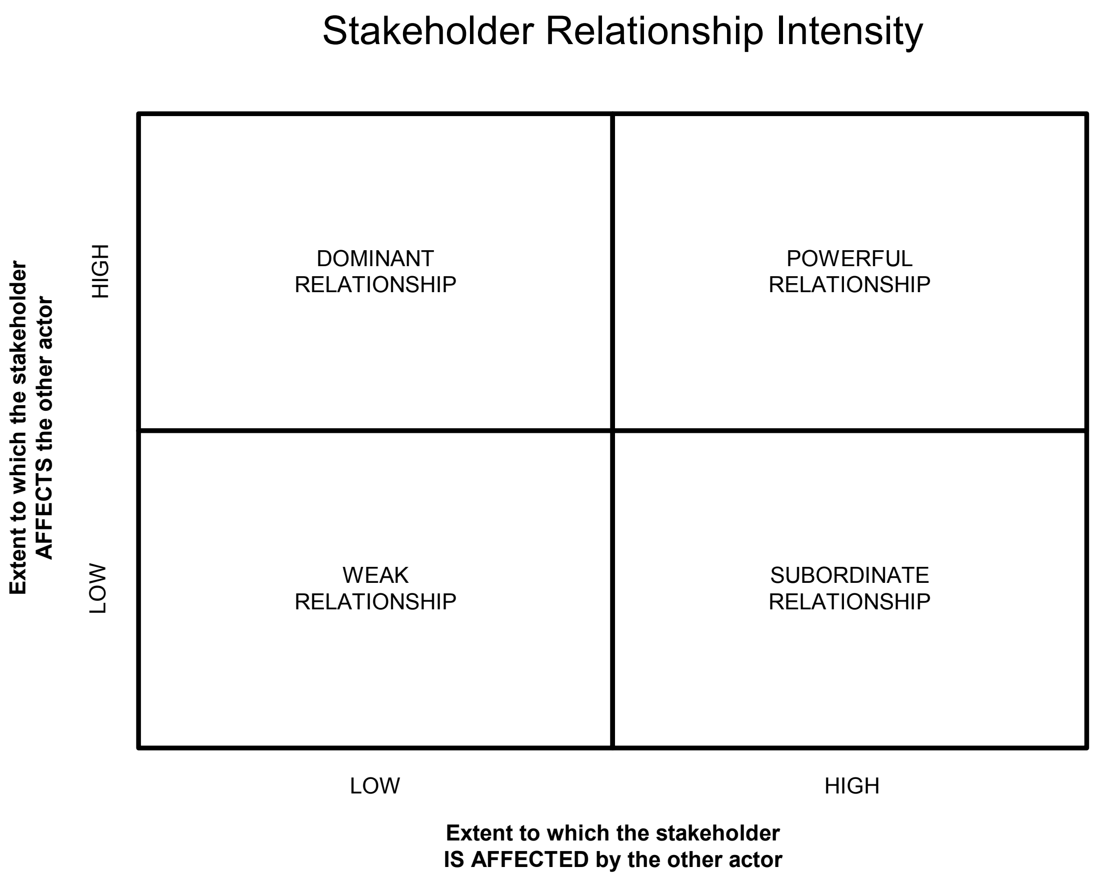


Figure 9: Stakeholder relationship intensity

As we can see in this figure, if the level by which a particular stakeholder affects, and the level by which it is affected by another stakeholder are both high, then their relationship is defined as *powerful*. In this case these two stakeholders together, through their relationship, can exert a great influence on the whole enterprise system. Consequently, this type of relationship is highly salient and determinant of the enterprise's value creation process results. Powerful in this context does not necessarily mean 'sparkling' in the sense that frictional competition is the only way in which to highly salient stakeholders can interrelate. They can also find cooperative or collaborative ways of interacting to obtain maximum value from their participation in the enterprise. Certainly they will have to precisely coordinate their activities if they want to positively influence the enterprise system. For example, when two mega-corporations merge their operations to access a new market or pursue a long-term strategic goal instead of trying to gain benefits on behalf of one another they would rather work together to obtain even further gains.

In the other extreme of the relationship intensity matrix, if both stakeholders lowly affect each other then the relationship intensity is catalogued as weak. In this case the salience of the relationship and its consequent influence abilities on the enterprise system will be also low.

If one of the stakeholders has an influence ability level very different from that of the other stakeholder, then the relationship intensity can be either *dominant* or *subordinate* depending on which extreme of the relationship we are analyzing. In any case, a wide difference in the influence levels constitutes a dangerous factor for the stability of the relationship and eventually the whole enterprise system. In these cases the dominant stakeholder will eventually try to obtain further gains taking advantage of the subordinate stakeholder. An essential role of the managers of enterprise systems like this is avoiding those types of situations to occur; or if they are inevitably present, implement the actions and strategies to avoid unfair takeovers.

In order to count with a method to measure the level of influence of relationships we propose the use of the Stakeholder Salience Index (or its corresponding normalized version) to measure the extent to which one stakeholder affects any other in a relationship. Although that index was obtained from the analysis of the influence of each stakeholder on the whole enterprise we reason that the above descriptions are still valid. Two relevant stakeholders interacting while they perform some of the enterprise value creation processes define an intense relationship; one that will be highly influential in the enterprise system.

Based on the above explanations we define the stakeholders' Relationship Salience Index (RSI) as the product of the salience index of each of the stakeholders participating in a relationship. Using the normalized versions of the stakeholder salience index (Eq. 2) and applying a normalization factor to produce an index ranging from 0 to 100, we obtain the following equation:

$$NRSI = \frac{NSSI_A \times NSSI_B}{100} \qquad \text{(Eq. 3)}$$

where NRSI is the Normalized Relationship Salience Index, and $NSSI_A$ and $NSSI_B$ correspond to the normalized stakeholder salience index for stakeholder A and stakeholder B respectively.

Note that, similarly to the case for the Stakeholder Salience Index, this Relationship Salience Index is proportional to the area of the rectangle formed by the values of the salience indices as depicted in Figure 9. The bigger the area defined by those two values the bigger the impact the relationship will have on the enterprise's value creation processes.

Stakeholder System Structure

Stakeholders and the set of relationships among them define the structure of the enterprise system. We are interested in assessing the characteristics of the enterprise system structure in order to obtain indications about the overall and detailed behavior of the system. Stakeholders' structural measurements provide information on which are the most important organizations or clusters of organizations in an enterprise's stakeholder network. Structural analysis allows determining the relative location of each stakeholder with respect to others in the stakeholder network. Consequently, the analysis of the relationships salience levels together with the interpretation of the stakeholder system structure will be essential to assess the efficiency of the enterprise's value creation processes.

We are also interested in measuring an enterprise's stakeholder network complexity. Every complex system has an associated form and function, and so does a stakeholders network system. The concepts of form and function and their interrelationship are essential to define the system architecture.[22] A system's form talks about the existence of structural complexity (morphological complexity) whereas a system's function(s) talks about the existence of functional complexity (physiological complexity). In a stakeholder system structural complexity informs about the *potentiality* of the system to achieve maximal efficiencies from all entities associated with the integrated enterprise. Structural complexity is an indicator of the maximum level of cooperation and efficiency that can be expected from the system. Structural complexity can be measured with

[22] Introductory lecture of MIT's graduate level course ESD.34J "System Architecture"

standard social network analysis tools such as network density, and centrality (degree, closeness, and betweenness centrality).

Functional complexity on the other hand, represents the actual level of interactions among the members of the stakeholder system. Functional complexity is representative of the actual efficiency level attained by the whole system.

Social Network Analysis

In order to assess the structure of a stakeholder system we will use standard metrics used in social network analysis (see Wasserman and Faust, 1994). In particular for the case of stakeholder networks, we propose the use of the following metrics: stakeholder relationship degree, stakeholder network density, and stakeholder centrality measures.

Stakeholder Relationship Degree

The first and simplest way of measuring stakeholder's network structure is through the calculation of the number of relationships each stakeholder maintains in the enterprise system network. The stakeholder relationship degree is directly calculated as the number of links that connects it with other stakeholders in the enterprise. The stakeholder relationship degree or nodal degree will be denoted as $d(s_i)$ where s_i identifies the i^{th}-stakeholder in the system.

A corresponding System Relationship Degree can be calculated by averaging the relationship degree of all the stakeholders in the enterprise system. It is calculated and denoted as:

$$\overline{d} = \frac{\sum_{1}^{N} d(s_i)}{N} \qquad \text{(Eq. 4)}$$

Where N is the total number of stakeholders in the system.

The variability of the stakeholder relationship degrees can be calculated as the variance of the degrees as follows:

$$S_D^2 = \frac{\sum_1^N \left(d(s_i) - \bar{d}\right)^2}{N} \qquad \text{(Eq. 5)}$$

The system relationship degree and its corresponding variance can also be calculated for any particular subgroup of interest within the stakeholder system.

Stakeholder Network Density

Stakeholder Network Density measures the actual number of ties or relationships between stakeholders with respect to the total possible number of links. The total possible number of links is determined by the number of pairwise combinations of all stakeholders in the system, which can be calculated as: $\binom{N}{2} = N(N-1)/2$. This corresponds to the maximum number of relationships that can exist in any stakeholder system comprised of N stakeholders. Then, Stakeholder Network Density can be calculated as follows:

$$SND = \frac{2R}{N(N-1)} \qquad \text{(Eq. 6)}$$

Where R corresponds to the number of relationships actually present in the network. The density of the stakeholder network can range from 0, in the hypothetical case of no relationships among the stakeholders ($R = 0$), to 1, when all possible relationships are present ($R = N(N-1)/2$).

In theory, a highly dense stakeholder network (density close or equal to 1) is a desired state because as the number of links between stakeholders increase, so does the possibility of achieving better information flows and resource transactions across the network. However, density also talks about the system functional complexity. In very dense networks consisting of large number of stakeholders managing the relationships among those stakeholders can represent a daunting task. Like in every complex system there is a point where more connections imply increasing levels of rigidity in the system. This dichotomy can be qualitatively described as depicted in Figure 10.

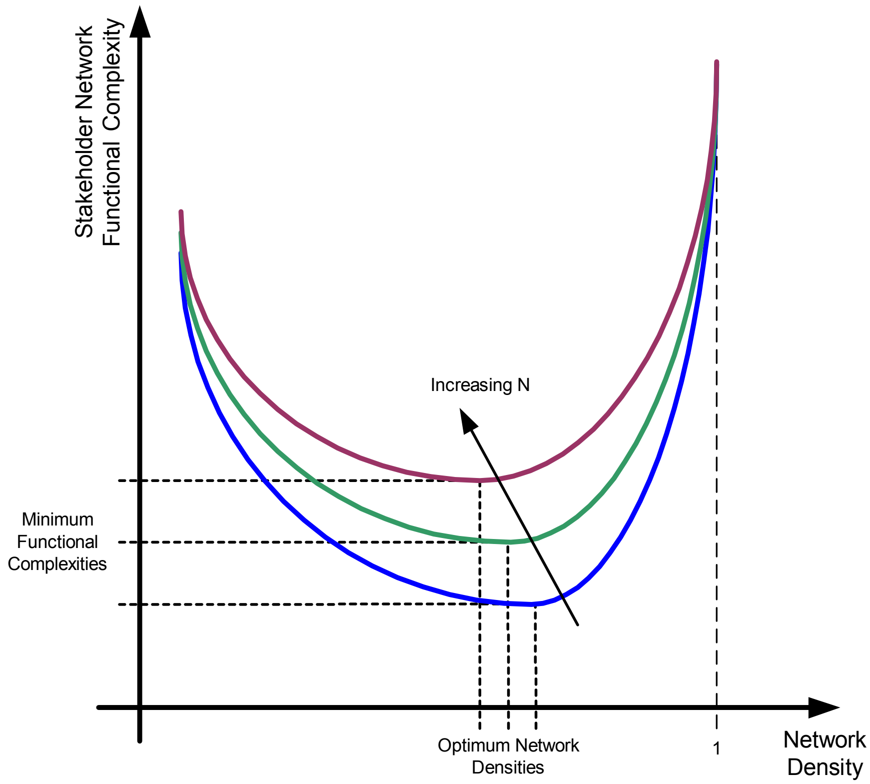


Figure 10: Stakeholder network density and its related functional Complexity

The hypothesis we sustain is that as the network density increases (an indication of increasing structural complexity), functional complexity, which is related with the ability of the stakeholder network to create value, first decreases until it reaches a minimum, and then starts to increase again until density reaches its maximum. As the number of stakeholders in the network (*N*) increases, the densities for which functional complexities are minimal decrease. Also, the functional complexity corresponding to those minimal network densities increases as the number of stakeholders in the network grows.

For relatively large networks it will be more difficult to make the enterprise system function properly, i.e. efficiently, when the number of links among stakeholders is small when compared with the maximum possible. This would mean, for example, that communication channels, supply chains, or distribution networks are not sufficiently developed to support the enterprise operations. In the other extreme, when every stakeholder is connected with nearly every other in the network, coordinating and managing all the relationships among stakeholders becomes an extremely difficult and usually inefficient (not lean) task. These are the situations where, for instance, decentralized management practices and outsourcing alternatives should be considered in order to make the enterprise operate more efficiently. When relationships density is very high it is rather impossible for a unique central organization to orchestrate the operations of the entire enterprise network. There has to be, for each particular enterprise and its corresponding stakeholder system, an optimum pattern of relationships for which the functionality of the enterprise system is maximum, which is the same as saying that functional complexity is the least possible.

There is another possible misinterpretation related with stakeholder network's densities. Calculating the density for the whole stakeholder network can probably lead to wrong conclusions about the functional efficiency of the enterprise. Because relationships are based on value exchanges between stakeholders, and because those value exchanges may very well differ for different pairs of stakeholders, it is not necessarily true that more dense networks provide better overall system level value. In terms of value creation a stakeholder network may be a highly efficient one with very low overall network densities. Instead, it is probably better to consider 'local densities' calculated over subgroups of stakeholders that perform certain well-defined high-level functions for the enterprise system, i.e. subgroups that provide certain well-defined type of value to the network. These subgroup densities will inform about how connected and functionally efficient each subgroup is. However, our previously stated hypothesis about highly dense networks and how that is related to functional efficiency is still valid for subgroups densities. High density within a subgroup does not necessarily imply better efficiencies in the operations carried out by that subgroup. There has to be a certain optimum subgroup relationship's density for which the efficiency is maximal, or equivalently, for which functional complexity is minimal.

Stakeholder Centralities

Stakeholder centrality measurements allow determining which stakeholders are "more important" in terms of the structural relationships they maintain with the rest of the network. They allow defining the location of each stakeholder in terms of their structural prominence in the stakeholder network. Stakeholder centralities also measure how many relationships each stakeholder manages and how this allows it to control the relationships among other stakeholders. When a stakeholder controls a great number of relationships his relevance or importance for the enterprise function is potentially larger. On the other hand, when a stakeholder is isolated or in the periphery of the network his power position and the ability to influence the enterprise will be very small.

However, it is important to note that these measures only consider the structural aspects of relationships among stakeholders. If we were to measure the real influential ability of a highly central stakeholder we will need to consider the type and intensity of the relationships that that stakeholder manages. The power position of a stakeholder that manages a great number of secondary relationships is very different from that of another stakeholder that controls fewer number but very relevant relationships. This is another indication of the dichotomy existent between a stakeholder network's structural and functional complexities.

There exist many ways to measure a stakeholder's centrality. Among them we find degree, closeness, and betweenness centrality. Each one of these metrics provides different and complementary ways of measuring stakeholder's structural prominence in the stakeholder network.

Degree Centrality. This centrality measure takes into account the number of relationships a particular stakeholder maintains with the rest of the stakeholder network. It is numerically equivalent to the stakeholder relationship degree that we have previously defined. We write the degree centrality as follows:

$$C_D(s_i) = d(s_i) \quad \text{(Eq. 7)}$$

In order to make this metric independent of the number of stakeholders in the network and be able to compare degree centralities between stakeholder networks of different composition we can normalize this measurement as follows:

$$C_D^{'}(s_i) = \frac{d(s_i)}{N-1} \quad \text{(Eq. 8)}$$

Where *N-1* corresponds to the maximum number of relationships any particular stakeholder can establish, which is equivalent to the number of stakeholders in the system minus the one for which we are calculating the degree centrality. This normalization allows comparing stakeholder networks of different size because centralities range from 0 to 1.

A stakeholder showing very high degree centrality is one that maintains relationships with almost every if not all of the rest of stakeholders in the enterprise system, hence its structural prominence is also high as the stakeholder is seen by others as a 'hub' of the system. On the contrary, a stakeholder with low degree centrality is one that is seen by the rest of the enterprise as peripheral or less relevant. Again, this description is valid only under the assumption that all the relationships in the system are all of similar functional importance.

Closeness Centrality. This metric measures how structurally 'close' a stakeholder is to the rest of the stakeholders in the system. How close is defined by the minimum number of links or relationships that separates the stakeholder from any other stakeholder in the enterprise system. Hence, a stakeholder would be more central if it does not need to use 'intermediary' stakeholders to reach any other stakeholder in the network. For example, if a highly closeness-central stakeholder needs to communicate something to the system it can do that directly using its own set of relationships with the rest of stakeholders in the network. In contrast, if one stakeholder needs to reach one another by using one or more stakeholders in the system then that stakeholder is less prominent because it depends on others to properly operate within the system. The firm in the hub or Figure 3 has a high closeness centrality (and also high degree centrality) as it does not depend on any other stakeholder in the network to communicate or relate with every other entity in the enterprise. In this case the 'distance' between the firm and any other stakeholder is just one link.

This metric can be calculated as follows:

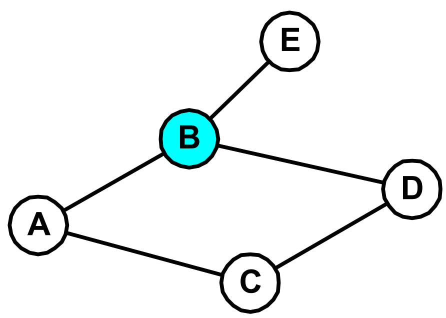
$$C_C(s_i) = \frac{N-1}{\sum_{j=1}^{N} d(s_i, s_j)}, \text{ for all } j \neq i \qquad \text{(Eq. 9)}$$

Where $d(s_i, s_j)$ represents the 'distance' between stakeholder *i* and stakeholder *j*. This distance is calculated as the minimum number of links that separate both stakeholders, or equivalently, as the minimum number of intermediary stakeholders plus one. The inverse of the summation of all distances to other stakeholders multiplied by a normalization factor (*N-1*) gives a measure of closeness centrality. The values for closeness centrality can range from 0, for the case of an isolated stakeholder who is at 'infinite distance' from the rest of the stakeholders, to 1, for the case of a hub-like stakeholder who is at distance 1 from any other stakeholder in the enterprise system. In general, a large closeness centrality is indicative of their independence to access other stakeholders in the network (Rowley, 1997: 899)

Betweenness Centrality. This metric is similar to the previous one but in this case we measure how many times a particular stakeholder acts as a necessary intermediary in the relationship of any other two stakeholders in the network. Using this metric a highly central stakeholder would be one that is intermediary (hence the term betweenness) and somehow responsible for many of the relationships between other stakeholders in the network. Intermediating in a relationship is a way of controlling the actions of part or the entire stakeholder network. This metric can be calculated as follows:

$$C_B(s_i) = \frac{\sum_{j<k} g_{jk}(s_i)/g_{jk}}{(N-1)(N-2)/2} \qquad \text{(Eq. 10)}$$

Where g_{jk} corresponds to the total number of minimal paths (geodesics)[23] connecting stakeholders *j* and *k*, and $g_{jk}(s_i)$ corresponds to the number of those minimal paths in which stakeholder ***i*** is involved. The denominator term is a normalization factor that corresponds to the total number of pairs of stakeholders not including ***i***. Figure 11 presents a simple illustrative example to help understanding the calculation of this centrality measure.



$g_{AE} = 1,\ g_{AE}(B) = 1$
$g_{AD} = 2,\ g_{AD}(B) = 1$
$g_{ED} = 1,\ g_{ED}(B) = 1$
$g_{EC} = 2,\ g_{EC}(B) = 2$
$g_{BC} = 2,\ g_{BC}(B) = 0$

Figure 11: Betweenness Centrality calculation example

We want to calculate the betweenness centrality of stakeholder B. This stakeholder is intermediary of the relationship between stakeholders A-D, A-E, E-D, and E-C. Stakeholder B is on the geodesic paths connecting all these stakeholders as the numbers in the figure demonstrates. There exist other geodesic between A-D (the path A-C-D) in which B does not participates. Hence, according to equation 10 above, the betweenness centrality of stakeholder B is:

$$C_B(B) = \frac{1/1 + 1/2 + 1/1 + 2/2}{(5-1)(5-2)/2} = 0.58$$

[23] A geodesic is defined as the shortest path between two stakeholders in the network. A path is a sequence of distinct nodes and distinct links connecting nodes.

Comparatively, the betweenness centralities for all other stakeholders are: $C_B(E) = 0$, $C_B(A) = C_B(D) = 0.167$, and $C_B(C) = 0.08$. Hence, according to this metric stakeholder B is the most central stakeholder of this network, which is also evident in the figure.

As a complement of the case of a stakeholder with high closeness centrality, a stakeholder showing high betweenness centrality is one that acts as a broker or gatekeeper of the relationships between less central stakeholders (Rowley, 1997: 899). A highly central stakeholder using this metric is one that lies along the shortest paths between many pairs of stakeholders as we have demonstrated in the example above.

Group Centralities

For each one of the structural centralities defined above there exist a corresponding metric that measures the variability of the centrality values for all the stakeholders in the network. These group-level metrics inform about how central each stakeholder is with respect to others in the network. Comparing the centrality of each stakeholder with this group-level metric will indicate the stakeholder's relative centrality position. Also, this group centrality metrics allow comparing different stakeholder networks or even stakeholder subgroups within the same enterprise system.

Essentially, group centralities are calculated by dividing the summation of the differences of the maximum centrality less each stakeholder's centrality by the maximum theoretically possible set of differences (which always occur for the star topology). In mathematical notation this would be:

$$Cx = \frac{\sum_{i=1}^{N}\left[Cx(s^*) - Cx(s_i)\right]}{\max \sum_{i=1}^{N}\left[Cx(s^*) - Cx(s_i)\right]}$$

Where the Cx notation represents any one of the centrality metrics described above, and $Cx(s^*)$ is the corresponding maximum centrality present in the network. The denominator is the theoretical maximum sum of differences in centralities, which is obtained from the consideration of all possible network structures containing N stakeholders (Wasserman & Faust, 1994: 176)

Hence, for each one of the stakeholder centrality types defined above, the corresponding group centralities are defined as follows (Wasserman & Faust, 1994: 180-192):

Group Degree Centralization, $$C_D = \frac{\sum_{i=1}^{N}\left[C_D(s^*) - C_D(s_i)\right]}{\left[(N-1)(N-2)\right]}$$ (Eq. 11)

Group Closeness Centralization, $$C_C = \frac{\sum_{i=1}^{N}\left[C_C(s^*) - C_C(s_i)\right]}{\left[(N-1)(N-2)/(2N-3)\right]}$$ (Eq. 12)

Group Betweenness Centralization, $$C_B = \frac{\sum_{i=1}^{N}\left[C_B(s^*) - C_B(s_i)\right]}{(N-1)}$$ (Eq. 13)

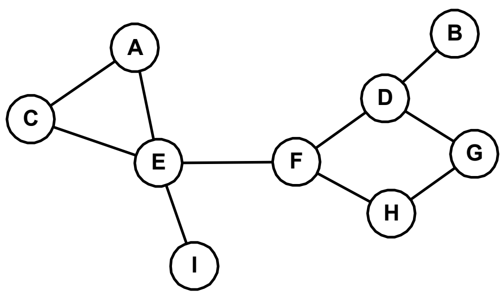
Each one of these stakeholder system-level centrality metrics can range from 0 to 1, or if expressed in percentages, from 0 to 100%. These network centralization indices will equal 0 when all stakeholders are connected with everybody else in the network (all having the same individual centrality index), and equal 1 when one stakeholder completely dominates the network. This latter case corresponds to the star topology where one stakeholder concentrates all the relationships and the others are exclusively connected to that central stakeholder.

Dependency Structure Matrix Methodology

Another way of describing the structure of a stakeholder network is through the use of a Dependency Structure Matrix (DSM). DSM and its associated methodology have been successfully applied to the study of engineering system's architectures, product development, project management, and internal organizational studies.[24] In these scenarios the DSM methodology is applied to represent patterns of information flow across components, activities, or people. In the social network literature a DSM resembles what is known as a sociomatrix. It

24 For applications in these areas of study see Eppinger S.D., Whitney D.E, Simth R.P., and Gebala D.A. (1994); Eppinger S.D. (2001); and Eppinger S.D., and Salminen V. (2001).

basically consists of a matrix where, for the case of our analysis, the rows and columns are representative of the identified stakeholders of the enterprise. Hence, a stakeholders DSM will always consist of *N x N* elements. Figure 12 shows an example of a stakeholder network and its associated DSM representation.

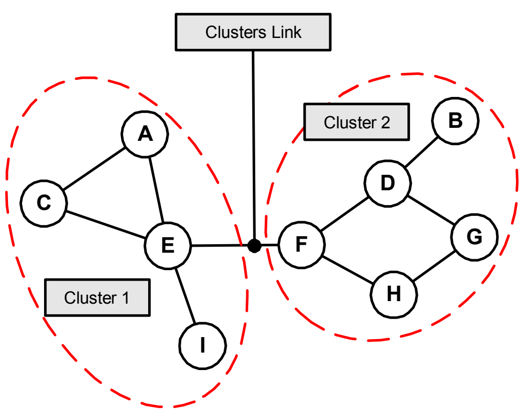


Stakeholder	A	B	C	D	E	F	G	H	I
A			1		1				
B				1					
C	1				1				
D		1				1	1		
E	1		1			1			1
F				1	1			1	
G				1				1	
H						1	1		
I					1				

Figure 12: Stakeholder DSM Example – DSM setup

The elements of the DSM are filled with blanks or ones depending on whether a particular stakeholder in a row maintains a relationship with one or many of the stakeholders listed in the columns. In other words, if stakeholder i maintains a relationship with stakeholder k then $x_{ij} = 1$. For example, in Figure 12 stakeholder A is linked to stakeholders C and E hence a 1 appears in the corresponding row/columns of the DSM (x_{AC}=1, and x_{AE}=1). The diagonal of a stakeholder DSM is filled with blanks as stakeholders cannot relate with themselves. Because we assume that relationships between stakeholders are bidirectional and balanced, i.e. value flows in both directions and is in equilibrium, the stakeholder DSM will be symmetrical. Then, the corresponding elements x_{ji} will also equal 1. It is also possible to assign different values, other than 0 or 1, to each element of the DSM in order to represent a particular characteristic of the relationships between stakeholders. For example, the importance, relevance, or intensity of the relationships can be used, which would allow us to study influence patterns across the network.

Details about the DSM methodology can be found in Eppinger et al. (1994) and Steward D.V. (1981). Basically the methodology provides heuristic algorithms that allow partitioning and clustering a DSM in such a way that relevant groups of elements within a network become evident. By applying these heuristics to a stakeholder DSM we will be able to identify some of the structural and functional characteristics of the stakeholder network. For instance, detecting structural clusters inside the network is easily performed once a DSM is partitioned, i.e. once its rows and columns are permuted in order to group closely related stakeholders. Further analysis of a stakeholder DSM may reveal key stakeholders or key relationships. For example, by closely inspecting a stakeholder DSM we can identify stakeholders that serve as nexus between two different subgroups within the enterprise system, or a relationship that is essential for the proper behavior of the enterprise.



Stakeholder	A	C	I	E	F	D	G	H	B
A		1		1					
C	1			1					
I				1					
E	1	1	1		1				
F				1		1		1	
D					1		1		1
G						1		1	
H					1		1		
B						1			

Figure 13: Stakeholder DSM Example – Partitioning and Clustering

Continuing with our example, in Figure 13 we have permuted some of the rows and columns in the DSM to reveal the existence of two important clusters within this network (identified as Cluster 1 and Cluster 2). Those two clusters are represented by the boxes traced on the diagonal of the DSM, which comprise the set of relationships maintained by stakeholders within each one of the clusters. Moreover, these two clusters are interconnected by just one relationship, the link between stakeholders E and F, which is also clearly shown in the stakeholder DSM as an element outside the cluster boxes. This single relationship is crucial for the operation of this network; if somehow it gets compromised the enterprise will literally be divided up in two, hindering communications or information flows between those two stakeholder clusters.

In short, a stakeholder DSM provides relevant information on the structure of a stakeholder network. Functional evaluations of the clusters and connections between them will depend on the characteristics of the enterprise under analysis. We will cover this aspect of a stakeholder DSM in our application example presented in the next chapter.

Measuring Functional Complexity

All the metrics and methods described above to assess stakeholders' networks have the problem of being exclusively based on the existence of dichotomous relationships among stakeholders; the relationships are either present or absent. This way all possible network measurements obtained will only be indicative of the network structural complexity, i.e. how stakeholders are interconnected. The hope is that those evaluations of structural complexity somehow will provide information about the way the stakeholder network functions. This goal is partially attained as the proposed metrics give an indication of the network potentiality to use its structural characteristics and connectiveness to provide the required network functionality. In our case this functionality is represented by local value exchanges among stakeholders and ultimately the delivery of the system level value for which the stakeholder network was created or evolved. The analysis above calls for a methodology to measure the functional characteristics of stakeholders' networks.

Closeness and betweenness centrality measures depend on the determination of the shortest paths (geodesics) linking pairs of stakeholders. Moreover, both indices exclusively rely on the number of geodesics connecting a pair of stakeholders excluding any other possible, although longer, path between them. This is an important drawback of these metrics as communications, information flow, or any other type of exchanges within the network can also make use of longer but functionally more efficient paths. Ultimately, value flow across the network will follow the paths of least resistance, which are not necessarily the structural shortest paths.

Stephenson and Zelen (1989) developed a method for measuring actor centralities in social networks that takes into account not only the geodesics but all the paths connecting any two actors in the network. Furthermore, the method can also be applied to valued relationships where each of the links between actors can take numeric values other than the mere zero or one indicating the absence or presence of a relationship. Their proposed centrality metric will reflect the relative weights of those valued relationships when measuring the relevance of each actor in the network.

Due to the consideration of those two important characteristics – path completeness and weighted or valued relationships – we propose this metric to assess the functional complexity of a stakeholder network. Furthermore, we propose the use of our Relationship Salience Index as the numeric value to consider when weighting the relationships among stakeholders. This index measures the intensity of the relationship between any two stakeholders and consequently we will be measuring how relationship's strengths mold the functional characteristics of the stakeholder network. The idea is that when this index is large, indicating a strong relationship between two stakeholders, the stakes that are into play in the relationship acquire more relevance for the rest of the network hence positively influencing value flow across that link. In other words, the relevance of the stakes present in the relationships is an attractor for the value creation processes of the entire enterprise. The assumption is that the whole stakeholder network will work (function) to firstly satisfy the most salient stakeholders and their corresponding relationships.

Stephenson and Zelen centrality metric is called "information centrality" because it considers relationships as channels through which information can flow across the network. The metric gives weights to the relationships according to the "information" they contain. They first derive the formulation based on the bare links between actors and then they extend the concepts to consider valued relationships. Basing their work on statistical estimation theory they state that, in general, information is the reciprocal of the variance of the observation. Paths in a network are envisioned as signals connecting any two nodes. The noise in the transmission of that signal is typically measured by the variance of the signal when it travels from one node to the other. Paths that are composed of more than one link can be thought as the transmission of as many independent signals as links are in the path. Consequently the variance (noise) in the transmission will be the sum of the variances of each of those links (the variance of the sum of two or more independent events equals the sum of the variances of each event). The variance of each link is defined as 1 for non-valued relationships hence the variance of a path will be equal to its length.

To account for the fact that there may be several paths connecting any two actors in a network, Stephenson and Zelen propose the idea of a combined path measure that is the summation of each path length connecting the actors, each one affected by a weight factor. This weight factor is simply the proportion of the total information that is transmitted through each corresponding path. Total information is the sum of the information carried by each one of the paths. The use of those weight factors maximizes the information transmitted through the combined path. Corrections on the weight factors are necessary if different paths use common linking elements (relationships).

Finally, Stephenson and Zelen define the information centrality of an actor as the harmonic average of the information associated with the paths connecting that actor to every other actor in the network. Mathematically,

$$C_I(i) = \frac{N}{\sum_{j=1}^{N} 1/I_{ij}}$$

Where $C_I(i)$ is the information centrality of actor i, I_{ij} is the information of actor i with actor j, and N is the number of actors in the network.

As Stephenson and Zelen demonstrate in their paper the calculation of the information between actors (I_{ij}) can be done by simply inverting a matrix that is easily derived from the adjacency matrix.[25] The square matrix $B = (b_{ij})$, containing NxN elements, is defined as follows:

$B = D(r) - A + J$, where $D(r)$ is a diagonal matrix of the nodal degrees (same as the ones used to calculate degree centralities) corresponding to each stakeholder; A is the adjacency matrix; and J is a square matrix with all elements unity.

Then, by defining the matrix $C = (c_{ij}) = B^{-1}$ (the inverse of the above defined B matrix) we can calculate the values for I_{ij} (the information in the combined path from stakeholder i to stakeholder j) as follows:

$$I_{ij} = (c_{ii} + c_{jj} - 2c_{ij})^{-1}$$

The denominator of the equation for information centrality is developed as follows:

$$\sum_{j=1}^{N} 1/I_{ij} = \sum_{j=1}^{N} (c_{ii} + c_{jj} - 2c_{ij}) = Nc_{ii} + T - 2R$$

where $T = \sum_{j=1}^{N} c_{jj}$ is the sum of the elements in the diagonal of C, and

$R = \sum_{j=1}^{N} c_{ij}$ is the sum of the elements of any of the rows of C (R is the same for any of the rows)

The information centrality for a stakeholder $\boldsymbol{i}$ will be:

25 Equivalently to a stakeholder DSM, the elements of the adjacency matrix contains the information of which actor is related with which other(s) in the network. The rows and the columns of the matrix represent the actors and a numeric value 1 in a particular element indicates that the actors in the corresponding row and column maintain a relationship.

$$C_I(i) = \frac{N}{Nc_{ii} + T - 2R} = \frac{1}{c_{ii} + (T - 2R)/N} \quad \text{(Eq. 14)}$$

This metric can be easily extended to the case when values are assigned to the links between stakeholders. In our case, as it was proposed above, the relationships will be assigned the values dictated by the Relationship Salience Index. The matrix B for the case of valued relationships is calculated as follows:

$$B = S - W + J$$

Where J is a square matrix with all elements unity as before, W is the Relationship Salience Indices matrix (similar to the adjacency matrix A but instead of ones indicating a relationship the value of the relationship salience index occupies that element), and S is a diagonal matrix of the sum of the weights (the sum of each row of W). Using this valued B matrix the procedure to calculate stakeholder's information centralities is identical as the case for non-valued relationships.

The methods and tools developed in this chapter will help analyzing the structural and functional characteristics of stakeholder networks. Ultimately, this analysis will allow assessing the efficiency or leanness of an enterprise's value creation processes in terms of the existence of wasteful structural and functional patterns within the network.

C H A P T E R 7

APPLICATION EXAMPLE

This chapter presents the application of the concepts and methods developed in previous chapters to a real case scenario. The example we have chosen to develop corresponds to the stakeholders' system in which the firm Payload Systems Incorporated, a small aerospace engineering company located in Cambridge, MA, participates.

Company Background[26]

Because Payload Systems will be the focus of our analysis we will provide a short description of the company background that will help understanding the environment in which it develops its activities.

Payload Systems has approximately 30 full-time, part-time, and consultant employees, all located in their Cambridge facilities. 90% of the employees are technical (engineers, technicians, and scientists). About half of these have advanced degrees. The company has approximately 2.5 M$ in revenue per year. It was founded in 1984 to provide engineering in support of spaceflight research, with a particular focus on manned spaceflight. Since that time, the company has developed a reputation for providing top-quality, high-value science, technology, and design services to a wide range of customers, both commercial and governmental, including several international clients. The company can claim that in 18 years of flying dozens of spaceflight experiments and other hardware, not a single experiment has had an unrecoverable failure once on orbit. In spite of its small size, Payload Systems can claim several "firsts": First US company to place a commercial payload onboard Mir space station; First US Payload Specialist; First complex payload on-board the International Space Station.

[26] The content of this section title is an adaptation from the introductory section of N. Clark, J. de Luis, I. Grossi, and T. Seitz, '*Lean Transformation of a NASA Flight Hardware Development Enterprise: Payload Systems Inc., Cell Culture Unit*', presented as a class project final paper for MIT's graduate course ESD.61J Integrating The Lean Enterprise, Fall 2002

Traditionally, the typical Payload Systems client was a researcher in a university that had already performed ground studies and experiments on an innovative technology or scientific theory that now required experimentation in space. Payload Systems would work with the researcher and help him or her obtain funding for the space-component of their experiment. Typically, this funding would come from one of the national space or defense agencies, e.g., NASA, USAF, NASDA (Japan), ESA (Europe), etc. Working closely with the researchers, Payload Systems would design and fabricate the experiment or hardware so that it met all the unique requirements of the spaceflight environment, as well as meeting the scientific objectives. Payload would also be responsible for astronaut training, launch support, mission control operations, and data and hardware recovery.

More recently, Payload Systems has expanded their expertise to become first-tier contractors to NASA, and first-tier subcontractors to Boeing, the company responsible for the fabrication of the International Space Station. This has led Payload to significantly upgrade their processes and capabilities to deal with the additional requirements that these new roles demand, particularly in the fields of safety, verification, and quality assurance.

More specifically, the company divides its expertise and services into the following three categories:

Experiment Support, which includes,

- Flight systems design
- Flight systems test protocol development
- Flight systems certification
- Payload integration
- Crew training
- Ground processing
- Mission support

Flight Systems Development. This focuses on the design and fabrication of the hardware and software itself. The company has developed flight systems that have addressed a wide spectrum of technical and scientific areas, including, fluid and structural, life sciences and biochemistry, Human performance, communication systems, as well as generic electronic and mechanical design of spacecraft components.

Ground Test Support. Payload Systems has also taken part in extensive ground research, and assisted dozens of investigators in preparation for and performance of parabolic flight proof-testing and data collection on the NASA/JSC KC-135, providing many of these clients with the preliminary results necessary to commence preparation for spaceflight.

Technology innovation and special projects. Over the years, Payload Systems has provided technical guidance and/or conducted numerous ground and preflight research or research & development projects in support of our clients' science and technology needs. These projects have ranged from a few weeks to a few years in duration, and have spanned fields from plant growth to telerobotics. Payload Systems' staff take pride in combining technical excellence and flexibility in approaching all of its projects, whether small or large, fundamental or applied, spacebound or earthbound.

Payload Systems' major competitors are other small aerospace firms, or firms with small aerospace enterprises, such as SHOT Technologies, Hernandez Engineering, and Veridian Inc. However, because of declining space budgets, Payload Systems often finds itself competing against much larger firms, such as Lockheed Martin and TRW. One competitive advantage, in addition to its lower costs and flexibility, is the fact that the company is a certified Small Disadvantaged Business, which allows prime contractors to meet their SDB subcontracting goals while obtaining value for their end products.

Focus of the Stakeholder Analysis

The focus of analysis in this application example will be related with Payload Systems' most important project: the Cell Culture Unit engineering system and its associated stakeholder system. This project accounts nowadays for the majority of the revenues and efforts of the company; hence the example will be rich in the importance and actuality of the enterprise stakeholders.

The Cell Culture Unit (CCU) system is the first of several habitats that will provide unprecedented access and capabilities for long duration life science experiments onboard the International Space Station (ISS). It will be capable of providing a controlled environment for the study of many different types of specimens, including animal, microbial or plant cells, aquatic specimens, and tissue aggregates. The unit can be operated manually, through ground control, or automatically. It will be delivered to the ISS, and returned to earth by the space shuttle. Specimens may be examined remotely during the mission via a video microscopy subsystem, by crew members using the Life Sciences Glovebox, or post-mission on Earth. The facility will allow scientists previously impossible opportunities to determine the role of gravity in the life cycle of living organisms, and understand how cellular organisms and cultures adapt to microgravity over multiple generations.

The CCU contract was awarded in October 1996 to Payload Systems and its partners: MIT's Tissue Engineering Laboratory and Midé Technology Corporation. Payload Systems acts as the prime contractor for this project. At present, CCU has successfully completed its Preliminary Design Review and is entering the critical design phase. Phase 0 and Phase 1 Safety Reviews have been successfully completed at the Johnson Space Center. Prototypical science evaluation hardware is currently being tested at Payload Systems laboratories, and will soon be shipped to scientists at NASA Ames Research Center and universities around the country to perform further experimentations. The first flight of the CCU system onboard the ISS is presently scheduled for year 2006.

CCU is one of the programs of the Space Station Biological Research Project (SSBRP) located at NASA Ames Research Center (ARC) in Mountain View, CA, who is responsible for the facilities that will be used to conduct life sciences research on board the ISS. Some of the features of these facilities include multiple habitats to support a variety of organisms, a centrifuge with a selectable rotation rate to house specimens at a variety of gravity levels, a holding rack to house specimens at microgravity, and a fully equipped workstation/Glovebox. Also provided will be microscopes, freezers, and other laboratory research equipment to conduct experimental procedures.

The SSBRP in turn, is part of the Astrobiology and Space Research Directorate (Code S) at Ames Research Center whose mission is to conduct research, develop products, and serve the space community in astrobiology and related areas of earth, space, and life science. The work of the Directorate supports, and is funded by all of the NASA Enterprises. This Directorate at NASA ARC is part of the Office of Biological and Physical Research (Code U) enterprise at NASA Headquarters.

NASA ARC working with international partners has played a significant role in the design and development of the ISS since the early 1980s. ARC's development of the first space-based, continuously available, life sciences research facility, the Space Station Fundamental Biology Research Facility (SSFBRF) (see Figure 14) was recognized as a major science benefit to all participating ISS investigators. Top-level science requirements have been developed by an on-going Science Working Group (SWG) and include the capability to provide "artificial gravity", life support and monitoring for animal, plant, and insect, aquatic cell research subjects and specimens on a large (2.5-m diameter), variable-speed centrifuge.

The Space Station Biological Research Project (SSBRP) is an integrated project team, which includes ARC staff matrixed from various organizations, with the mission to design and develop the systems required to support a wide range of fundamental gravitational biology research on the ISS. The SSBRP also performs all system integration functions for hardware, software phases and flight. SSBRP is responsible for managing the development of several habitats (CCU being one of them) with international collaboration that provide life support, environmental control, and monitoring systems for various research subjects and specimens. The habitats are being developed to operate with three major host systems: the variable-gravity, 2.5-m centrifuge; the microgravity holding racks; and the Life Sciences Glovebox. In addition, SSBRP will manage the development of various Lab equipment items needed for science operations in the SSFBRF.

Source: SSBRP web site

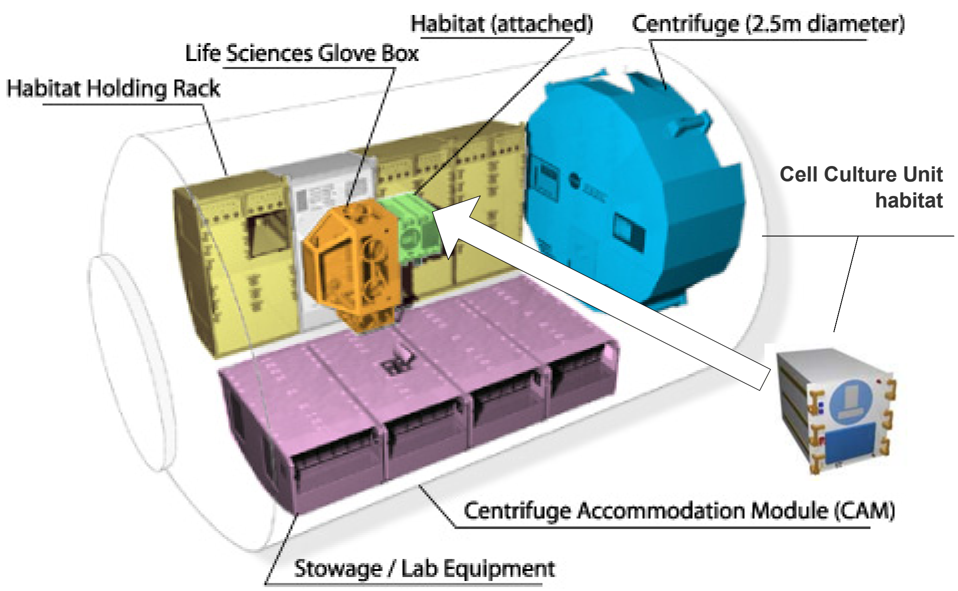


Figure 14: Space Station Fundamental Biology Research Facility (SSFBRF)

The habitats, host systems, and lab equipment items are being fabricated by a mix of several outside contractors (among them, Payload Systems Inc.) and other space agencies. Testing will be done at various developmental stages by both the hardware developers and SSBRP staff consisting of engineering, science, and operations specialists.

CCU Stakeholder Analysis

The sections that follow will cover the application of the methodologies to identify, prioritize, and structurally and functional assess stakeholder's networks we have described in previous chapters of this thesis to the particular case of the CCU enterprise.

CCU Stakeholders Identification

The first step in the stakeholder identification process is to define the system level value. For the case of the CCU enterprise we will define the system level value in the form of a "To… By" grammatical construction as follows:

> *To conceptualize, design, implement, deliver, and operate a high quality Cell Culture Unit payload By complying with NASA's safety requirements and performing the science functions for it was conceived.*

This will be the guiding intent for the CCU enterprise system that will allow for the identification of potential stakeholders and stakeholder groups.

The next step is to choose the initial focal organization. We will start with Payload Systems as the initial organization to consider for the identification of stakeholders. Although we recognize that this selection may result in a rather firm-centric view of the CCU enterprise system it will allow for a simpler determination of the enterprise's boundaries.

The methodology used to identify groups that could constitute potential stakeholders was by conducting several interviews with Payload Systems' CEO, Dr. Javier de Luis. In those interviews the CCU enterprise was analyzed in depth to allow the appearance of tacit or hidden groups that may act as potential stakeholders. Another method we used extensively was the analysis of factual evidence from NASA's myriad of organizations. This was carried out delving into the agency's and other relevant Internet web sites. Whenever possible we have omitted the real names of the companies, organizations, and individuals participating as stakeholders in the CCU project in order to protect their real and ongoing stakes at risk in the enterprise.

As it is foreseeable Payload Systems maintains relationships with several stakeholders that contribute to the value creation processes related with the CCU project. Traditional stakeholders such as suppliers and customers/end-users acquire particular relevance for this enterprise as relationships with them present noteworthy characteristics. In the case of suppliers it is the general rule for space engineering companies that their corresponding supply chains are actually quite short. This is the case because of the one-of-a-kind or very short production series typical of this industry, which does not allow suppliers to attain appropriate economies of scale to let them decentralize or outsource their operations. Therefore, the number of suppliers is small and they are typically organized in a single layer below the contracting organization. In other words, only first-tier suppliers exist in space engineering payloads development.[27]

The description above is not different for the CCU project. Only one Science Evaluation Unit and one Flight Unit are being produced and the majority of the fabrication and integration is being done in-house. Suppliers for the CCU enterprise reduce to a few companies that basically provide raw materials, semi-elaborated components, or very critical parts for the fabrication of the CCU prototypes and flight unit. For clarity purposes we have classified and grouped those suppliers as pertaining to three different stakeholder groups, named Suppliers A, B, and C. Type A Suppliers are those whose products or services are essential for the development of the project. These stakeholders are very difficult if not impossible to replace; they are, for example, unique suppliers of critical CCU's components such as very specific peristaltic pumps, digital cameras, and microscopes used in certain subsystems of the payload. Type B Suppliers include those suppliers that, although important or critical for the development of the CCU payload, can be substituted with little effort for other similar suppliers. This is the case, for example, of suppliers of design-specific electronic parts or specific materials for structural components of the CCU payload. Type C suppliers are those providing commodity-type components or supplies such as office products, nuts and bolts, or packaging materials. All of these supplier types are in direct

[27] These concepts are further developed in de Luis J., *'A Lean Safety Review Process for Payloads on the International Space Station'*, Thesis M S (in preparation) - Massachusetts Institute of Technology, System Design and Management program

relationship with Payload Systems. We haven't found in our stakeholder's identification process second tier suppliers that were relevant for the CCU enterprise.

In a slightly different supplier's category we find some important subcontractors. This is the case of the company that performs all the mechanized parts that later on Payload Systems will be integrating in the prototypes or flight hardware. The relationship with this supplier is a highly cooperative one and although the subcontractor is an independent company there exists a sort of symbiotic relationship between the two firms. They mutually depend on each other for their operations. Payload Systems relies almost exclusively on this subcontractor for every mechanism it has to implement from the blueprints produced by the company. For the subcontractor this relationship contributes a substantial portion of its revenues. They have learned to work together as allied partners in this industry. The interfaces between the two firms are somewhat fuzzy in the sense that they show large integration of their activities, almost to the point that the subcontractor acts as a Payload's internal working group. In our water-drop model terminology this subcontractor constitutes an allied supplier.

On the side of customers and end users we find different NASA organizations participating in the CCU enterprise. Although all these organizations and different groups within them belong to a common entity – NASA – they act, for the purposes of the CCU project, as different stakeholders. The core of the relationships is with groups belonging to NASA Ames Research Center. Under the organizational umbrella of ARC's Space Station Biology Research Project there exist a number of groups that can potentially affect or be affected by the development actions of the CCU project. Among them we find the groups developing other type of habitats for the facility (there are 6 other habitats under development), the groups developing supporting systems (like holding racks, glovebox system, and the centrifuge device), project management office, safety & mission assurance office, operation groups, systems engineering groups, and system integration groups. Also, the SSBRP office must coordinate the CCU development efforts with projects of other divisions of the Astrobiology and Space Research Directorate to which the CCU project ultimately belongs. The project also has ties with NASA's agency wide program in fundamental biology: the Fundamental Biology Program at NASA headquarters, which have a Science Working Group and a Project Scientist supervising, among others, the CCU development efforts.

Two other centers at NASA are deeply involved in the CCU enterprise: the Johnson Space Center (JSC) in Houston TX, and the Kennedy Space Center (KSC) in Cape Canaveral, FL. The JSC is home of the ISS program coordination, Mission Control Center facilities for both the space shuttle and the ISS, and Astronauts Training Facility. Subgroups within these three organizations have important stakes in the development of the CCU. First, because the final destination and operational environment of the CCU is the SSFBRF on board the ISS all the interfaces and safety guidelines of the CCU with the ISS must be worked out with the ISS program at JSC. Second, because operations of the CCU can be directed from ground, these activities are typically carried out by specialty groups at the MCC, hence the necessity of coordination of all the operational aspects of the CCU payload. Third, because the CCU is transported into orbit, installed, and operated by astronauts either of the shuttle or temporary residents of the ISS there exist a set of operational training that must be done with different groups of astronauts.

On the other hand, the KSC is in charge of the coordination of the launching activities of the space shuttle, which is the carrier of the CCU payload to its final destination: the ISS. Within KSC there exist a Shuttle Safety group and a Payload Integration group, both having strong interests (stakes) in the development of the CCU, particularly in what concerns the schedule and safety issues related with the CCU mission.

Table 8 summarizes the results of the first cycle of the stakeholder identification process where all potential stakeholders with whom Payload Systems maintains relationships have been listed. A brief rationale for them passing the litmus test of the identification process is included together with the type of relationship each of the potential stakeholders maintains with Payload Systems. Table 9 presents other stakeholders that although not directly connected to Payload Systems are essential for the value creation processes related with the CCU project.

Table 8: Payload Systems – CCU project stakeholders

Stakeholder	Rationale	Relationship type
NASA Ames Research Center		
Habitat Development Group	Responsible for the development of the seven habitats that will be installed in the SSFBRF module onboard ISS	Bidirectional transfer of project and programmatic information.
Habitat Development – CCU	This is the interface office at NASA for all technical issues regarding CCU's development	Bidirectional transfer of project information and evaluation unit prototypes
Flight Unit Integration – CCU	Coordinates integration and testing activities within the SSFBRF	Transfer of integration and testing information and science evaluation unit prototypes
CCU Project Control	Provides and requires programmatic information regarding CCU	Transfer of programmatic information
Systems Safety & Mission Assurance	Provides safety requirements, requires its enforcement, and participates in CCU's safety reviews	Transfer of safety information
Operations	Provides and receives CCU operations information	Transfer of operations information
SSBRP office	Provides organizational umbrella for the CCU project	Transfer of programmatic information
NASA Johnson Space Center		
Mission Control Center	Provides operational capabilities to the CCU mission	Transfer of CCU's operational information and support
ISS Payloads office	Provides ISS safety and interface requirements to the CCU mission. Commission CCU payload for nominal operations	Transfer of ISS related safety and interface information
Shuttle Astronauts	They are responsible for the transportation and installation of the CCU	Transfer of safety, setup, and installation information
ISS Astronauts	They are responsible for onboard operations of the CCU payload	Transfer of safety, and operational information
NASA Kennedy Space Center		
Shuttle Safety Group	They establish and enforce safety requirements for the transportation of CCU to the ISS onboard the space shuttle	Transfer of safety information: requirements and compliance documents
Shuttle Payload Integration Group	Coordinate the integration activities of the CCU payload to the space shuttle	Transfer of CCU payload flight unit, and safety related information
CCU Principal Investigators	Are responsible for the definition of the scientific requirements of the CCU mission and its scientific results	Transfer of science requirements and trade-offs information. Transfer of science data
PSI employees	Provides engineering capabilities and logistics support to the CCU project	Transfer of work hours and wages. Affiliation to PSI

Stakeholder	Rationale	Relationship type
PSI owners	Provides company financial support and strategic guidance	Ownership formal role, receives dividends from company revenues
Subcontractors		
Mechanisms Subcontractor	Provides mechanical workshop capabilities to Payload Systems.	Transfer of raw materials, elaborated parts, and financial resources
Mide Technologies Co.	Provides mechanical subsystems design, fabrication and testing capabilities to the CCU project	Transfer of requirements, designs, components, and financial resources
Other Subcontractors	Provide services related with the CCU project	Transfer of services and financial resources
Class A Suppliers	These suppliers provide critical components and are hard or impossible to replace. There are a total of … of this supplier type	Transfer of engineering information, goods or services, and financial resources
Class B Suppliers	These suppliers provide less critical or important components or there exist alternate suppliers and it is easy to switch to them	Transfer of engineering information, goods or services, and financial resources
Class C Suppliers	These suppliers provide commodity type components or services and/or it is very easy to switch to alternate, cheaper, or more reliable providers	Transfer of order forms, components specifications, goods or services, and financial resources
MIT Tissue Engineering Lab	Provides guidance for the development of the scientific aspects of the payload	Transfer of research information, and best alternatives to science trade-offs

Table 9: CCU enterprise – Other relevant stakeholders

Stakeholder	Rationale	Relationship type with stakeholders other than PSI
NASA Ames Research Center		
Other Habitat Development Groups	Share habitat hardware interfaces with CCU within the SSFBRF	Transfer of programmatic information and other relevant SSFBRF common ground knowledge
Host Systems – Glovebox	Provides astronauts physical access to each one of the habitats of the SSFBRF	Transfer of technical and programmatic information and other relevant SSFBRF common ground knowledge
Host Systems - Holding Rack	The system provides functional support services to each one of the different habitats including structural, mechanical, power, thermal conditioning, data, video, and command and control functions	Transfer of technical information regarding mechanical and electrical interfaces
Laboratory Support Equipment	Provides lab equipment to support CCU operations	Transfer of technical information on the available lab equipment
NASA Headquarters		
Fundamental Biology Program – Science Working Group	Provides general guidelines for the science objectives of the CCU mission	Transfer of science requirements information
Fundamental Biology Program – Project Scientist	Supervises detailed science objectives of the CCU mission	Transfer of science objectives, requirements, and science results information
Programmatic Office	Provides funding and programmatic requirements to the program	Transfer of funds and programmatic information
US Congress	Provide budgetary support for space research	Transfer of financial resources, and program evaluations and government strategic decisions
US Federal Government	Provide strategic vision and support for space research activities	Transfer of influences
US Taxpayers/Society	Provides direct or indirect support to space programs and their related research applications	Collective evaluation of the legitimacy of space research
Media	Provides media coverage of the success or failure of different space programs and	Transfer valued evaluations to other networks or facilitates information flow within the CCU project network
International Space Research Community	Provides support for space activities onboard the ISS, which includes the CCU payload	Transfer of research data and results. Transfer of financial resources, goods, and services

CCU Stakeholders Saliencies

Table 10 provides a complete picture of CCU enterprise's stakeholders where the relevance of each stakeholder in the system and their relationships has been assessed using the salience quantification methodology described in Chapter 6. This methodology is based on the quantification of the power, legitimacy, and criticality attributes of each one of the stakeholders when evaluated from a system level perspective.

For the power attribute we have only averaged the utilitarian and symbolic types of power since it is hard to find in this industry stakeholder groups willing to exert coercive (force, violence, or restraint) form of power. For the legitimacy attribute, and for the sake of clarity in the presentation of the data, we have condensed and averaged the legitimacy subtypes characteristics into one of the three types – pragmatic, moral, and cognitive legitimacy.

The result of the quantification of the salience of each stakeholder using the Stakeholder Salience Index shows interesting results. Among the most relevant stakeholders, those that most affect the system level value we have defined for the CCU enterprise, we find that Payload Systems is the most salient stakeholder (NSSI = 100). This comes as no surprise since it is precisely this organization that is the one that concentrates the majority of the efforts in the development of the CCU payload. Also high in the rank of salience we find the CCU Habitat Development liaison office at NASA ARC. This stakeholder is the most notorious interface of the project with the customer (NASA), Payload Systems' Employees and Owners, and the SSBRP office at NASA ARC which is the overall technical customer of the CCU project. Other important stakeholders include the Habitat Development Head at NASA ARC and the US Congress. This latter stakeholder is the one that ultimately provides the necessary financial resources in the form of approval of annual budgets for ISS research programs development.

Table 10: CCU Stakeholder Salience Indices calculations

		Power Attribute				Legitimacy Attribute				Criticality Attribute			Salience Index		
Stakeholder	**ID**	Coercive	Utilitarian	Symbolic	**Power Average**	Pragmatic	Moral	Cognitive	**Legitimacy Average**	Urgency	Importance	**Criticality Average**	**SSI (Eq. 1)**	**NSSI (Eq. 2)**	**Rank**
Payload Systems Inc.	S01	0	10	10	10.0	10	10	10	10.0	10	10	10.0	129.9	100.0	1
NASA Ames Research Center															
Habitat Development Groups Head	S02	0	10	6	8.0	10	10	10	10.0	10	8	9.0	104.8	80.7	6
Habitat Development – CCU	S03	0	10	9	9.5	10	10	10	10.0	10	10	10.0	125.6	96.7	2
Other Habitats Development Groups	S04	0	2	4	3.0	6	8	8	7.3	2	4	3.0	22.9	17.7	33
Host Systems – Glovebox	S05	0	2	5	3.5	5	7	4	5.3	4	5	4.5	25.3	19.5	31
Host Systems - Holding Rack	S06	0	2	5	3.5	6	7	4	5.7	5	5	5.0	28.4	21.9	30
Laboratory Support Equipment	S07	0	2	3	2.5	6	7	4	5.7	4	5	4.5	22.0	17.0	34
Flight Unit Integration – CCU	S08	0	8	6	7.0	8	7	6	7.0	7	7	7.0	63.7	49.0	14
CCU Project Control	S09	0	10	9	9.5	9	6	7	7.3	9	9	9.0	95.8	73.7	7
Systems Safety & Mission Assurance	S10	0	10	9	9.5	9	4	8	7.0	8	8	8.0	86.0	66.2	10
Operations	S11	0	6	6	6.0	6	6	8	6.7	6	8	7.0	55.7	42.9	20
SSBRP office	S12	0	10	9	9.5	9	7	8	8.0	9	10	9.5	104.9	80.8	5
NASA Headquarters															
FBP – Science Working Group	S13	0	4	5	4.5	4	6	5	5.0	6	7	6.5	36.5	28.1	25
FBP – Project Scientist	S14	0	4	5	4.5	5	7	5	5.7	6	7	6.5	39.7	30.5	23
Programmatic Office	S15	0	9	8	8.5	7	8	7	7.3	8	8	8.0	81.8	63.0	11
NASA Johnson Space Center															
Mission Control Center	S16	0	3	7	5.0	8	8	8	8.0	8	7	7.5	59.5	45.8	17
ISS Payloads office	S17	0	3	6	4.5	8	8	8	8.0	8	7	7.5	56.2	43.3	19
Shuttle Astronauts	S18	0	1	10	5.5	8	9	9	8.7	6	7	6.5	60.5	46.6	16
ISS Astronauts	S19	0	1	10	5.5	8	9	9	8.7	6	8	7.0	63.6	48.9	15
NASA Kennedy Space Center															
Shuttle Safety Group	S20	0	7	4	5.5	2	5	4	3.7	6	6	6.0	32.5	25.1	27
Shuttle Payload Integration Group	S21	0	7	4	5.5	2	4	4	3.3	7	4	5.5	29.0	22.3	28
CCU Principal Investigators	S22	0	7	7	7.0	9	9	9	9.0	9	10	9.5	93.1	71.7	8
PSI employees	S23	0	9	9	9.0	9	9	10	9.3	9	10	9.5	111.8	86.1	3
PSI owners	S24	0	10	7	8.5	10	10	10	10.0	8	10	9.0	108.9	83.8	4
Class A Suppliers	S25	0	8	8	8.0	9	8	9	8.7	5	6	5.5	69.7	53.7	12
Class B Suppliers	S26	0	6	6	6.0	7	7	5	6.3	5	6	5.5	45.8	35.3	21
Class C Suppliers	S27	0	3	3	3.0	5	7	4	5.3	4	4	4.0	21.4	16.4	35
US Congress	S28	0	10	6	8.0	10	10	8	9.3	8	8	8.0	92.4	71.1	9
US Federal Government	S29	0	5	7	6.0	8	8	8	8.0	7	8	7.5	66.3	51.0	13
US Taxpayers/Society	S30	0	3	10	6.5	1	5	7	4.3	1	6	3.5	28.6	22.0	29
Media	S31	0	0	10	5.0	2	2	2	2.0	6	2	4.0	16.5	12.7	36
International Research Community	S32	0	6	7	6.5	4	4	5	4.3	4	6	5.0	35.7	27.4	26
MIT Tissue Engineering Lab	S33	0	3	5	4.0	6	8	8	7.3	5	5	5.0	37.2	28.7	24
Subcontractors															
Mechanisms Subcontractor	S34	0	5	8	6.5	8	8	6	7.3	5	7	6.0	56.6	43.6	18
Mide Technologies	S35	0	4	6	5.0	8	7	4	6.3	5	7	6.0	43.2	33.2	22
Other Subcontractors	S36	0	3	3	3.0	5	7	4	5.3	5	5	5.0	25.0	19.2	32

On the other side of the scale we find the least relevant stakeholders – those showing low Stakeholder Salience Index. Among them we can mention the news Media that, although interested in the overall objectives of the CCU project, remain waiting expectant for the final results of the mission. Also, Class C Suppliers and Other Subcontractors show low relevancies in CCU's value creation efforts, which is logical since their goods are not critical for the project or their supplies can be easily replaced by goods coming from alternate suppliers or subcontractors.

In between those extremes we find stakeholders with medium saliencies that, although important for CCU's development efforts, are not as critical, powerful, or legitimate as other more relevant stakeholders. Among those we find, for example, the Astronauts of both the Space Shuttle and the ISS. They are fundamental for the transportation and operation of the CCU payload on orbit, and they should be trained accordingly, but being those tasks part of the regular activities of any astronaut they should be capable of doing those operational activities as part of their normal responsibilities. In this sense the CCU payload is just another piece of equipment they have to operate. Therefore, the astronaut's relevance for the CCU project is not that important, at least for the current state of the project.

CCU Stakeholders Relationship Saliencies

Table 11 presents the stakeholder relationships information in the form of an adjacency matrix – equivalent to a sociomatrix, or a DSM construction – where the rows and columns both represent each one of the stakeholders related with the CCU enterprise. A number one in a particular row and column element indicates that the stakeholder in that row maintains a relationship with the stakeholder in the corresponding column. These relationships are established because two stakeholders have some particular interest in the value creation processes of the CCU project. A blank cell in the matrix is indicative of no relationship, or, in the case of the diagonal elements of the matrix, that each stakeholder cannot relate to itself. If the relationships are bidirectional – like it is the case for all the CCU enterprise stakeholders – the adjacency matrix will end up being symmetrical.

Table 11: CCU Stakeholder Relationships – Adjacency Matrix

Stakeholder	ID	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20	S21	S22	S23	S24	S25	S26	S27	S28	S29	S30	S31	S32	S33	S34	S35	S36
Payload Systems Inc.	S01		1	1					1	1	1	1					1	1	1	1	1	1	1	1	1	1	1	1				1		1	1	1	1
NASA Ames Research Center																																					
Habitat Development Groups Head	S02	1		1	1	1	1	1	1	1	1	1	1				1	1					1									1	1				
Habitat Development – CCU	S03	1	1		1	1	1	1	1	1	1	1					1	1	1	1	1	1	1											1			
Other Habitats Development Groups	S04		1	1									1																								
Host Systems – Glovebox	S05		1	1						1		1					1			1																	
Host Systems - Holding Rack	S06		1	1					1	1	1							1		1																	
Laboratory Support Equipment	S07		1	1						1		1					1			1																	
Flight Unit Integration – CCU	S08	1	1	1			1			1								1			1	1															
CCU Project Control	S09	1	1	1		1	1	1	1		1	1	1			1		1				1											1				
Systems Safety & Mission Assurance	S10	1	1	1			1			1		1	1		1		1	1	1	1	1	1															
Operations	S11	1	1	1		1		1		1	1						1		1	1			1										1				
SSBRP office	S12		1		1					1	1			1	1	1			1	1			1									1	1				
NASA Headquarters																																					
FBP – Science Working Group	S13												1		1	1							1						1	1		1	1				
FBP – Project Scientist	S14										1		1	1		1							1						1	1		1	1				
Programmatic Office	S15									1			1	1	1		1	1					1						1	1			1				
NASA Johnson Space Center																																					
Mission Control Center	S16	1	1	1		1		1			1	1				1			1	1			1										1				
ISS Payloads office	S17	1	1	1			1		1	1	1					1																					
Shuttle Astronauts	S18	1		1							1	1	1				1			1	1	1															
ISS Astronauts	S19	1		1		1	1	1			1	1	1				1		1				1									1					
NASA Kennedy Space Center																																					
Shuttle Safety Group	S20	1		1					1		1								1			1															
Shuttle Payload Integration Group	S21	1		1					1	1	1								1		1																
CCU Principal Investigators	S22	1	1	1								1	1	1	1	1	1			1												1	1	1			
PSI employees	S23	1																																			
PSI owners	S24	1																																			
Class A Suppliers	S25	1																																	1	1	
Class B Suppliers	S26	1																																	1		
Class C Suppliers	S27	1																																	1		
US Congress	S28													1	1	1														1	1	1					
US Federal Government	S29													1	1	1													1		1	1					
US Taxpayers/Society	S30																												1	1		1					
Media	S31	1	1										1	1	1					1			1						1	1	1						
International Research Community	S32		1							1		1	1	1	1	1	1						1														
MIT Tissue Engineering Lab	S33	1		1																			1														
Subcontractors																																					
Mechanisms Subcontractor	S34	1																								1	1	1									
Mide Technologies	S35	1																								1											
Other Subcontractors	S36	1																																			

It is important to recall here that whenever a relationship exists between any two stakeholders it will be necessarily associated, in this particular example, to the CCU enterprise. In other words, although any two stakeholders may maintain a relationship for some other reasons other than the CCU project, they do not necessarily use that relationship to obtain or provide value from or to the CCU enterprise. For example, although Other Habitat Development Groups stakeholder maintains a relationship with the Host Systems-Glovebox stakeholder, this relationship is not held because it affects or can be affected by CCU enterprise's value creation processes, but rather because they need to resolve the problems arising from their particular payloads. In cases like these the elements in the adjacency matrix are left blank indicating that those stakeholders are not linked due to the CCU project. Generalizing this idea, the same concept can be applied to any stakeholder network pursuing some system level value.

The adjacency matrix only informs about the existence of a relationship between two stakeholders, but it does not account for the type, or even less, the intensity of that relationship. Table 12 presents the calculation of the stakeholders' normalized Relationship Salience Index according to Eq. 3 in Chapter 6. In the table the values entered in the diagonal of the matrix correspond to the Stakeholder Salience Indices calculated before. Then, if there is a value one in a particular element of the adjacency matrix – indicative of a relationship between two stakeholders, the Normalized Relationship Salience Index is calculated simply by multiplying the elements in the diagonal of the matrix corresponding to the row and column of that element.

Some of the most intense or important relationships are those held by Payload Systems and other relevant stakeholders, like CCU's Habitat Development program office or the Habitat Development Groups Head at NASA ARC. The intensity of the relationships between these stakeholders is high because they need to communicate frequently to define different programmatic issues regarding CCU development. Another very important relationship is that maintained by Payload Systems and its employees (NRSI = 86.1). Employees are a key development factor for these types of labor and ingenuity intensive projects, hence the necessity to articulate a good and strong relationship.

Table 12: CCU Stakeholder's Relationship Salience Indices

Stakeholder	ID	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20	S21	S22	S23	S24	S25	S26	S27	S28	S29	S30	S31	S32	S33	S34	S35	S36
Payload Systems Inc.	S01	100.0	80.7	96.7					49.0	73.7	66.2	42.9					45.8	43.3	46.6	48.9	25.1	22.3	71.7	86.1	83.8	53.7	35.3	16.4				12.7		28.7	43.6	33.2	19.2
NASA Ames Research Center																																					
Habitat Development Groups Head	S02	80.7	80.7	78.0	14.3	15.7	17.7	13.7	39.5	59.5	53.4	34.6	65.1				37.0	34.9					57.8									10.2	22.1				
Habitat Development – CCU	S03	96.7	78.0	96.7	17.1	18.8	21.2	16.4	47.4	71.3	64.0	41.5					44.3	41.8	45.0	47.3	24.2	21.6	69.3											27.7			
Other Habitats Development Groups	S04		14.3	17.1	17.7								14.3																								
Host Systems – Glovebox	S05		15.7	18.8		19.5				14.4		8.4					8.9			9.5																	
Host Systems - Holding Rack	S06		17.7	21.2			21.9		10.7	16.1	14.5							9.5		10.7																	
Laboratory Support Equipment	S07		13.7	16.4				17.0		12.5		7.3					7.8			8.3																	
Flight Unit Integration – CCU	S08	49.0	39.5	47.4			10.7		49.0	36.1								21.2			12.3	10.9															
CCU Project Control	S09	73.7	59.5	71.3		14.4	16.1	12.5	36.1	73.7	48.8	31.6	59.5			46.4		31.9				16.4											20.2				
Systems Safety & Mission Assurance	S10	66.2	53.4	64.0			14.5			48.8	66.2	28.4	53.4		20.2		30.3	28.6	30.8	32.4	16.6	14.8															
Operations	S11	42.9	34.6	41.5		8.4		7.3		31.6	28.4	42.9					19.7		20.0	21.0			30.7										11.8				
SSBRP office	S12		65.1		14.3					59.5	53.4		80.8	22.7	24.7	50.9			37.6	39.5			57.9									10.2	22.2				
NASA Headquarters																																					
FBP – Science Working Group	S13												22.7	28.1	8.6	17.7							20.1						20.0	14.3		3.6	7.7				
FBP – Project Scientist	S14										20.2		24.7	8.6	30.5	19.2							21.9						21.7	15.6		3.9	8.4				
Programmatic Office	S15									46.4			50.9	17.7	19.2	63.0	28.9	27.2					45.2						44.8	32.1			17.3				
NASA Johnson Space Center																																					
Mission Control Center	S16	45.8	37.0	44.3		8.9		7.8			30.3	19.7				28.9	45.8		21.4	22.4			32.8										12.6				
ISS Payloads office	S17	43.3	34.9	41.8			9.5		21.2	31.9	28.6					27.2		43.3																			
Shuttle Astronauts	S18	46.6		45.0							30.8	20.0	37.6				21.4		46.6	22.8	11.7	10.4															
ISS Astronauts	S19	48.9		47.3		9.5	10.7	8.3			32.4	21.0	39.5				22.4		22.8	48.9			35.1									6.2					
NASA Kennedy Space Center																																					
Shuttle Safety Group	S20	25.1		24.2					12.3		16.6								11.7		25.1	5.6															
Shuttle Payload Integration Group	S21	22.3		21.6					10.9	16.4	14.8								10.4		5.6	22.3															
CCU Principal Investigators	S22	71.7	57.8	69.3								30.7	57.9	20.1	21.9	45.2	32.8			35.1			71.7									9.1	19.7	20.5			
PSI employees	S23	86.1																						86.1													
PSI owners	S24	83.8																							83.8												
Class A Suppliers	S25	53.7																								53.7									23.4	17.8	
Class B Suppliers	S26	35.3																									35.3								15.4		
Class C Suppliers	S27	16.4																										16.4							7.2		
US Congress	S28													20.0	21.7	44.8													71.1	36.3	15.7	9.0					
US Federal Government	S29													14.3	15.6	32.1													36.3	51.0	11.2	6.5					
US Taxpayers/Society	S30																												15.7	11.2	22.0	2.8					
Media	S31	12.7	10.2										10.2	3.6	3.9					6.2			9.1						9.0	6.5	2.8	12.7					
International Research Community	S32		22.1							20.2		11.8	22.2	7.7	8.4	17.3	12.6						19.7										27.4				
MIT Tissue Engineering Lab	S33	28.7		27.7																			20.5											28.7			
Subcontractors																																					
Mechanisms Subcontractor	S34	43.6																								23.4	15.4	7.2							43.6		
Mide Technologies	S35	33.2																								17.8										33.2	
Other Subcontractors	S36	19.2																																			19.2

On the low values of relationship intensities we can mention the relationship indices corresponding to the ties of the news Media and every other stakeholder. The news Media does not hold very strong relationships with any of the stakeholders in the CCU enterprise network. This is understandable since the project, in its current state, is not at risk nor has flown yet, making it of low importance to the media. In other words, the CCU payload development activities are not breaking news.

CCU Stakeholders Network Structure

Network Density

CCU enterprise's stakeholder network density can be calculated using Eq. 6 in Chapter 6. The number of relationships in CCU's stakeholder network (*R*) is 143. Because the adjacency matrix is symmetrical, to obtain R we only need to count the total number of elements equal 1 in the matrix and divide that number by two.

The total possible number of relationships in CCU's stakeholder network adds up to 630. This figure is calculated knowing that the number of stakeholders N in the network is 36 and applying the combinatory equation $N(N-1)/2$.

Then, CCU's stakeholder network density can be calculated as follows:

$$SND = \frac{2R}{N(N-1)} = \frac{2 \times 143}{36 \times (36-1)} = 0.23$$, or equivalently 23%

Although CCU stakeholder network's density is not very high we shall recall that this network attribute is only an indicator of structural complexity and that its calculation over the entire stakeholder network can lead to wrong conclusions about the ability of the network to function properly or more efficiently. When we analyze the densities for subgroups of stakeholders then this figure starts to acquire some relevance. For example, we can calculate the density of relationships in the subgroup formed by Payload Systems and all the stakeholders related with NASA ARC. This subgroup of stakeholders altogether is the one that technically and programmatically defines the CCU project. In other words, this is the value exchanged by this subgroup with the rest of the enterprise system. For this subgroup the density is calculated again using Eq. 6 but with its variables constrained to the stakeholders in that subgroup. Then, the density of relationships for this subgroup of 12 stakeholders is:

$$SND_S = \frac{2R_S}{N_S(N_S - 1)} = \frac{2 \times 38}{12 \times (12 - 1)} = 0.57 \text{ , or } 57\%$$

This figure is now indicative of a somewhat dense stakeholder sub-network, which can be corroborated by visually inspecting the adjacency matrix for stakeholders S01 to S12. A possible explanation of why this is so the case is that the development of a complex payload like CCU requires great amounts of coordination activities among all the participants of this subgroup, hence the necessity of a large number of relationships that allow for easily transferring information and resources. Moreover, the safety requirements imposed in a payload that will fly onboard both the space shuttle and the ISS require active and permanent involvement of many of the constituents of this stakeholder network subgroup, which also increases the need for fluent and complex relationships among its members.

As we mentioned in our analysis of the density attribute of stakeholder networks in Chapter 6, larger densities do not mean that the network will function better. The set of relationships in this CCU development subgroup seem to be adequate for the progress of the project given its duration, budget, and the relative size of the stakeholders involved in it. According to Payload Systems' CEO the project is not under big pressures, either on budget or schedule, which would indicate that this subgroup is functioning adequately with this set of established relationships. More relationships (higher density) in this stakeholder sub-network will make the system to work less efficiently as stakeholders will have to devote much more time to maintain the relationships with the rest of the stakeholders in the subgroup.

Stakeholders Centralities

The calculations of CCU stakeholders' degree centralities and the overall network degree centrality are quite straightforward from the data contained in the adjacency matrix. Their calculation involves the computation of the nodal degrees, i.e. the number of relationships entering or leaving a stakeholder node. Those figures can be easily obtained by summing up the row or the column corresponding to that stakeholder in the adjacency matrix. For example, for Payload Systems the nodal degree adds up to 23 indicating that this stakeholder maintains relationships with 23 other stakeholders in CCU enterprise's network. This happens to be also the maximum degree centrality of the whole stakeholder network ($C_D(s^*)$), which will be used to calculate the overall network degree centrality once the centralities for every stakeholder have been computed. The normalized version of the degree centrality is obtained dividing each stakeholder nodal degree by the maximum number of relationships each stakeholder can hold in the network. For the CCU stakeholder network this number is 35 since there are a total of 36 stakeholders and each one of them can hold a maximum of (36 – 1) relationships with any other stakeholder in the system. Hence for Payload Systems the corresponding normalized degree centrality is 23/35 = 0.66 or 66%, which means that this stakeholder maintains relationships with 66% of the stakeholders in the CCU enterprise. Consequently, according to this measure Payload Systems is a highly central stakeholder one that controls many of the relationships in the network.

For the calculation of closeness and betweenness centralities it is necessary to calculate the geodesics, or shortest path lengths, connecting any two stakeholders. Geodesics can be calculated by analyzing the successive powers of the adjacency matrix (Wasserman & Faust, 1994: 161). If an element in the adjacency matrix has value 1 then a geodesic of length 1 connecting the corresponding row and column stakeholders exist. If the square power of the adjacency matrix turns an element from 0 to a value greater than zero then there exist a geodesic of length 2 connecting the corresponding stakeholders. In other words, the power for which a particular element in the adjacency matrix turns from 0 to a non-zero value is the length of the geodesic connecting the row and column corresponding to that element.

But instead of doing this process manually in MS Excel we have relied on UCINET, a software application specifically developed for social network analysis.[28] This software calculates the typical metrics used in social network analysis such as densities and centralities (in all of its forms) among others, and allows for different ways of visually presenting the structural position of actors in a social network. UCINET is able to use the stakeholders' adjacency matrix (Table 11) as input to calculate the above-mentioned metrics. Table 13 presents the results of the calculations performed with UCINET on the relationship data contained in the adjacency matrix of the CCU stakeholder network. Also included in this table are some statistical measures on each of the centrality measures data.

The different centrality metric's data confirms that Payload Systems is the most central stakeholder of the CCU enterprise system. In fact, because this stakeholder is the one that concentrates all the development efforts of the CCU payload, it has to coordinate activities and operations with many other stakeholders in the network – exactly with 66% of the stakeholders according to the degree centrality metric, constituting one of the most important hubs of the CCU enterprise. Payload Systems also accounts for the highest closeness centrality, meaning that it needs of very few intermediaries to reach every other stakeholder in the network. Its farness to every other stakeholder adds up to 47, which represents the total number of links separating Payload Systems from all other stakeholders in the enterprise. This is the lowest farness of the CCU network. Betweenness centrality is also maximum for Payload Systems and far greater than the corresponding centrality for every other stakeholder, which is also evidenced by a very high standard deviation of this data set. A large betweenness centrality means again that Payload Systems is a hub in the stakeholder system because it lies between the communication or relationship paths of many other stakeholders in the network. All other stakeholders have much less ability of being an intermediary in the relationship of other stakeholders.

[28] see Borgatti, S.P., Everett, M.G. and Freeman, L.C. (2002). A fully functional demonstration version of the software can be downloaded from http://www.analytictech.com

Table 13: CCU Stakeholders Centralities

	Degree Centrality				Closeness Centrality				Betweenness Centrality			
ID	Degree Centrality	Normalized Degree Centrality	Rank	Cmax - C	Farness	Normalized Closeness Centrality	Rank	Cmax - C	Betweenness	Normalized Betweenness Centrality	Rank	Cmax - C
S01	23	65.71	1	0	47	74.47	1	0.00	264.54	44.46	1	0.00
S02	16	45.71	3	7	54	64.82	2	9.65	39.77	6.68	4	37.78
S03	18	51.43	2	5	55	63.64	3	10.83	41.86	7.04	3	37.43
S04	3	8.57	27	20	78	44.87	25	29.60	0.14	0.02	28	44.44
S05	6	17.14	22	17	77	45.46	23	29.01	0.33	0.06	26	44.41
S06	7	20.00	19	16	75	46.67	21	27.80	0.98	0.16	22	44.30
S07	6	17.14	22	17	77	45.46	23	29.01	0.33	0.06	26	44.41
S08	8	22.86	16	15	67	52.24	14	22.23	3.17	0.53	18	43.93
S09	14	40.00	4	9	57	61.40	4	13.06	29.11	4.89	6	39.57
S10	14	40.00	5	9	57	61.40	4	13.06	23.55	3.96	7	40.50
S11	12	34.29	7	11	61	57.38	10	17.09	9.45	1.59	13	42.87
S12	12	34.29	8	11	66	53.03	13	21.44	19.74	3.32	9	41.14
S13	8	22.86	16	15	76	46.05	22	28.42	3.85	0.65	17	43.82
S14	9	25.71	13	14	72	48.61	20	25.86	10.57	1.78	12	42.69
S15	10	28.57	11	13	69	50.73	16	23.74	21.26	3.57	8	40.89
S16	12	34.29	8	11	59	59.32	8	15.15	15.88	2.67	11	41.79
S17	8	22.86	16	15	63	55.56	11	18.91	6.85	1.15	14	43.31
S18	9	25.71	14	14	64	54.69	12	19.78	4.52	0.76	16	43.70
S19	12	34.29	8	11	58	60.35	7	14.12	18.59	3.12	10	41.34
S20	6	17.14	22	17	70	50.00	17	24.47	0.43	0.07	25	44.39
S21	7	20.00	19	16	67	52.24	14	22.23	0.90	0.15	23	44.31
S22	13	37.14	6	10	57	61.40	4	13.06	33.39	5.61	5	38.85
S23	1	2.86	34	22	81	43.21	31	31.26	0.00	0.00	29	44.46
S24	1	2.86	35	22	81	43.21	31	31.26	0.00	0.00	29	44.46
S25	3	8.57	27	20	79	44.30	27	30.16	0.50	0.08	24	44.38
S26	2	5.71	31	21	80	43.75	28	30.72	0.00	0.00	29	44.46
S27	2	5.71	32	21	80	43.75	28	30.72	0.00	0.00	29	44.46
S28	6	17.14	21	17	83	42.17	34	32.30	2.37	0.40	19	44.06
S29	6	17.14	22	17	83	42.17	34	32.30	2.37	0.40	19	44.06
S30	3	8.57	27	20	91	38.46	36	36.01	0.00	0.00	29	44.46
S31	10	28.57	11	13	60	58.33	9	16.14	70.81	11.90	2	32.56
S32	9	25.71	14	14	71	49.30	19	25.17	5.27	0.89	15	43.58
S33	3	8.57	27	20	70	50.00	17	24.47	0.00	0.00	29	44.46
S34	4	11.43	26	19	78	44.87	25	29.60	1.50	0.25	21	44.21
S35	2	5.71	33	21	80	43.75	28	30.72	0.00	0.00	29	44.46
S36	1	2.86	36	22	81	43.21	31	31.26	0.00	0.00	29	44.46
				542				840.60				1494.38

Mean	7.94	22.70
StdDev	5.15	14.71
Variance	26.50	216.30
Minimum	1.00	2.86
Maximum	23.00	65.71

Mean	70.11	51.12
StdDev	10.41	8.18
Variance	108.27	66.84
Minimum	47.00	38.46
Maximum	91.00	74.47

Mean	17.56	2.95
StdDev	44.58	7.49
Variance	1986.91	56.12
Minimum	0.00	0.00
Maximum	264.54	44.46

Other stakeholders with high centrality measurements are the Habitat Development Group Head, and the CCU Habitat Development office, which maintain important number of relationships with the rest of the stakeholder in the network. This is coherent with their function of providing the voice of the client to the CCU enterprise. They are responsible for coordinating and enforcing the budgetary, programmatic, and mission assurance aspects of the CCU payload, having to interact with many other stakeholders to this achieve this end.

On the low side of the centralities measures we find stakeholders like Class C Suppliers and Other Subcontractors. Their relevancy for the value creation processes of the CCU enterprise is comparatively very low with respect to those of more central stakeholders. Correspondingly their centralities – degree, closeness, and betweenness are small. By inspecting the adjacency matrix we see that those stakeholders maintain very few relationships with the network and very few stakeholders use them as intermediaries to relate with other stakeholders. In a sense, they belong to the periphery of the stakeholder network.

Network Centralization Indices

Using equations 11, 12, and 13 in Chapter 6 we can calculate the variability of each centrality measure along the whole stakeholder network. To ease the process we have pre-calculated the numerator for each centrality type in Table 13. Each of the columns labeled 'Cmax – C' contains the difference between the maximum centrality in the network and the centrality value corresponding to each stakeholder. At the bottom of each column the summation of those differences over all the stakeholders in the network is performed. Then, the corresponding network centralities are calculated as follows (Eq. 11, 12, and 13):

Network Degree Centralization:

$$C_D = \frac{\sum_{i=1}^{N}\left[C_D(s^*) - C_D(s_i)\right]}{\left[(N-1)(N-2)\right]} = \frac{542}{(36-1)(36-2)} = 45.55\%$$

Recall that this metric reaches value 100% when there is one and only one stakeholder that concentrates all the relationships with all other stakeholders. This would be the case of the star or hub-and-spokes network topology exemplified in Figure 3. Then, this network centralization metric accounts for the degree of presence of a single stakeholder concentrating all the relationships in the network. For the case of the CCU stakeholder network there exists an important degree of centralization, 45.55%, indicating that only a few stakeholders concentrate most of the relationships in the network. This is effectively the case as it can be visually corroborated by inspecting the adjacency matrix.

Network Closeness Centralization:

$$C_C = \frac{\sum_{i=1}^{N}\left[C_C(s*) - C_C(s_i)\right]}{\left[(N-1)(N-2)/(2N-3)\right]} = \frac{840.60}{[(36-1)(36-2)/(2\times 36-3)]} = 48.74\%$$

Similar to the previous network centralization measure this Network Closeness Centrality reaches value 100% for a star-like network topology. This would indicate the presence of a hub that is at distance one of every other stakeholder in the network not necessitating of any intermediary stakeholder to reach any of those other stakeholders. For the case of the CCU enterprise the result of this metric is representative of a very connected network, one with enough relationships to allow for value exchanges along the network using very few intermediary stakeholders. For example, if a Class A Supplier would need to reach the Principal Investigator to resolve a technical issue it would need to ask Payload Systems to act as an intermediary of that relationship.

Network Betweenness Centralization:

$$C_B = \frac{\sum_{i=1}^{N}\left[C_B(s*) - C_B(s_i)\right]}{(N-1)} = \frac{1494.38}{(36-1)} = 42.7\%$$

Again this is a measure of the concentration of power (relationships) by a single stakeholder. In this case it measures the brokerage capabilities present in the whole stakeholder network. Like the previous two network centralization metrics this one reaches 100% for the star-like topology. A central stakeholder in this case is an intermediary of every other stakeholder, hence, its power to control the network. For the CCU stakeholder network the value obtained for this measure is representative of just a few stakeholders acting as brokers or intermediaries of the exchanges between less central stakeholders.

In any of these measures of network centralization, one needs to be careful about their interpretation. The question of structural versus functional complexity arises again here. The existences of many relationships among stakeholders in the network and of a few central stakeholders that can potentially relay value across the network do not guarantee that the network will function more efficiently. Value flows can encounter functional barriers in the network that may hinder the achievement of a lean enterprise, one in which relationship related waste is minimal or non existent. It is the way the network uses those relationships which provide the real ability of the system to be more functionally efficient. Structural connectivity is a necessary condition for stakeholder networks' efficiency but it is not a sufficient one. The functional characteristics of the network will be the determinant of the efficiency of the system.

Stakeholder DSM analysis

Our next step in the stakeholder analysis process is to perform a DSM type of study about the structure of the CCU enterprise system. Partitioning and clustering the stakeholder's adjacency matrix will inform us about elements of structure of the CCU stakeholder network. Those operations will allow for the identification of subgroups or clusters of stakeholders that can be potentially relevant for the value creation processes of the CCU enterprise. Moreover, it will be important to analyze the relationships among those subgroups in order to qualitatively assess the network's functional efficiency.

Figure 15 shows the DSM analysis performed on the CCU stakeholder's adjacency matrix (Table 11) where we have manually partitioned and clustered the matrix using the techniques described in Chapter 6. To perform the row and column permutations we have relied on assumptions regarding both the structural and functional aspects of the CCU enterprise. We have highlighted and labeled the resultant stakeholders' subgroups according to the high-level function they perform in the CCU enterprise.

The DSM analysis shows the existence of five relevant stakeholders' subgroups within the CCU enterprise. We have identified those subgroups as follows: Payload Development, Mission Definition, Mission Assurance & Operations, Suppliers, and Financial & Societal Support. Each one of these subgroups performs functions that are essential for the CCU enterprise's value creation processes. The Payload Development subgroup is in charge of the schedule, budget administration, and technical issues of the CCU payload. Internally they coordinate all sorts of technical development activities as well as all programmatic aspects of the CCU development. The Mission Definition subgroup has the responsibility of defining the science objectives of the CCU mission. There are many stakeholders that participate in this process; several groups from NASA, different Principal Investigators and MIT's Tissue Engineering Lab. Together they define and continuously refine the CCU's mission goals and requirements. The Mission Assurance & Operations subgroup is in charge of coordinating all the activities within the CCU enterprise network that allows guaranteeing that CCU will provide the required scientific results, and that it will do so in a safe manner for both the space shuttle transporter and the whole ISS system. Note that for this subgroup we have artificially duplicated two of the stakeholders in the DSM – Systems Safety & Mission Assurance, and Operations stakeholders, as they actively participate in this subgroup and also in the Payload Development subgroup. We also find the Suppliers subgroup where all the relevant suppliers and subcontractors interact, fundamentally with Payload Systems but also among them, to provide components, products, and services that are going to be integrated into the CCU payload.

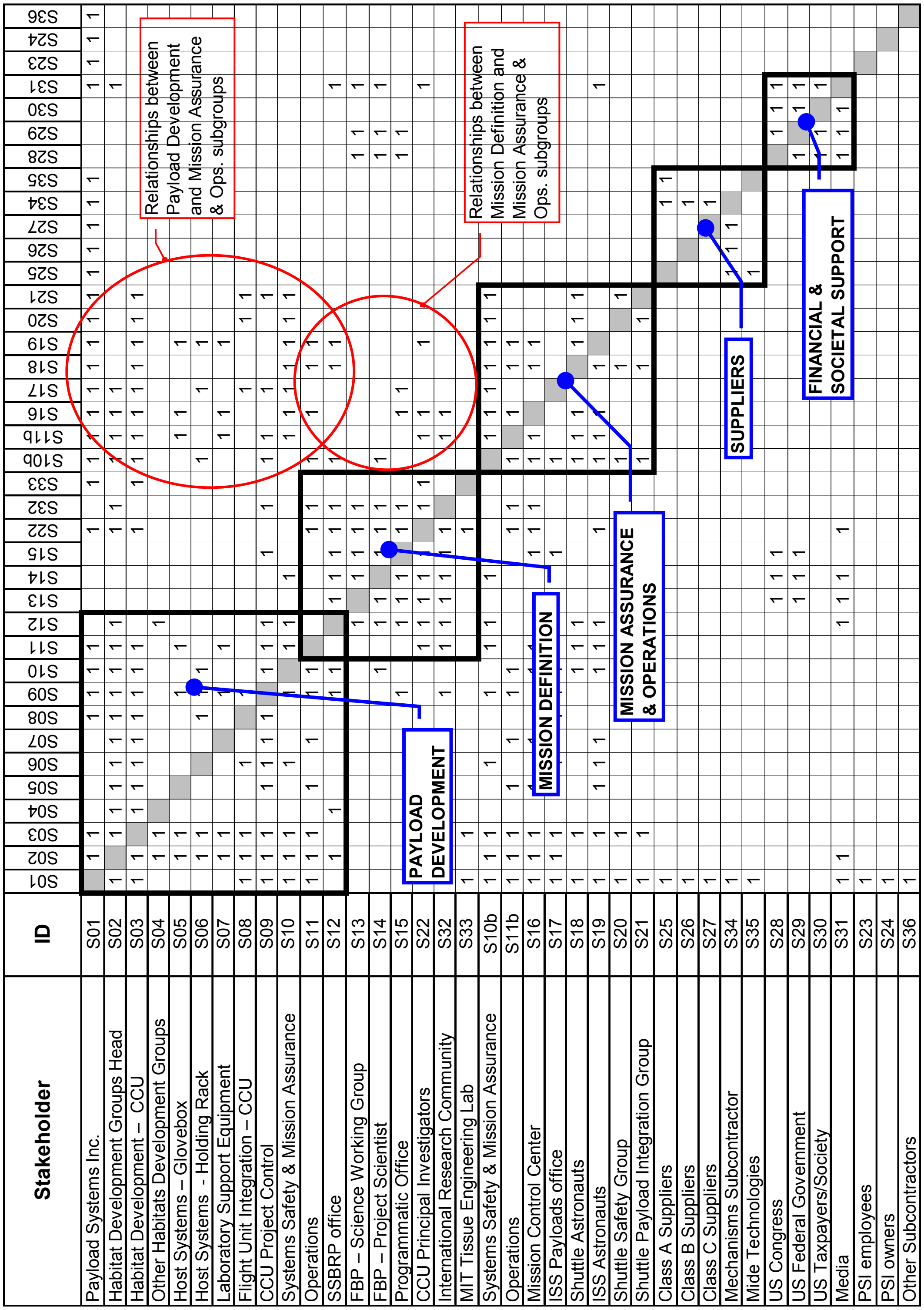


Figure 15: CCU Stakeholders – DSM Analysis

Lastly, but not less important, there is the Financial & Societal Support subgroup which provides the necessary funds to the CCU enterprise through the indirect participation of taxpayers, the direct budgetary approval actions by the US Congress, and the overall mission objectives support by the US Federal Government. Also in this group the presence of the Media stakeholder helps in communicating the benefits of the program to the different stakeholders within it and to other stakeholders in the network as well.

All these five subgroups do not work in isolation, they need to interact and cooperate with many other subgroups in order to make the CCU enterprise progress towards its required value creation objectives. The interactions among subgroups are evidenced in the DSM by the non-zero elements of the matrix outside each of the identified subgroups. For example, the Mission Assurance & Operations subgroup interacts heavily with the Payload Development and the Mission Definition subgroups. This is the case because the former subgroup needs input from the latter subgroups in order to guarantee the required mission objectives while guarding the safety of all the assets and people on ground and in orbit. On the other hand, the Mission Assurance & Operations subgroup provides requirements, tradeoffs, and constraints to both before mentioned interacting subgroups.

It is interesting to note that Payload Systems maintain relationships with all of the above mentioned stakeholders' subgroups and as such its position in the DSM is at the top of the matrix embracing all other stakeholders and subgroups. This confirms that Payload Systems is the most central stakeholder in the CCU enterprise as our different centrality metric results had previously shown.

Summarizing, a DSM analysis allows obtaining a higher-level view of the CCU stakeholder network abstracting from the low level details of the interactions among individual stakeholders. This higher level view allows for the identification of relevant functional groups and the important interactions among them that in combination defines the value creation processes and results of the CCU enterprise. The complexity of the analysis of the relationships in the CCU stakeholder network and their structural and functional implications is reduced significantly when using a DSM analysis methodology.

CCU Stakeholders Network Functionality

We turn now to the calculation of the information centrality metric for each of the stakeholders of the CCU enterprise. This metric will allow us to a better understanding of the functional characteristics of CCU's stakeholder network.

Table 14 shows the ***B*** matrix necessary to perform the calculations of the information centralities according to Eq. 14 in Chapter 6. The matrix was easily constructed in MS Excel from the data in Table 12 corresponding to the stakeholders' Relationship Salience Indices. Also, we used MS Excel's MINVERSE standard function to calculate ***C***, the inverse of the ***B*** matrix, and from there we calculated the ***T*** and ***R*** parameters necessary in Eq. 14 as it was explained in Chapter 6. Table 15 presents the Information Centralities calculated for each one of the stakeholders in the CCU enterprise network.

Very much like the previously calculated centrality measures, Information Centrality ranks the more salient and highly connected stakeholders as the more central ones. This is the case of Payload Systems (S01), Habitat Development –CCU (S03), and Habitat Development Group Head (S02) among some others. Also, either low salient or less connected stakeholders that should be located in the periphery of the stakeholder network receive coherent low centrality values. For instance, Class C Suppliers (S27) and Other Subcontractors (S36) are ranked as the lowest central stakeholders in accordance with their corresponding degree, closeness, and betweenness centrality measures. Consequently, we can assume that this new metric is consistent with the other proposed structural measures of stakeholder centralities.

Table 14: Information Centrality – B matrix

ID	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20	S21	S22	S23	S24	S25	S26	S27	S28	S29	S30	S31	S32	S33	S34	S35	S36
S01	#####	-79.7	-95.7	1.0	1.0	1.0	1.0	-48.0	-72.7	-65.2	-41.9	1.0	1.0	1.0	1.0	-44.8	-42.3	-45.6	-47.9	-24.1	-21.3	-70.7	-85.1	-82.8	-52.7	-34.3	-15.4	1.0	1.0	1.0	-11.7	1.0	-27.7	-42.6	-32.2	-18.2
S02	-79.7	635.1	-77.0	-13.3	-14.7	-16.7	-12.7	-38.5	-58.5	-52.4	-33.6	-64.1	1.0	1.0	1.0	-36.0	-33.9	1.0	1.0	1.0	1.0	-56.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-9.2	-21.1	1.0	1.0	1.0	1.0
S03	-95.7	-77.0	794.4	-16.1	-17.8	-20.2	-15.4	-46.4	-70.3	-63.0	-40.5	1.0	1.0	1.0	1.0	-43.3	-40.8	-44.0	-46.3	-23.2	-20.6	-68.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-26.7	1.0	1.0	1.0
S04	1.0	-13.3	-16.1	46.6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-13.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
S05	1.0	-14.7	-17.8	1.0	76.7	1.0	1.0	1.0	-13.4	1.0	-7.4	1.0	1.0	1.0	1.0	-7.9	1.0	1.0	-8.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
S06	1.0	-16.7	-20.2	1.0	1.0	101.3	1.0	-9.7	-15.1	-13.5	1.0	1.0	1.0	1.0	1.0	1.0	-8.5	1.0	-9.7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
S07	1.0	-12.7	-15.4	1.0	1.0	1.0	67.0	1.0	-11.5	1.0	-6.3	1.0	1.0	1.0	1.0	-6.8	1.0	1.0	-7.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
S08	-48.0	-38.5	-46.4	1.0	1.0	-9.7	1.0	228.1	-35.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-20.2	1.0	1.0	-11.3	-9.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
S09	-72.7	-58.5	-70.3	1.0	-13.4	-15.1	-11.5	-35.1	539.5	-47.8	-30.6	-58.5	1.0	1.0	-45.4	1.0	-30.9	1.0	1.0	1.0	-15.4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-19.2	1.0	1.0	1.0	1.0
S10	-65.2	-52.4	-63.0	1.0	1.0	-13.5	1.0	1.0	-47.8	503.3	-27.4	-52.4	1.0	-19.2	1.0	-29.3	-27.6	-29.8	-31.4	-15.6	-13.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
S11	-41.9	-33.6	-40.5	1.0	-7.4	1.0	-6.3	1.0	-30.6	-27.4	298.7	1.0	1.0	1.0	1.0	-18.7	1.0	-19.0	-20.0	1.0	1.0	-29.7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-10.8	1.0	1.0	1.0	1.0
S12	1.0	-64.1	1.0	-13.3	1.0	1.0	1.0	1.0	-58.5	-52.4	1.0	459.0	-21.7	-23.7	-49.9	1.0	1.0	-36.6	-38.5	1.0	1.0	-56.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-9.2	-21.2	1.0	1.0	1.0	1.0
S13	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-21.7	115.6	-7.6	-16.7	1.0	1.0	1.0	1.0	1.0	1.0	-19.1	1.0	1.0	1.0	1.0	1.0	-19.0	-13.3	1.0	-2.6	-6.7	1.0	1.0	1.0	1.0
S14	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-19.2	1.0	-23.7	-7.6	145.1	-18.2	1.0	1.0	1.0	1.0	1.0	1.0	-20.9	1.0	1.0	1.0	1.0	1.0	-20.7	-14.6	1.0	-2.9	-7.4	1.0	1.0	1.0	1.0
S15	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-45.4	1.0	1.0	-49.9	-16.7	-18.2	330.7	-27.9	-26.2	1.0	1.0	1.0	1.0	-44.2	1.0	1.0	1.0	1.0	1.0	-43.8	-31.1	1.0	1.0	-16.3	1.0	1.0	1.0	1.0
S16	-44.8	-36.0	-43.3	1.0	-7.9	1.0	-6.8	1.0	1.0	-29.3	-18.7	1.0	1.0	1.0	-27.9	312.9	1.0	-20.4	-21.4	1.0	1.0	-31.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-11.6	1.0	1.0	1.0	1.0
S17	-42.3	-33.9	-40.8	1.0	1.0	-8.5	1.0	-20.2	-30.9	-27.6	1.0	1.0	1.0	1.0	-26.2	1.0	239.4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
S18	-45.6	1.0	-44.0	1.0	1.0	1.0	1.0	1.0	1.0	-29.8	-19.0	-36.6	1.0	1.0	1.0	-20.4	1.0	247.2	-21.8	-10.7	-9.4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
S19	-47.9	1.0	-46.3	1.0	-8.5	-9.7	-7.3	1.0	1.0	-31.4	-20.0	-38.5	1.0	1.0	1.0	-21.4	1.0	-21.8	305.2	1.0	1.0	-34.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-5.2	1.0	1.0	1.0	1.0	1.0
S20	-24.1	1.0	-23.2	1.0	1.0	1.0	1.0	-11.3	1.0	-15.6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-10.7	1.0	96.4	-4.6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
S21	-21.3	1.0	-20.6	1.0	1.0	1.0	1.0	-9.9	-15.4	-13.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-9.4	1.0	-4.6	103.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
S22	-70.7	-56.8	-68.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-29.7	-56.9	-19.1	-20.9	-44.2	-31.8	1.0	1.0	-34.1	1.0	1.0	492.7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-8.1	-18.7	-19.5	1.0	1.0	1.0
S23	-85.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	87.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
S24	-82.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	84.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
S25	-52.7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	95.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-22.4	-16.8	1.0
S26	-34.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	51.6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-14.4	1.0	1.0
S27	-15.4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	24.6	1.0	1.0	1.0	1.0	1.0	1.0	-6.2	1.0	1.0
S28	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-19.0	-20.7	-43.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	148.4	-35.3	-14.7	-8.0	1.0	1.0	1.0	1.0	1.0
S29	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-13.3	-14.6	-31.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-35.3	117.0	-10.2	-5.5	1.0	1.0	1.0	1.0	1.0
S30	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-14.7	-10.2	30.7	-1.8	1.0	1.0	1.0	1.0	1.0
S31	-11.7	-9.2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-9.2	-2.6	-2.9	1.0	1.0	1.0	1.0	-5.2	1.0	1.0	-8.1	1.0	1.0	1.0	1.0	1.0	-8.0	-5.5	-1.8	75.1	1.0	1.0	1.0	1.0	1.0
S32	1.0	-21.1	1.0	1.0	1.0	1.0	1.0	1.0	-19.2	1.0	-10.8	-21.2	-6.7	-7.4	-16.3	-11.6	1.0	1.0	1.0	1.0	1.0	-18.7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	142.9	1.0	1.0	1.0	1.0
S33	-27.7	1.0	-26.7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-19.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	77.9	1.0	1.0	1.0
S34	-42.6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-22.4	-14.4	-6.2	1.0	1.0	1.0	1.0	1.0	1.0	90.5	1.0	1.0
S35	-32.2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-16.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	52.1	1.0
S36	-18.2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	20.2

Table 15: CCU Stakeholders – Information Centralities

T	0.4437
R	0.0278

Stakeholder	ID	c_{ij}	Information Centrality	Rank
Payload Systems Inc.	S01	0.001943	78.58	1
Habitat Development – CCU	S03	0.002386	75.94	2
Habitat Development Groups Head	S02	0.002677	74.29	3
CCU Project Control	S09	0.002952	72.81	4
CCU Principal Investigators	S22	0.003089	72.09	5
Systems Safety & Mission Assurance	S10	0.003091	72.08	6
SSBRP office	S12	0.003339	70.81	7
Mission Control Center	S16	0.004242	66.55	8
ISS Astronauts	S19	0.004343	66.11	9
Operations	S11	0.004427	65.75	10
Programmatic Office	S15	0.004487	65.49	11
Shuttle Astronauts	S18	0.005143	62.79	12
ISS Payloads office	S17	0.005248	62.38	13
Flight Unit Integration – CCU	S08	0.005526	61.32	14
International Research Community	S32	0.008054	53.09	15
FBP – Project Scientist	S14	0.008448	52.00	16
US Congress	S28	0.010329	47.37	17
FBP – Science Working Group	S13	0.010463	47.07	18
Shuttle Payload Integration Group	S21	0.010669	46.62	19
Host Systems - Holding Rack	S06	0.010901	46.12	20
Shuttle Safety Group	S20	0.011363	45.15	21
US Federal Government	S29	0.012211	43.49	22
Class A Suppliers	S25	0.012912	42.20	23
PSI employees	S23	0.012918	42.19	24
PSI owners	S24	0.013209	41.68	25
Mechanisms Subcontractor	S34	0.013596	41.02	26
MIT Tissue Engineering Lab	S33	0.013734	40.79	27
Host Systems – Glovebox	S05	0.013981	40.38	28
Media	S31	0.0142	40.03	29
Laboratory Support Equipment	S07	0.015819	37.59	30
Class B Suppliers	S26	0.021364	31.11	31
Mide Technologies	S35	0.021503	30.97	32
Other Habitats Development Groups	S04	0.022373	30.16	33
US Taxpayers/Society	S30	0.039	20.09	34
Class C Suppliers	S27	0.042722	18.69	35
Other Subcontractors	S36	0.051076	16.17	36

Mean	50.58
StdDev	17.25
Variance	297.68
Minimum	16.17
Maximum	78.58

However, Information Centrality is also able to capture some of the functional characteristics of the CCU's stakeholder network. In particular, this metric allows for the identification of relevant stakeholders that are very important for the CCU enterprise. This is the case, for example, of Payload Systems' employees (S23) and owners (S24). Because they maintain very few relationships with other stakeholders in the network they are catalogued with very low centralities by any of the structural measures (degree, closeness, and betweenness centralities) as can be seen in Table 13. According to these measures those two stakeholders belong to the periphery of the network. For instance, betweenness centralities for both stakeholders (and many others) end up being zero, mainly because no other stakeholder depends on them to communicate with the rest of the network. But, we know that they are highly important, that their function in the enterprise is essential for the successful development of the CCU payload. Information Centrality measures on those two stakeholders are able to provide a better picture of their relative position in the network. In fact, using this metric they are ranked 24 and 25 among the 36 CCU's stakeholders. In our view these are more correct values since both stakeholders maintain a single but strong relationship with the most central stakeholder in the network (Payload Systems). This is to say that if those relationships get disrupted the whole network will functionally suffer somehow. Hence, we assert that this metric is better able to capture the way in which stakeholders are functionally organized while still providing a good structural view of the network.

One might argue that because we have calculated information centralities using the relationship indices as input data, the results will be biased when compared to the other structural measures. Using UCINET we have calculated degree, closeness, and betweenness centralities using valued relationships and have found that the rankings for PSI Employees and PSI Owner are still very low, i.e. they show very low centrality indices. On the other hand, we have calculated the information centrality measures using the adjacency matrix as input instead of the relationship indices. We have found similar results in the sense that centralities for those two stakeholders end up being very low. These calculations confirm that using valued relationships together with the proposed information centrality metric produce better determination of the functional position of stakeholders in the network.

CCU enterprise qualitative models

Water Drop Model

Figure 16 presents the water-drop model corresponding to the CCU enterprise system. The diagram shows a firm-centric view of the CCU enterprise where Payload Systems Inc. is depicted at the center of the stakeholders system. PSI Employees, one of the main stakeholders of the CCU enterprise are not depicted explicitly as a stakeholder group but rather occupying all the positions at the center of the figure, those corresponding to the different internal functional organizations of the firm. Around Payload Systems all its primary stakeholder groups were represented as maintaining more or less collaborative relationships with the firm. As explained in Chapter 5, overlapping circles are representative of the collaboration and cooperation degree among stakeholders. Arrows connecting two stakeholder groups are indicative of a more formal, contractual, or utilitarian based type of relationship. This is the case, for example, of Class C Suppliers that exchange necessary goods and services with Payload Systems in exchange of financial resources, but they do so after formal purchase orders or service contracts.

Altogether Payload Systems and all its primary stakeholders form a closely-knit enterprise that jointly works to create value for the whole CCU enterprise. The relatively small size of the company and the characteristics of the CCU payload it develops for space research activities demand a highly collaborative enterprise system.

Much less visible or relevant Stakeholders such as Media, Taxpayers/Society, US Congress, and US Federal Government occupy a secondary position in this firm-centric view of the CCU enterprise, although they definitely are in Payload Systems' radar screen. In fact, these stakeholders do not affect CCU project's daily operations but provide the necessary support – both financial and societal – to the CCU enterprise system.

Overall this representation allows abstracting many of the details of the relationships among stakeholders concentrating on the main stakeholder groups and the way they collaborate or interact in relation with the value creation processes of the enterprise.

Figure 16: CCU Stakeholders – Water Drop Model representation

Network Model

Drawing a network model like the one proposed in Chapter 5 for the CCU stakeholder network considering its dimensions, both in number of stakeholders and relationships, is a challenging task. Fortunately, we found that UCINET is able to depict a very similar representation to the one we have proposed. The software provides several configurable options not only to adjust the graphical elements but also to define the position of the stakeholders within the network map.

Figure 17 shows the Multidimensional Scaling representation provided by UCINET's NetDraw tool corresponding to CCU's stakeholder network. Circles represent each one of the 36 stakeholders in the CCU enterprise. Their relative size is proportional to each stakeholder's Salience Index. The lines connecting the circles represent the relationships among stakeholders and their width is proportional to the strength of the relationship as indicated by the Relationship Salience Indices.

Figure 17: CCU Stakeholders – Network Model representation

Beyond the confusion generated by the large number of intersecting lines in this network representation it is still possible to extract some conclusions from it. First of all, this representation allows the rapid detection of which of the stakeholders are the most central (powerful) in the CCU enterprise system. The size of the circles and the widths of the lines both are indicative of stakeholders and relationships' relevance. It is clearly seen in the figure that Payload Systems (S01), Habitat Development Group Head (S02), and CCU Habitat Development (S03) are the most relevant stakeholders. They not only have important stakes into play that give them high salience in the network, but also they maintain a myriad of important relationships with other stakeholders in the network. As such they occupy the center of the network model representation.

Less central stakeholders showing much lower Salience Indices and/or lower Relationship Salience Indices are depicted in the periphery of the figure indicating their less demanding or powerful position in the CCU stakeholder network. This is the case, for example, of Other Habitats Development Groups (S04), Media (S31), Taxpayers/Society (S30), and Class C Suppliers (S27) stakeholders among many others.

Also, we can clearly see in this representation why Payload Systems' Employees (S23) and Owner (S24) both deserve a more central role in the network as it was indicated by their information centrality measures. Their corresponding Salience Indices – the importance of their stakes at risk in the CCU enterprise, and Relationship Salience Indices are in both cases high. Also, they are clearly connected to the most central stakeholder in the network that is precisely Payload Systems (S01). Although they are not depicted in a more central position with respect of less central stakeholders they are visually embossed by the size of the circle representing each stakeholder and the width of the lines connecting them to the rest of the network.

UCINET via a related application, Mage 3D, also allows for the construction of a 3D dynamic representation of stakeholders or any other type of network. The graph can be rotated and zoomed in real time to better visualize the structure and the stakeholders' relative positions in the network. For obvious reasons we cannot include such a representation in this document, hence we encourage the reader to explore the additional options contained in this software package.

C H A P T E R 8

CONCLUSIONS AND FUTURE WORK

In every enterprise environment the most central stakeholders are not very difficult to identify. They are the more active, visible, or powerful groups that urgently claim their stakes at risk in the enterprise. Their "voice" is heard in every aisle of the extended enterprise. Less visible or tacit groups that may very well influence on the enterprise operations and strategies are much more difficult to recognize as salient stakeholders. Not only that, but also recognizing how all those stakeholders are structurally and functionally organized in the enterprise to accomplish its value creation processes is a hard task.

In this thesis work we have been able to develop several new methodologies to address the above mentioned issues that, when combined with known techniques and tools, altogether provide new capabilities for the analysis and understanding of stakeholder systems. Among the methods and tools we have developed and explored are:

- Two qualitative frameworks to visually represent and understand stakeholder systems
- A stakeholder identification methodology that is consistent with the value creation framework proposed by the Lean Aerospace Initiative
- A stakeholder salience quantification methodology
- A relationship intensity quantification methodology
- Several different measures associated with stakeholder networks' structural and functional complexities
- A DSM approach for analyzing stakeholder networks

We have applied and tested all these methods in a real case application example: Payload Systems Inc., a Cambridge based company devoted to the development of space application payloads. Using this real case scenario we have demonstrated how to use the developed and proposed tools to the study of stakeholder systems, and have showed the weaknesses and strengths to map this kind of systems.

The social network analysis methodologies we have used in this thesis have proven to be effective for the determination of stakeholder networks' structural characteristics. Although these methodologies were almost all based on the mere presence or absence of relationships among actors, they still provided useful information for understanding some of the stakeholder network's characteristics. However, social network analysis methodologies fall short of providing a good assessment of the functional characteristics and complexity of the stakeholder network. Because the functional characteristics of stakeholders and their relationships are not considered in the analysis, the results obtained lack of any behavioral content. We have proposed additions to the social network methodologies to attempt rectifying this inherent problem. The distinction between stakeholder systems' structural and functional complexities and their treatment is one of the most important conclusions of this thesis.

The validity of the DSM methodology for the analysis of stakeholder systems has also been demonstrated. Partitioning and clustering operations allowed us to discover relevant functional groups within a stakeholder system. Moreover, the DSM clearly showed patterns of relationships within and among those groups.

The implications of this thesis work for the implementation of lean enterprise initiatives are quite evident. Firstly, the stakeholder identification and prioritization process we have described is essential to map an enterprise's stakeholder system. Obtaining such maps implies understanding the extended enterprise composition, which in turn is necessary to assess the value creation processes of the integrated enterprise. Secondly, understanding structural and functional patterns within the stakeholder network will allow discovering sources of waste within the enterprise system that typically hinder the implementation of lean principles and practices. Lastly, assessing the stakeholder network's characteristics will help in creating sound and robust value propositions for each and every stakeholder participating in the enterprise. Most importantly, stakeholder systems analysis will allow for the implementation of balanced value propositions in which every stakeholder will receive a fair payoff for its contributions to the enterprise.

With respect to the future developments related with the contents of this thesis we can mention those that derive from two major assumptions we made in our analysis of stakeholder networks:

- The links between any two stakeholders are balanced relationships in which both parties obtain a fair value from their corresponding contributions to the enterprise. The value flowing in both directions along those relationships is in equilibrium.

- The intensity of the relationship between any two stakeholders is defined by the salience of each one of the stakeholders as defined by their corresponding attributes of power, legitimacy, and criticality

The first assumption allowed us to consider the relationships between stakeholders as being symmetrical which for certain stakeholder systems might not be the case, especially during transitory states. For instance, in situations where a certain stakeholder is trying to gain a more central position in the stakeholder network it may be providing more value to other stakeholders than the value it is receiving or will receive in the future from its contributions. The study of this type of asymmetrical relationships is an area for future development.

The second assumption allowed for a simple way to assign values to the relationships between stakeholders and the use of those values for analyzing the structure and functionality of the stakeholder network. However, relationships between human organizations are hardly as linear as we have assumed. New or enhanced ways of valuing relationships among stakeholders will have to be studied.

There exist a myriad of methods for social network analysis and other graph theoretic calculations that we have not explored in this thesis work due to the lack of time or space to explain them properly. Hence, another area of further development will be the study of other techniques and new ways for measuring structural as well as functional complexity in stakeholder networks. A very tempting one is the study of communication systems theory and their entropy measure as a way of characterizing stakeholder network's functional complexity.

Although we have repeatedly said that the analysis of stakeholder networks is a dynamic process, one that must be repeated frequently to capture variability in the components of the network, we have performed our analysis assuming that the stakeholder network was a stationary system. Studying the dynamics of stakeholder systems, possibly by making use of system dynamic models, is another interesting area for future development. These system dynamic models will allow answering questions such as how the stakeholder system would respond to the addition or elimination of one or more stakeholders, and how strengthening some strategic relationships would affect the enterprise system.

REFERENCES

Baranger M., *Chaos, Complexity, and Entropy: A physics talk for non-physicists*, http://necsi.org/projects/baranger/cce.html

Bar-Yam Y., *Dynamics of Complex System'* (Reading MA: Addison-Wesley, 1997)

Borgatti, S.P., Everett, M.G. and Freeman, L.C., *UCINET for Windows: Software for Social Network Analysis* (Harvard: Analytic Technologies, 2002)

Brandenburger A.M. and Nalebuff B.J., *Co-opetition* (New York: Currency and Doubleday, 1998)

Christensen C.M., *The Innovator's Dilemma* (Boston: HarperBusiness, 2000)

Carroll A.B. and Buchholtz A.K., *Business & Society: Ethics and Stakeholder Management*, 5th edition (Ohio: South-Western, 2003)

Donaldson T. and Preston L.E., *The Stakeholder Theory of the Corporation: Concepts, Evidence, and Implications*, Academy of Management Review, Vol. 20, No. 1, pp. 65-91, 1995

Doz Y.L. and Hamel G., *Alliance Advantage: The Art of Creating Value through Partnering* (Boston: Harvard Business School Press, 1998)

Eppinger S.D., *Innovation at the Speed of Information*, Harvard Business Review, Vol. 79, No. 1, pp. 149-158, 2001

Eppinger S.D., and Salminen V., *Patterns of Product Development Interactions*, International Conference on Engineering Design, ICED 01 Glasgow, August 2001

Eppinger S.D., Whitney D.E., Smith R.P., and Gebala D.A., *A Model-Based Method for Organizing Tasks in Product Development*, Research in Engineering Design, Vol. 6, No. 1, pp. 1-13, 1994

Freeman L., *Visualizing Social Groups*, American Statistical Association, 1999 Proceedings of the Section on Statistical Graphics, pp. 47-54, 2000

Freeman R.E., *Strategic Management: A Stakeholder Approach* (Boston: Pitman, 1984)

Frooman J., *Stakeholder Influence Strategies*, Academy of Management Review, Vol. 24, No. 2, pp. 191-205, 1999

Kochan T.A. and Rubinstein S.A., *Toward a Stakeholder Theory of the Firm: The Saturn Partnership*, Organization Science, Vol. 11, No. 4, pp. 367-386, July-August 2000

Kuhn H.W. and Nasar S., *The Essential John Nash* (New Jersey: Princeton University Press, 2002)

Maier M.W. and Rechtin E., *The Art of Systems Architecting*, 2nd edition (Boca Raton: CRC Press, 2002)

Mitchell R.K., Agle B. R., and Wood D.J., *Toward a Theory of Stakeholder Identification and Salience: Defining the Principle of Who and What Really Counts*, Academy of Management Review, Vol. 22, No. 4, pp. 853-886, 1997

Murman E. et al., *Lean Enterprise Value* (New York: Palgrave, 2002)

Polonsky M.J., Schuppisser S.W., and Beldona S., *A Stakeholder Perspective for Analyzing Marketing Relationships*, Journal of Market-Focused Management, Vol. 5, pp. 109-126, 2002

Rowley T.J., *Moving Beyond Dyadic Ties: A Network Theory of Stakeholder Influences*, Academy of Management Review, Vol. 22, No. 4, pp. 887-910, 1997

Stephenson K. and Zelen M., *Rethinking Centrality: Methods and Examples*, Social Networks 11, pp. 1-37, 1989

Steward D.V., *Systems Analysis and Management: structure, strategy, and design* (New York: Petrocelli Books, 1981)

Suchman M.C., *Managing Legitimacy: Strategic and Institutional Approaches*, Academy of Management Review, Vol. 20, No. 3, pp. 571-610, 1995

Wasserman S. and Faust K., *Social Network Analysis: Methods and Applications* (New York: Cambridge University Press, 1994)

Womack J.P. and Jones D.T., *Lean Thinking* (New York: Simon & Schuster, 1996)

Womack J.P., Jones D.T., and Roos D., *The Machine That Changed The World: The Story of Lean Production* (New York: HarperPerennial, 1991)