A METHODOLOGY TO DEFINE STRATEGIC INNOVATION PROJECTS AND NEW PRODUCT DEVELOPMENT PORTFOLIO BASED ON MEGATRENDS EXPLORATION AND TECHNOLOGY FORESIGHT

CASE OF STUDY: MEXICAN MAGNET WIRE INDUSTRY

TESIS
PRESENTADA COMO REQUISITO PARCIAL PARA OBTENER EL GRADO ACADÉMICO DE MAESTRO EN DIRECCION PARA LA MANUFACTURA

POR:
DANIEL RODRIGUEZ OROZCO

MONTERREY, N. L.  
SEPTIEMBRE 2009
A METHODOLOGY TO DEFINE STRATEGIC INNOVATION PROJECTS AND NEW PRODUCT DEVELOPMENT PORTFOLIO BASED ON MEGATRENDS EXPLORATION AND TECHNOLOGY FORESIGHT

CASE OF STUDY: MEXICAN MAGNET WIRE INDUSTRY

TESIS

PRESENTADA COMO REQUISITO PARCIAL PARA OBTENER EL GRADO ACADEMICO DE MAESTRO EN DIRECCION PARA LA MANUFACTURA

POR:
DANIEL RODRIGUEZ OROZCO

MONTERREY, N. L. SEPTIEMBRE 2009
A methodology to define strategic innovation projects and new product development portfolio based on megatrends exploration and technology foresight

Case of study: Mexican Magnet wire industry
ACKNOWLEDGEMENTS

When I started to study my master degree in EGADE almost three years ago, I’d never realized the amount of work ahead of me. Now that I see the culmination of this stage in my life makes me think that maybe today I am not only a wiser man; thing that I am hoping, but also a more committed person with all those people that somehow believed in me and that expected from me a better person too. This thesis represents a small testimony that I have pursued that goal.

I would like to acknowledge and to thank Dr. David Guerra Zubiaga Ph.D., for accepted me as his thesis student, and who was my main advisor during the development of this work; for all his support and advices given which guided me during this hard-working process, for believe in what I was proposing and for encouraged me to get a better final product.

To Juan Garza Herrera which without his invaluable support by offering me a full scholarship to study this master degree, this thesis would had never even existed. My full gratitude for this opportunity big boss!

To Ricardo Trujillo Silva with whom I have shared many professional projects and travels, for his support and advices during almost ten years of collaboration with him, which have in deed leveraged my professional career. Thanks for joined me also on this last journey of this important stage of my life as part of my thesis committee as examiner.

To Dr. Guillermo Jiménez Pérez Ph.D., who honored me by accepting to be part of my thesis committee as examiner and for had been one of my professors during the class of Enterprise Integration Engineering; his valuable advices helped me to enrich this thesis work.

And to all the professors and teachers - wherever you are - that during my scholar life have enriched me with their knowledge, teachings, and lectures that helped me to build the bridge that put me where I am now. Many of you never even thought that naughty Danny boy would have been on the brink to earn a master’s degree diploma some years later. Thanks for all!

Daniel Rodríguez Orozco
DEDICATION

To Almighty God, for giving me all the blessings I have received

To my lovely wife Angie, without you my life would be empty and you fill me with love and tenderness
   Thank you for your loving support all the time

To my two fallen little pieces of heaven, my lovely kids Bárbara Daniela and Andrés Eugenio
   I see in your small beautiful eyes the hope and courage I need to go on

To my father Daniel Rodriguez Sr., who taught me the value of work and has been an example that
   guided me to become a man of good

To my mother Yolanda, who has always given me true unconditional love, education and care
   and be my confident friend

To my sisters and brother; Liliana, Dalia and Adrián; nephews, nieces and political family

To my grand parents, I miss you!

To my uncle Luciano, who was my inspiration to keep learning
   I hope you are proud from high above

Daniel Rodríguez Orozco
ABSTRACT

Today our world seems to spin faster; technology develops at a rapid pace as new societal, industrial and environmental needs appear as part of the changes that human activity imposes over our blue planet. Some of these changes follow patterns or trends, which effects are felt not only by a small particular group, region or environment, but they extend their reach to a global context. These global patterns of change are called Megatrends.

With an appropriate mechanism, megatrends can be explored, understood, analyzed and broke down to foresight possible pathways for the responses that societies, governments and industries might follow to address them. These potential responses become roadmaps that can be further translated into opportunities but also as threats to the status quo. For industries, they represent a challenge that enforces them to react and strategically deal with new paradigms sometimes before they come out. New technologies, products, services and processes can be foresighted and an innovation effort can be leveraged to promote projects that are aimed to provide solutions.

An innovation portfolio of R&D projects and new product developments can be constructed upon megatrends and with the right and structured process these projects can be evaluated based on strategic fit and expected financial performance as they help to strengthen firm’s competitive position. This research work is aimed to explore and develop this mechanism that could become a tool for industry’s managers to incorporate megatrends understanding into their business’ technologic strategy.
# TABLE OF CONTENTS

1. Introduction ............................................................................................................. 1
   1.1 Background ........................................................................................................ 3
   1.2 Problem definition .............................................................................................. 5
   1.3 Aims and objectives ........................................................................................... 6
   1.4 Scope of the thesis .............................................................................................. 7
   1.5 Structure of the thesis ......................................................................................... 7

2. Literature review ...................................................................................................... 9
   2.1 Introduction ........................................................................................................ 9
   2.2 Global trend or megatrends ............................................................................. 10
      2.2.1 Strategy and analysis of megatrends ....................................................... 10
      2.2.2 Exploring megatrends ............................................................................ 12
      2.2.3 Megatrends Analysis and Portfolio Strategy – MAPS ......................... 11
   2.3 Foresight ........................................................................................................... 13
   2.4 Foresight methodologies ............................................................................... 16
      2.4.1 Trend analysis ............................................................................................ 16
      2.4.2 Scenario planning ..................................................................................... 16
         2.4.2.1 Concepts and definition ................................................................. 16
         2.4.2.2 Benefits of scenario planning ....................................................... 17
         2.4.2.3 Constructing scenarios ................................................................. 18
         2.4.2.4 Shortcomings of scenario planning ........................................... 21
      2.4.3 Technology roadmapping ....................................................................... 21
         2.4.3.1 Concepts and definitions ................................................................. 21
         2.4.3.2 Roadmapping process ................................................................. 22
         2.4.3.3 Link between technology roadmapping and scenario planning .... 24
   2.5 Project portfolio management ............................................................................ 25
      2.5.1 Concepts of project portfolio management .............................................. 25
      2.5.2 Implications of portfolio management to business’ strategy ............... 27
      2.5.3 Portfolio management process ............................................................... 29
      2.5.4 Methods and models ................................................................................. 30
         2.5.4.1 Financial methods ........................................................................... 30
         2.5.4.2 Strategy-based methods .................................................................. 31
         2.5.4.3 Bubble diagrams and portfolio maps ............................................ 34
LIST OF FIGURES

Figure 1-1 NAFTA Magnet wire capacity vs. demand [Source: CRU W&C Quarterly, 2009] ........4
Figure 2-1 Level of granularity when breaking down megatrends for analysis, adapted from The McKinsey Quarterly [2008b] .......................................................... 11
Figure 2-2 Delphi’s Megatrends Analysis and Portfolio Strategy (MAPS) [Sultan et al., 2008] ....13
Figure 2-3 Multi-layer Roadmap structure adapted from EIRMA 1997 [Phaal et al., 2007] ..........22
Figure 2-4 T-Plan: standard process steps, showing linked analysis grids. [Phaal et al., 2001] ......23
Figure 2-5 Project portfolio and product lines [Cauchick Miguel, 2008] .................................. 25
Figure 2-6 Portfolio planning process proposed by Terwiesch & Ulrich [2008] ......................... 28
Figure 2-7 Rank ordered projects against Expected Commercial Value [ECV]. [Cooper et al., 1997a and 1998a] ................................................................. 31
Figure 2-8 The Strategic Buckets method [Cooper et al., 2001] ............................................. 32
Figure 2-9 Strategic buckets for automotive company [Terwiesch & Ulrich, 2008] .................. 33
Figure 2-10 Typical Bubble diagram for new product projects [Cooper et al., 1997] ................. 34
Figure 2-11 Basic diagram of IDEF0 showing arrows positions and roles [Processing Standards publication 183, 1993] ......................................................... 37
Figure 2-12 Diagram decomposition structure [Processing Standards publication 183, 1993] ....38
Figure 3-1 Methodology main structure ........................................................................ 41
Figure 3-2 Megatrends Breakdown process model ................................................................. 43
Figure 3-3 Megatrends breakdown process model level A0 decomposition ......................... 43
Figure 3-4 Strategic portfolio management process .............................................................. 53
Figure 3-5 Strategic portfolio management process level A0 decomposition ......................... 54
Figure 3-6 Innovation management process ....................................................................... 61
Figure 3-7 Innovation management process A0 level decomposition ..................................... 62
Figure 4-1 Magnet wire used in electric motors on HEV’s cars [Source: Honda] .................. 67
Figure 4-2 IDEF0 activity decomposition – Define key megatrends and driving forces ......... 68
Figure 4-3 Breakdown by sector of CO2 [Source: WBCSD adaptation from IEA 2003; 2004a] ....72
Figure 4-4 Emissions scenarios [Source: WBCSD 2004a, 2005] ......................................... 72
Figure 4-5 IDEF0 activity decomposition - Identify the subtrends and remaining uncertainties 73
Figure 4-6 Projected growth in light duty vehicle (LDV) ownership [WBCSD, 2004a] .......... 74
Figure 4-7 IDEF0 activity decomposition – Assess uncertainties through scenario planning ....76
Figure 4-8 Low carbon technologies in the road transport sector [Source: WBCSD, 2005] .... 78
Figure 4-9 Roadmap of the electric vehicle from today to 2015 [Source: EPRI, 2003] .......... 78
Figure 4-10 IDEF0 activity decomposition – Strategic Position Mapping sub-process .......... 81
Figure 4-11 High Temperature Superconductors Roadmap, [adapted from US DOE, 2004] .... 84
LIST OF TABLES

Table 2-1 Frequently used corporate foresight methods [Jeong et al., 2007] .......................... 15
Table 2-2 Different scenarios approaches and their steps [Lankila, 2004] ................................. 20
Table 2-3 Project Portfolio managing processes adapted from Sanchez et al. [2008] .................. 30
Table 3-1 Foresight Stage report table ..................................................................................... 51
Table 4-1 Electric motors in today's automobiles [Source: Asmo Co Ltd cited in Just-Auto 2009] ........................................................................................................................................ 67
Table 4-2 Megatrends list from exploration and search according megatrends definition ........ 69
Table 4-3 Magnet wire related high impact key megatrends ...................................................... 70
Table 4-4 Summary of the first two activities ........................................................................... 75
Table 4-5 Scenarios development framework [adapted from EPRI, 2006] ............................. 77
Table 4-6 Experiment #1 report table ..................................................................................... 79
Table 4-7 Subtrends and potential responses for Energy power generation to 2050 [adapted from WBCSD, 2005] ....................................................................................................... 80
Chapter 1

1. Introduction

Thriving in global economy has become one of the most challenging endeavors of today’s companies and businesses. Faced with rapidly changing technologies, shorter product life cycles and heightened global competition more than ever businesses must determine on what, where, how and when their scarce resources will be invested for its future prosperity and even its own survival [Cooper et al., 2001].

Nowadays, most businesses compete not only locally but also in a global context and this latter paradigm has put companies facing a higher level of competition and increased number of competitors; hence the increasingly importance of determine a well defined business strategy to thrive in this heightened competitive era. Porter [1979] portrayed in his work the implications that competitive forces have to do with the business strategy. Among other forces, he identified that rivalry among competing businesses becomes more intense when the products and services that they offer are nearly identical or exist few switching costs for buyers, and it tends to be especially destructive if it gravitates solely in price since it transfers profits directly to the customers. Hamel [2000] goes beyond and defines that only new wealth can be created for those companies that can take their old business models and create revolutionary new ones that in turn would create new markets, serve new customers and generate entirely new revenue streams.

Today many firms define their business strategy launching into innovation as business model, which has been gaining more and more importance as part of the strategy to compete in global economy. By riding the innovation wave, firms intent to leverage their efforts to outperform their competitors by developing and introducing new products, technologies, processes and services that will seek to drive and enhance differentiation which in turn would strengthen the firm’s value proposition thus maintaining or increasing business profitability and chances of survival. Here, that managing the innovation and new products portfolio has become of increasing importance for companies to remain competitive in global economy [Killen et al, 2008].

But deciding towards innovation as the core business strategy or model will not by itself guarantee that firms will thrive and succeed. For this reason and in order to develop successful and innovative new products that will have the power to drive wealth back to the business; companies should first identify market opportunities and align them with its capabilities; hence the selection of a portfolio of projects and new products is a central factor to increase company’s chances of success [Cauchick Miguel, 2008; Cooper et al, 2001; Terwiesch & Ulrich, 2008]. For this reason portfolio management and project
selection is considered the number one issue in new product development and technology management [Copper et al. 1997b] and should be imprinted and supported by the business strategy [Cauchick Miguel, 2008; Cooper et al., 1997a].

Since new opportunities are the main drivers for an innovation process; screening, identifying and defining these opportunities is critical to construct a portfolio of innovation projects. They will determine somehow what products, technologies and processes are or will be required, thus a good projects portfolio selection and definition is a must, otherwise serious negative consequences should be expected from the new products effort if a wrong portfolio management and selection is defined [Cooper & Kleinschmidt, 2007; Cooper et al., 2001]. In general terms most firms start working in new product opportunities "when they first recognize in a semiformal way, an opportunity" and if the newly discovered opportunity worth exploring, a small group to develop the product concept and definition is assigned. But identifying opportunities for new products and business remains most of the time unclear and uncertain. For example, when a disruptive innovation is involved, it usually results to be hard to identify in advance and the market growth difficult to be forecasted [Christensen, 1997; Drew, 2006]. Top management commonly asks questions as "What might give us continued competitive advantage?" and "What new product or markets should we enter and how?" Both questions lie at the heart of the firm's strategic vision [Schoemaker, 1997].

Innovation provide help to firms to prepare for an uncertain future and since most of them are exposed to all manner of uncertainty like for example: fluctuating supply prices for inputs, aggressive moves by competitors, changes in regulations, or the emergence of formerly unimportant regions as key markets, it is important to systematically make bets across a range of possible scenarios to close future gaps or seize opportunities before they open through innovation [Schoemaker, 1995, 1997; Terwiesch & Ulrich, 2008].

Scenarios are used to examine the external environment and more specially those trends and key uncertainties that affect all players [Schoemaker, 1997]. Terwiesch and Ulrich [2008] explain: "It is important to know what the biggest uncertainties in your industry are and how well prepared you are to handle each of the scenarios you set for your services and products". Today's external environment changes rapidly in our quick evolving world; nevertheless many of the associated changes can be anticipated with the proper analysis. These changes that affect significantly societies, economies and political environments fit general patterns and change less rapidly; this patterns are called Megatrends [Sultan et al, 2008].

Megatrends or global trends affect a significant portion of the global population and they have a profound effect on nearly every aspect of a society affecting individuals and businesses. Society's
responses to these challenges could be predicted within a varying degree of certainty and business opportunities screened and anticipated [Sultan et al, 2008]. Acquiring knowledge and understanding why certain products, processes and technologies are being developed and to what specific customer’s needs are they currently responding but also envisioning to where the global driving forces are steering societies, industries, markets, competition, governments and groups to newer behavior patterns and needs to be fulfilled is vital to establish a better oriented strategic definition. Today most businesses executives around the world consider that global trends or Megatrends are generally more important to the corporate strategy than they were five years ago [The McKinsey Quarterly, March 2008].

The link between global Megatrends analysis and its breakdown as a source to screen and detect business opportunities, which will derive to a strategy redefinition and subsequent portfolio management of innovation and new product development projects that in turn would seek to improve the current and future competitive position of the firm and thus thrive and maximize the financial outcome of a business is the main objective of this work.

A case of analysis of a particular industry has been selected to be part of this research since in recent years it has been struggling to take back profit lost from fierce rivalry centered basically in price due to the “commoditization” of their products and the increased bargaining power of customers [Porter, 1979]. For this reason embracing innovation as strategy is vital to seek new streams of wealth for this business, where the need to define current and future opportunities, adjust or redefine the business strategy to promote a well-oriented innovation and new products portfolio management to enhance the competitiveness and financial performance is needed. The industry to which this research is aimed is the magnet wire business with particular emphasis in the Mexican industry.

1.1 Background

The magnet wire industry has existed for many years and in practically every part of the world magnet wire companies can be found and many are capable to manufacture magnet wire or winding wires in different products types, ranges, configurations and applications.

Magnet wire is the primary component of electrical coils for the generation of magnetic fields in electric machines when an electrical current flow through a core conductor which is externally and continually isolated to avoid short-circuits of the electric current. Main components are conductive metals in the form of wires and cables like copper or aluminum and in more sophisticated and specialized applications, silver, nickel, and superconducting alloys. Dielectric materials, mainly polymers such as organic enamels and varnishes, oil-impregnating papers, inorganic compounds and tapes are used to
isolate dielectrically the conductive material. These materials are applied by specific and different manufacturing methods upon wire design and dielectric material configuration onto the external surface of the conductor to electrically isolate it. Industries and markets served by the magnet wire business are: electric energy generation and transformation, electric motors industry, automotive industry, lighting, electronic components and home appliances.

Magnet wire industry has been struggling lately to thrive and more recently to survive since many of its products had become commodities and in some regions of the world exists a production over capacity for most of its products, which has drove profit margins to shrink dramatically and differentiation is almost completely driven by price and service.

The magnet wire industry in the North American Free Trade Agreement [NAFTA] region and where Mexican magnet wire businesses compete; have presented this behavior for at least the last decade, driving industry into a consolidation process derived from its over capacity, downsize of market volume due to migration of customer's operations to low cost countries [i.e. China] and very few differentiation degrees. See Figure 1-1 for reference about magnet wire market in NAFTA behavior.

Innovations and product development are not easy tasks in the Mexican magnet wire business, first because magnet wire is considered a matured product and market and defining an innovative portfolio of projects for Mexican companies sometimes turns out to be difficult since many times is driven by very specific customer needs; where projects are defined on specific requirements once they have been disclosed during the technical feasibility of already developed products by foreign competition. Second, because for many years Mexican magnet wire business has followed the technologic leadership of
competitors from the USA and Japan. And third, because technologic developments in electrical devices and apparatus are mainly done outside Mexico and Mexican magnet wire businesses' participation is scarce in this field. These three arguments converge to lead that Mexican magnet wire businesses tend to behave more reactive than proactive on regard innovation which in turn is translated into a lag in technical, technological and productive capabilities to meet new requirements and seize new commercial opportunities.

1.2 Problem definition

With today rapidly changing world where once successful business strategies become outmoded at a faster rate and product lifecycles shorten, identifying needs created by the effects of global megatrends over societies and businesses environments and scoping and envisioning future developments through a methodology is believed necessary.

The development of this methodology could help to identify opportunities which can be translated into gaps on current business strategies, products and technologies This has become increasingly necessary in order to anticipate and respond to changes driven by global megatrends by reshaping business strategy and launching or defining the innovation effort with a well oriented projects and new products development portfolio to address and close these gaps. Thus, this will help to guarantee that the business is not being left with outmoded technologies and products or missing opportunities to expand into commercial white spaces [Sultan et al., 2008], and will help to enhance the competitive position of the firm and its financial performance.

The Mexican magnet wire industry presents an excellent case to develop and apply a methodology to define a strategic innovation and new products portfolio based on megatrends analysis and foresight methodologies for the following reasons:

1. Serves to a wide range of industries, markets and applications that include mostly all types of electric energy transformation; from industrial, commercial and traction electric motors, power generators, large power, industrial and distribution transformers; electric and electronic components for the automotive industry, lighting industry, control and electronic components and home appliances. This diversity translates into a large series of requirements and needs of products that are aimed to meet certain societal, economical, technological and environmental trends.
2. Megatrends and its related effects are not understood and are not taken into consideration when addressing its technologic strategy, but also do not posses a methodology to incorporate them into the definition.

3. Geographic location which allows it to serve not only Mexican operations but also the large US market and other Latin American countries

4. Need to define a clear innovation strategy and projects portfolio management to achieve a better competitive position to access to higher profit margins by allocating strategically the scarce resources, balancing the mix and risk of projects and to compete and thrive in global economy

1.3 Aims and objectives

This thesis is aimed to develop a methodology that will help as a guiding light for managers in the Mexican magnet wire industry as a tool to identify business opportunities, redefine the business strategy, determine direction for innovation, define and manage the portfolio for new products development in order to respond to current and future needs in the markets it serves when megatrends are considered and analyzed using foresight methodologies to understand its strategic implications in the innovation effort. For this purpose a case of study will be developed in a Mexican magnet wire company to prove the proposed methodology.

The main objectives of this thesis are:

- To generate understanding about megatrends, its implications to societies, industries and business
- To research why is important to manufacturing businesses' strategy the incorporation of megatrends
- To explore what proposed frameworks and methodologies to analyze megatrends have been already developed
- To study other foresight methodologies and its applicability to be used to analyze megatrends and forecast technologic trends and product needs
- To research on portfolio management literature and explore its applicability as a tool to define innovation projects and new products development portfolio when current and future needs arise from megatrends
- To design or adapt a methodology that incorporates global megatrends analysis, foresight methodologies to foresee technologic developments, and projects portfolio management
techniques, which together might constitute a tool for managers to help in the strategic technologic definition and further development of innovation and new products portfolios

- To explore modeling techniques to generate understanding about the methodology operability
- To develop a case of study inside a Mexican magnet wire company

1.4 Scope of the thesis

This study is focused to provide a tool for managers that recognize the importance of addressing the effects of megatrends in their business strategic-technological definition; and thus provide the elements and processes intended to guide the analysis of global megatrends and to help identify possible current and future competitive gaps in manufacturing firms when potential responses to megatrends are anticipated and opportunities are scoped. These opportunities (or threats) can be further used by managers to define innovation projects and new product development portfolios to enhance firm’s competitive position, help increase the chances to improve its financial performance and strengthen its scarce resources allocation when the best strategically balanced selection of projects is defined. The main contribution of this thesis is the proposed methodology, which the author believes highlight the processes and activities needed to explore and identify megatrends and incorporate its effects into the technologic strategy and consequently innovation projects and new product development portfolio.

This study is not about developing a comprehensive strategic technologic planning process, neither is to define a detailed new product development process (NPD) nor to define a specific portfolio of projects or to validate it during the case of study development.

Although the proposed methodology is intended for the magnet wire industry and will be demonstrated through a case of study in a Mexican company, the author of this thesis believes that can be easily adapted or used by other industries in different nations, since megatrends affect all societies and industries around the world in one or another manner.

1.5 Structure of the thesis

This thesis is structured in the following way:

Chapter 1 portrays the tasks of this research thesis including its background and justification so as its aims, objectives and scope.
Chapter 2 includes the compilation of literature review and research of concepts in the state of the art used for the development of this thesis.

Chapter 3 presents the main objective of this work by introducing a methodology that will guide companies to build a strategic innovation and new products portfolio based on the exploration, analysis and breakdown of global Megatrends into potential responses, which in turn will become opportunities and threats for the business and where by a strategic evaluation and portfolio management will be translated into and innovation and new products development portfolio. At the end, a simple innovation management process is depicted to formulate the innovation pipeline.

Chapter 4 presents a Case Study in a Mexican company in the magnet wire industry that validates the usefulness of the proposed methodology in chapter 3.

Chapter 5 discusses the results obtained from the implementation of the methodology in the Case Study described in chapter 4, as well as it presents the conclusions obtained. At the end of this chapter some recommendations for further research and future work are described.
Chapter 2

2. Literature Review

2.1 Introduction

Since the purpose of this research and thesis work is to develop a methodology intended to be used by managers in the Mexican magnet wire industry as a tool to adopt a wider vision based on global megatrends analysis and further integration of business opportunities to the strategic stage of building a portfolio of projects and new product development; this chapter is aimed to outline the elements that will support the concepts and ideas that will subsequently be proposed in the methodology in Chapter 3.

This section is divided in four folds:

- First part deals with the concepts surrounding megatrends, how they affect our life and businesses. Why is important to consider them during the definition of the strategy, study methodologies about how can they be analyzed to detect opportunities or threats to current and future business operation.

- Second part deals with the concepts surrounding foresight methodologies, like trend analysis, scenario-planning and technology roadmapping to analyze their usefulness during the analysis of megatrends in order to scope future opportunities and threats

- Third part deals with the concepts of project portfolio management since projects scoped by the foresight stage must be then evaluated and prioritized and must have a clear relationship to business' strategy, primarily from the view of the top management since it is the first and direct responsible of defining it, which will attempt to maximize firm's profit by taking decisions on where and what the resources of the organization will be allocated while developing innovation projects, developing new products [NPD] or R&D projects, recognizing current and future gaps in the strategy derived from the foresight stage and analysis of the megatrends, evaluating firm's current competitive and technology position and determining the decisions that would lead to a balanced portfolio of projects to respond adequately to newer business' environments.

- Last fold, deals with the concepts surrounding Integration Definition for Function Modeling (IDEF0), since it is presumably useful to design the proposed methodology
2.2 Global trends or megatrends

“Megatrends are significant movements, tendencies or forces that are commencing or occurring in one or more parts of the world, and they are expected to continue well into the foreseeable future” [Sultan et al., 2008]. Global trends or Megatrends impact every industry internationally, nationally, regionally and locally, are already in motion, difficult to alter, and completely out of someone control [Gabriel, 2007]. According to Sultan et al. [2008], Megatrends have caused major disruptions to life in general and to regional and global markets; they fit general patterns of significant change in social, economic, politic and technologic contexts.

2.2.1 Strategy and analysis of megatrends

Today more and more top executives believe that integrating global social, environmental, political and technological trends into the strategy is important to the businesses [The McKinsey Quarterly, 2008a]. Consequences of not responding to Megatrends and not developing strategic plans to anticipate the potential responses to socio-political or environmental disruptions can leave a firm with outmoded technologies and products, or will lead it to miss opportunities [Sultan et al., 2008].

Identifying global trends and its drivers is important to estimate the impact on the world over a period of time, in which analysis will help senior leaders to better cope with uncertainties [US NIC 2000]. Also, exploring the impact of key megatrends can help senior management to foresee outside changes in the economics and priorities of customers and potential market disruptions [Kachaner et al., 2008]. From the March 2008a issue of The McKinsey Quarterly on regard how companies act on global trends, almost 70 percent of the executives agree that global trends have become more or much more important to corporate strategy over the past five years. Around 75% of the executives surveyed in Latin America and in the manufacturing sector worldwide indicate the growing importance of megatrends. Although the recognized importance that megatrends have on the corporation strategy; many executives do not act and address on megatrends, and according to this survey the lack of skills or resources to respond to a megatrend are important reasons for inaction [The McKinsey Quarterly, 2008a].

According to Kachaner et al. [2008], business' strategy needs to be considered and created along three distinct time horizons: long, medium and short term. If a company’s strategy process focuses only on short-term imperatives, there is a danger of myopia, which leads a company to miss the weak signals that suggest how the future competitive environment will evolve and miss a strategic turn. To overcome this tendency, they suggest that companies must analyze megatrends and developing scenarios,
anticipate and prepare for likely developments and, shape the future by influencing the competitive environment. In another recent research, a leading consulting firm suggests that companies should navigate important trends by first studying their impact on sub-industries, segments, categories, and micromarkets. That kind of analysis breaks down megatrends into microtrends that companies can invest with confidence. The starting point is to incorporate a “granular view” and megatrend analysis is to break down market information into increasingly fine-grained levels – from world market; to broad industry groups; to individual industries. These in turn can be divided both by sub-industries and by country or region into product categories [The McKinsey Quarterly, 2008b]

<table>
<thead>
<tr>
<th>Level of market information and granularity</th>
<th>World market</th>
<th>Industry groups</th>
<th>Industries</th>
<th>Subindustries</th>
<th>Product categories by region</th>
<th>Individuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of segments</td>
<td>1</td>
<td>Tens</td>
<td>Hundreds</td>
<td>Thousands</td>
<td>Millions</td>
<td>Billions</td>
</tr>
</tbody>
</table>

![Fig 2-1 Level of granularity when breaking down megatrends for analysis, adapted from The McKinsey Quarterly [2008b]](image)

2.2.2 Exploring megatrends

Many government and no-government agencies and consulting firms, issue periodically reports, surveys and analyses on regard what are the megatrends that are affecting current and future developments in strategic areas and regions. For example, the US National Intelligence Council released in 2000 its Global Trends 2015 paper by surveying a panel of non-government experts, where key drivers of change and trends in different areas were identified [US NIC 2000-2]:

- **Demographics**: world population growth by 2015, people living longer, larger growth rate in developing countries, aging phenomena in advance economies, etc.
- **Natural resources and environment**: Food production will keep pace with growing population, with exceptions in some regions of Africa, increase of 50% in energy demand but with enough
resources to meet it, although some regions like: Middle East, Sub-Saharan Africa, South Asia and northern China would face food, energy and water scarcities, rising tensions

- **Science and technology:** Continuing quantum leaps in IT technology, new applications of biotechnology, breakthroughs in material technologies, etc.

- **Global economy and globalization:** Increasing flow of information, ideas, cultural values, capital, goods, services and people, etc.

- **National and international governance:** governments will have less and less control over information, technologies, diseases, migrants, arms and financial transactions, etc.

- **Etc.**

In a report released by the firm Ernst & Young [2009] *Global Megatrends 2009*, the firm identified seven Megatrends to be considered for its influential power in the world of business, these global trends were depicted as follows:

1. Accelerating shift of power from West to East
2. Changing financial landscape
3. Overhaul and globalization of the regulatory environment
4. Rising economic importance of energy and commodities
5. Responsibility firmly on the corporate agenda
6. Next wave of technological innovation
7. Increasing challenges of managing and developing talent

### 2.2.3 Megatrends Analysis and Portfolio Strategy – MAPS

Sultan, Mantese, Ulciny and Brown Jr. introduced the Megatrends Analysis and Portfolio Strategy or MAPS in 2008. This process is part of Delphi’s strategic planning process. According to the proposed methodology, responses of societies to megatrends can be anticipated and these can be converted into business opportunities if the appropriate analysis is done; this in turn will drive the strategic definition to develop roadmaps and research projects ahead of time helping the firm to address new products and technologies and seize opportunities in white spaces. The methodology also stipulate that it can be useful to virtually any company to align its strategy with megatrends, subtrends and potential responses as well as to help develop its own specific portfolio [Sultan et al., 2008]

The MAPS process consists of four steps:

1) Identifying world megatrends
2) Anticipating the subtrends that result from each Megatrend, and developing a matrix
3) Potential responses, and
4) Product opportunities.

Sultan et al defined a subtrend as "consequences of the megatrends" and they produce major impacts with its own problems, consequences and business opportunities and threats. First part of the process is considered non-specific to firm's effort or "corporate independent", since it is proposed that much of the identification of megatrends, subtrends and potential responses would be done in a pre-competitive basis. This would mean that is supported mainly by the help of external experts. Second part is considered "corporate specific" and it corresponds to the internal identification and definition of business opportunities and portfolio strategy. Figure 2-2 depicts the Delphi's MAPS process.

![Fig. 2-2 Delphi's Megatrends Analysis and Portfolio Strategy (MAPS) [Sultan et al., 2008]](image)

The failure to adequately respond to rising megatrends, stems from the fact that major corporations often expand their business opportunities from their existing portfolio of products and technologies, whereas significant innovations have more often occurred by asking. How will the world change? How must business and products change to bring maximum value to the company? [Sultan et al., 2008]

2.3 Foresight

Foresight, is the act of looking forward, is an inherent human activity used every day by individuals throughout society and businesses [Loveridge & Street, 2005]. According to the Webster's dictionary, the meaning of "foresight" is 'providence by virtue of planning prudently for the future' [cited in Jeong et al., 2007]. Van der Heijden [2000] argues that the reason why we find it useful to discuss and foresight the future is that we consider that at least something in the future is predictable.
Foresight is equivalent to a bundle of systemic efforts to look ahead and to choose more effectively. Thereby, foresight takes into account that there is not a single future [Kok et al., 2001].

Public institutions and many governments and international organizations (e.g. UN) have adopted foresight as part of their policy processes. For example, foresight studies became important as national approaches in science and technology in Europe at the beginning of the 1990’s following the example from Japan [Cuhls & Blinds, 1998; Loveridge & Street, 2005].

Corporations have been also very sensitive to social, political, economic, social and technological changes [Sultan et al., 2008]. Such environmental changes impact the organization’s strategies in order for corporations to survive and prosper [Jeong et al., 2007]. Consequently, the relevant changes in the environment require monitoring [Becker, 2002]; therefore, corporate foresight focuses on corporate or organizational level foresight activities [Jeong et al., 2007], which look to establish a corporate system that warns about unpleasant surprises and identifies emerging opportunities – a skill that large companies have proven to have difficulties with [Day & Schoemacker, 2004; Rohrbeck & Thom, 2008; Schwarz, 2005]. Today’s environmental change is rapid, dynamic and with increasing discontinuities; which are characterized to be new and difficult to predict; discontinuities were later developed by Christensen [2000] under the name “disruptions”. In consequence, companies have to develop methods to increase their ability to detect changes and react to them rapidly and effectively; since discontinuities can be translated by aggressive entrepreneurial management into opportunities [Rohrbeck & Thom, 2008].

According to Kachener et al. [2008], a clear strategic vision of potential futures produces three main advantages:

1. **Readiness**: To understand the potentialities that lie ahead and be ready to respond
2. **A head start**: Lead-time to shape the competitive environment to a company’s advantage
3. **Alignment**: A shared vision of the future can help to align company’s efforts and investments with its business strategy

Foresight methodologies emphasize on technology; and this arises from its historical roots [Loveridge & Street, 2005]. For example, the OECD define foresight as “the process involved in systematically attempting to look into the longer-term future of science, technology, the economy and society with the aim of identifying the areas of strategic research and the emerging generic technologies likely to yield the greatest economic and social benefits” [cited in Kok et al., 2001]. Thus technology foresight is aimed to identify emerging technologies and it supports the link between technology and the business’ strategy [Albright & Kappel, 2003; Phaal et al., 2007; van Wyk, 1997], and traditionally have relied
heavily on the participation of experts [Loveridge & Street, 2005]. According to a survey performed by a consulting firm and presented in Jeong et al. [2007] the most popular foresight methodologies are shown in Table 2-1:

<table>
<thead>
<tr>
<th>Method</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Publication Analysis</td>
<td>79%</td>
</tr>
<tr>
<td>Brainstorming</td>
<td>58%</td>
</tr>
<tr>
<td>Scenario Methods</td>
<td>46%</td>
</tr>
<tr>
<td>Simulations</td>
<td>29%</td>
</tr>
<tr>
<td>Trend Extrapolation</td>
<td>29%</td>
</tr>
<tr>
<td>Expert Surveys or interviews</td>
<td>33%</td>
</tr>
<tr>
<td>Delphi, only seldom</td>
<td>42%</td>
</tr>
<tr>
<td>Future Workshops</td>
<td>8%</td>
</tr>
</tbody>
</table>

Table 2-1 Frequently used corporate foresight methods [Jeong et al., 2007]

Though the preceding table, technology roadmapping and scenario-planning are methods used in different domains [Rohrbeck & Thom, 2008]. Scenario planning has been widely associated with strategic planning [Schoemaker, 1995, 1997] and technology roadmapping is used often in product and R&D [Albright & Kappel, 2003; Phaal et al., 2007; van Wyk, 1997]. Trend analysis, on the other hand has been proposed as a foresight method [Jeong et al, 2007].

In short, the purpose of foresight is to increase a company’s ability to recognize and benefit from shifts and disruptions in the business environment by creating a shared vision of the future and company’s desired position within it. The process typically involves exploring possible “futures” and, for each one, determining, the current business model’s relevance and potency, as well as the moves that would be required to retain and enhance advantage. This outside view can be developed by exploring the impact of key megatrends on the economics and priorities of customers, on the universe of choices that customers are likely to have, and on the potential for market disruptions [Kachaner et al, 2008].

The foresight methodologies of scenario-planning and technology roadmapping will be researched and detailed, since the objective of this work is to design a methodology that will used as an internal foresight process to scope opportunities and threats that Global trends or megatrends create over businesses and the need to redefine the strategy in order to respond adequately with an innovation and new products portfolio in the Mexican magnet wire industry.

Although other foresight methodologies have been used like the Delphi method to forecast the future development of megatrends and emerging technologies in countries like Japan, Germany, and Austria [Cuhls & Blinds, 1998] it will not be considered since it relies on the use of surveys applied to mostly external expert panels in one or two rounds, that could discourage its use in a business organization since the large amount of resources needed.

Daniel Rodriguez Orozco
2.4 Foresight methodologies

2.4.1 Trend analysis

Trends, defined generally as "general inclinations or tendencies," are in analytical usage directions of change in one variable over time [Kok et al., 2001]. Trend analysis monitors changes in chosen variables from the past into the present, focusing on the cumulative tendency of the change over and above any seasonal cycles or statistical "noise" generated by unique events, and is one of the methods based on empirical examination of a phenomenon with repeated measurements taken across time. Trend analysis links our ability to observe change with our ability to plan it [Cetron, 1994; Shultz, 1995; Shultz & Ayesha, 1997; Slaughter, 1994].

Identifying and monitoring trends require us to investigate the current and past states of any phenomenon whose possible futures we wish to consider. Not being a tool of forecast; none of the varieties of trend extrapolation can "predict the future" but all of them can augment how well and widely we question patterns of change [Kok et al., 2001].

2.4.2 Scenario Planning

2.4.2.1 Concepts and definition

Scenario planning originated in the military strategy and the work of the RAND Corporation. Royal Dutch/Shell has used scenarios since the 1970's as part of the process to generate and evaluate its strategic options and has been successful in envisioning changes in the oil industry ahead of their competition [Drew, 2006; Schoemaker, 1995; Wack, 1985a,b]. Scenario planning is a disciplined method for imaging possible futures that companies and organizations have used to a great range of issues [Schoemaker, 1995]. Scenarios are images of the future and are increasingly popular as analytical tools for assessing the impacts of policies and as tools for assessing the robustness of policy measures in case of unanticipated events. In many organizations scenario construction is an important step in their strategic planning process [Enserink, 2003]. Other scenario planning definitions range from "tools for ordering one's perceptions about alternative future environments in which one's decisions might be played out" [Schwartz, 1996]. Also as "pen-pictures of a range of plausible futures" [van der Heijden, 2002]. Godet [2000] defined also a scenario as "the set formed by the description of the future situation and the course of events that enables one to progress from the original situation to the future situation".
Godet [2000] identified that scenarios can be classified in two major categories based on the time perspective. Scenarios are either:

1. Exploratory: starting from the past and present trends and leading to likely futures, or
2. Anticipatory or normative: built on the basis of alternative visions of the future they may be desired or, on the contrary, feared.

### 2.4.2.2 Benefits of scenario planning

Schoemaker [1995] defined the main objective of scenario planning as to attempt to capture the richness and range of possibilities, stimulating decision makers to consider changes they would otherwise ignore. At the same time, it organizes those possibilities into narratives that are easier to understand and use rather than great volumes of data. Above all, however, scenarios are aimed at challenging the prevailing mind-set.

According to Drew [2006], the essence of scenario planning and its application has been variously summarized as:

- Analysis of multiple views and different perspectives on the future [Wack, 1985a]
- Combination of traditional research with expert opinion and judgment [Schwartz, 1996]
- Organizational learning and systems thinking [Senge, 1990]
- A comprehensive and open approach to understanding competition and the business environment [Fahey, 1999]
- Consideration of multiple stakeholders and their interest [van der Heijden, 2002]
- Critical and creative approaches to strategic thinking [Schoemaker, 1995]
- Use of storytelling and strategic conversation [van der Heijden, 2002]

Also, Schoemaker [1997] identified that organizations could benefit greatly from scenario planning when some of the following conditions are present:

- High environmental uncertainty relative to manager’s ability to predict or adjust
- Costly surprises have already been suffered
- Insufficient generation and perception of new opportunities for the business
- Low quality in the strategic thinking
- Industry is about to experience a disruption or already has went through
- Need for a common language and framework without stifling diversity
- Strong differences of opinion exist with many of them having merit
- Competition uses scenario planning
Scenario planning differs from other planning methods; first, because it explores the joint impact of various uncertainties, which stand side by side as equals. Second, they can change several variables at a time. Third, it is not just an output of complex simulation since it attempt to identify patterns and clusters among the millions of possible outcomes a computer simulation might generate. Also, often include elements that were not or cannot formally modeled, such as new regulations, value shifts, or innovations. Hence, scenarios go beyond objective analyses to include subjective interpretations [Schoemaker, 1995].

2.4.2.3 Constructing Scenarios

Scenarios are creative by their nature both in thought and expression, but they are likely to be more useful if they have structure [Lankila, 2004]. Various approaches have been developed to construct scenarios; for example Schoemaker [1997] depicted a scenario planning framework aimed to addressed the strategic implications related to the creation of a vision of what a firm should be and how it must change; the method consists of the following:

- Examine the external environment, specially those trends and key uncertainties that affect all players [Sultan et al, 2008]
- Industry analysis and strategic segmentation will help define the battlefield in terms of competitors, barriers, and profit potential [Porter, 1979]
- Core capabilities analysis provides the basis for developing a strategic vision for the future [Prahalad & Hamel, 1990]
- Strategic options help make the vision into reality

Scenario approaches can be classified into two opposite groups according their characteristics: intuitive logic scenarios, and formal or statistical models. Intuitive approaches concentrate on storytelling narratives, which are created in relatively informal ways [Lankila, 2004]. Schwartz [1996] emphasizes the intuitiveness of scenario working and narrative writing. This approach rather useful to get quick results and vision; tends to require skills and experience of the facilitator to be applicable and helpful. On the other hand, statistical and formal models approaches are “doubly powerful in that they stimulate the imagination, reduce collective biases, and promote appropriation” [Godet, 2000]. Schoemaker [1995] argues that either approach is better, since intuitive approaches lead to often too irrational results and lack of discipline; but on the other hand statistical methods resemble too mechanical requiring little use of the imagination and might not be considered truly scenarios, as they entail internal inconsistencies or lack a compelling story line; rather suggest the use of heuristic approaches which combines discipline and imagination at the same time [Schoemaker, 1995, 1997]. Heuristic approaches are used by selecting the top key uncertainties and then cross them [Schoemaker, 1995], the combination of high and low uncertainties in each of the two factors leads to four distinct scenarios.
[Drew, 2006]. Lankila [2004] adapted and resumed the approaches to construct scenarios from literature, see table 2-2. According to Schoemaker's approach, the process to construct scenarios is divided into ten basic steps:

1. Define the issues, time frame and scope of analysis
2. Define the stakeholders in the form of who will be interest in the issues
3. Identify trends; political, social, environmental, technological, legal, etc.
4. Identify the key uncertainties, what remains unclear (events and outcomes)
5. Construct initial scenarios; either intuitively, heuristically, or statistically wise
6. Check for consistency and plausibility; to assure they sound at least reasonable
7. Construct learning scenarios; to identify key themes that are strategically relevant and organize possible outcomes around them
8. Identify research needs; further research to flesh out the understanding of key uncertainties and trends
9. Develop formal models; define if certain interactions should be modeled
10. Create decision scenarios; converge the process into useful scenarios to test strategies and ideas.

Drew [2006] developed a similar methodology by using a scenario planning process to foresee technologic disruptive innovations. This methodology is based on the identification and analysis of the strategic issues connected with disruptive technologies [Christensen, 1997] by scanning threats and opportunities in current markets, discovering disruptive applications of existing technologies, exploring un-served and over served market segments, examination of facts, stimuli and internal and external inspiration, and storytelling studies to facilitate deeper understanding. Drew also considered the identification of key driving forces since they are essential for understanding the changes in the business macro-environment - political, economic, social and technologic dimensions - and how they might unfold in future scenarios. Key trends and patterns must be considered to the driving forces because of their potential impact on the business. Remaining uncertainties arising from the analysis of driving forces must be identified, classified and ranked for further scenarios development [Drew, 2006].
There are no strict limits about how many scenarios should be constructed and the appropriate number differs from authors [Lankila, 2004]. Although is not supported by leading authors on scenario planning [Coyle, 2004; van der Heijden, 2002; Schwartz, 1996], it is common to use a set of three possible outcomes during scenario development:

1. A surprise-free projection
2. Worst case scenario
3. Best case scenario

Coates [2000] suggests the use of even number of scenarios to avoid the temptation of choosing the middle one and suggest that the minimum number should be four to avoid the tendency to develop optimistic, realistic and pessimistic scenarios and further preference to choose the middle case by considering the other two unrealistic. Nevertheless, although a minimum of four is preferable, a high number of scenarios can be constructed, for these reason Godet [2000] suggest that scenarios should be limited to the number of key hypothesis and should depend of how much is the uncertainty; higher the uncertainty, higher the number of scenarios. Mannermaa; cited in Lankila [2004], explained on the other hand that the a suitable amount should be between three and five, because two are easily driven to depict just a good one and a bad one and more than five scenarios get too hard to handle.
Scenarios can be written as a story of events from the present day to an envisaged future situation, either intuitively, heuristically or statistically [Schoemaker, 1995]. Supporting quantitative data, models, and forecasts might be developed for each scenario. Initially, scenarios can be written as short stories of no more than one or two pages. However, a finer grained analysis could be developed if necessary to go deeper in exploring the trajectories of disruptive technologies. The use of technology roadmaps is an example [Drew, 2006], and will be discussed further in the next section.

2.4.2.4 Shortcomings of scenario planning

Scenario are not free of biases since people tend to look for confirming evidence and discount disconfirming evidence, and this bias can creep into scenario development. Also, sometimes people presume correlations among uncertainties that are inconsistent [Schoemaker, 1995]. Drew [2006] argued the drawbacks as: the need to involve busy line managers who may not see it a relevant to pressing concerns, occasionally too little focus on the decision context; too much reliance on soft data; and the time and resources needed for research and analysis. Mannermaa cited in Lankila [2004], points out that the main shortcoming of scenarios is that the size of empirical material and data does not define the credibility and plausibility of the results; since many times a large amount of empirical material lead to superficial results, while on the other hand with too small material, the results may be hard to generalize. Van der Heijden [2002] emphasize on the importance of execution, since poor-executed scenarios lead managers to feel that not much has been achieve.

2.4.3 Technology roadmapping

2.4.3.1 Concepts and definitions

Technology roadmapping represents a powerful technique for supporting technology management and planning in the firm. Roadmapping has been widely adopted in industry [Albright & Kappel, 2003; Barker & Smith, 1995; Bray & Garcia, 1997; EIRMA, 1997; McMillan, 2003; Groenveld, 1997; Strauss et al., 1998; Willyard & McClees, 1987]. Technology roadmapping approach was first developed by Motorola in the late 1970’s to support an integrated product-technology planning [Phaal et al., 2007; Willyard & McClees, 1987]. Roadmaps have become one of the most widely used approaches for supporting innovation and strategy at both firm and sector levels and more recently have been used to support national and sector 'foresight' initiatives [Phaal et al., 2007].

Groenveld [1997] defined roadmapping as a process that contributes to the integration of the business and technology and to the definition of technology strategy by displaying the interaction between
products and technologies over time, taking into account both, short and long-term product and technology aspects. Albright and Kappel [2003] defined it as “the base for corporate technology planning, identifying needs, gaps, strengths and weaknesses in a common language across the corporation”. Similarly, McMillan [2003], describe it as “knowledge-capture and communication tools”. The process of developing roadmaps itself encourages thinking and cross-organizational communication [Drew, 2006; Strauss & Radnor, 2004]

2.4.3.2 Roadmapping process

Roadmaps can take various forms, but the most common approach is encapsulated in the generic form proposed by EIRMA (1997). Figure 2-3 shows the Phaal’s et al. [2007] adaptation from EIRMA. The generic roadmap is a time-based chart, comprising a number of layers that typically include both commercial and technological perspectives. The roadmap enables the evolution of markets, products and technologies to be explored, together with the linkages between the various perspectives [Albright & Kappel, 2003; Phaal et al., 2003]. According to Phaal et al., [2004] organizations struggle with the application of roadmapping because there are many specific forms of roadmaps, which often have to be tailored to the specific needs of the firm and its business context. EIRMA [1997], Bray & Garcia [1997], Groenveld [1997], Strauss et al., [1998] summarize key technology roadmapping process steps. These authors indicate that the development of an effective roadmapping process within an organization is reliant on significant vision and commitment for what is an iterative, and initially exploratory, process.

Fig 2-3 Multi-layer Roadmap structure adapted from EIRMA 1997 [Phaal et al., 2007]
Phaal et al. [2001], developed and proposed the T-Plan "fast-start" process resulted from the need for guidance to support the implementation of roadmapping being limited, and as an effective roadmapping process within a business, which is reliant on significant vision and commitment for what is an interactive, and initially exploratory, process. This process is aimed to accomplish the following:

- Support the efficient start-up of the organization-specific roadmapping processes
- Establish key linkages between technology resources and business drivers
- Identify important gaps in market, products, and technology intelligence
- Develop a "first-cut" technology roadmap
- Support technology strategy and planning initiatives in the organization
- Support communication between technical and commercial functions

The process relies on a series of workshops, bringing together key stakeholders and experts to capture, share, and structure knowledge about the issues being addressed, to identify strategic issues, and to plan the way forward. The T-Plan approach is shown in Figure 2-4, and is comprised by three broad phases:

1) **Planning**: to ensure that both process and roadmap architecture are appropriate
2) **Roadmapping**: development of the first roadmap, based on multifunctional workshops
3) **Roll-out**: aimed to develop the first draft of the roadmap as economically and quickly as possible [Phaal et al., 2001].

Fig. 2-4 T-Plan: standard process steps, showing linked analysis grids. [Phaal et al., 2001]
Technology roadmapping is an inherently flexible technique, in terms of the following:

- The wide range of aims that roadmapping can contribute towards.
- The timeframe covered by the roadmap (past and future).
- The structure of the roadmap, in terms of layers and sub-layers, which can be adapted to fit the particular application.
- The process that is followed to develop and maintain the roadmaps.
- The graphical format that is selected to present information and communicate the roadmap.
- The set of existing processes, tools and information sources in the firm, which the roadmap and roadmapping process need to integrate with.

The application of the T-Plan approach in a wide range of organizational and strategic contexts has enabled the flexibility of the roadmapping method to be explored. The approach can (and should) be customized to suit the particular application, in terms of roadmap architecture and the process for developing the roadmap [Phaal et al., 2004, 2007].

2.4.3.3 Link between technology roadmapping and scenario planning

Strauss & Radnor [2004], explain that technology roadmapping and scenario planning are complementary techniques. Roadmaps can be elaborated to describe how technologies, market, products, and processes in each scenario, and should highlight different opportunities for shaping and managing potentially disruptive innovation as they unfold [Drew, 2006]. The construction of high level technology roadmaps guides identification of the business model most compatible with each scenario. The roadmaps should also help identify decision flex points, when change to a new or modified business model might be advised as the future unfolds [Drew, 2006].
2.5 Project portfolio management

"Most companies have more opportunities for investment than their limited resources will allow. So management needs dynamic, robust criteria to evaluate these opportunities and select a mix of businesses and R&D projects that reflect its corporate strategy. Portfolio management can be that link" [Stevens, 1997].

2.5.1 Concepts of project portfolio management

Portfolio management for product innovation and development has surfaced as one of the most important senior management functions [Cooper & Kleinschmidt, 2007; Roussel et al., 1991] and it is seen as the manifestation of the business strategy [Cooper et al., 2001]. Even if portfolio management is not performed in a formal manner, project portfolio exists in some fashion in an organization [Sanchez et al., 2008].

Cauchick Miguel [2008] described that early studies defined portfolio management as "project selection". Archer & Ghazemzadeh [1999] described it, as "a group of projects that share and compete for the same resources and are developed under the sponsorship or management of an organization". Later on, the term portfolio management was used to mean "prioritizing the development of products" [Cooper et al., 2000]. Turner & Müller [2003, p. 7] defined it as "an organization (temporary or permanent) where projects are managed together to coordinate interfaces, prioritize resources between projects, and thereby reduce uncertainty" [Müller et al., 2008], and more recently to mean "multiple project management" [Dooley et al., 2005].

![Fig. 2-5 Project portfolio and product lines [Cauchick Miguel, 2008]]
A comprehensive definition of portfolio management was defined by Cooper, Edgett and Kleinschmidt [1997a] as follows:

*Portfolio management is a dynamic decision process, whereby a business’s list of active new product and R&D projects are constantly up-dated and revised. In this process, new projects are evaluated, selected and prioritized; existing projects may be accelerated, killed or de-prioritized; and resources are allocated and re-allocated to the active projects. Uncertain and changing information, dynamic opportunities, multiple goals and strategic considerations, interdependence among projects, and multiple decision makers and locations characterize the portfolio decision process.*

*This process encompasses or overlaps a number of decision-making processes within the business, including periodic reviews of the total portfolio of all projects [looking at the entire set of projects, and comparing all projects against each other], making Go/Kill decisions on individual projects on an ongoing basis [using gates or Stage-Gate™ process, and developing a new product strategy of the business, complete with strategic resource allocation decisions. [Cooper et al, 1998a; Graves et al, 2000; Roussel et al, 1991].*

In a comprehensive research made by Cooper et al. [2001] of the most cited reasons why portfolio management is important to senior management; the top cited reasons were portrayed as follows:

1. **Financial** – Maximize return and R&D investment, to achieve financial goals
2. **Strategy** – Maintain competitive position; increase sales and market share
3. **Efficient and proper resource allocation** – Launch more new products and faster with practically same resources
4. **Strategic issues of project selection** – Implementation of strategy through resource allocation to projects
5. **Focus** – Allocating scarce resources to high value and prioritized projects
6. **Balance** – Right balance between long and short term projects, and high risk and low risk ones, consistent with the business’s goals
7. **Improve communication** – Communicate priorities within the organization, both vertically and horizontally
8. **Objectivity** – Improve project selection by weeding out bad projects
Portfolio management and project selection is then seen as a “number-one issue” in new products development and technology management and it is considered between the top three strategic issues of today’s senior management [Cooper et al., 1997b]. Organizations with a more sophisticated new product development process have a formal and systematic portfolio management approach which in turn translates in a better resource allocation and balance between radical or breakthrough projects and incremental ones [Cooper et al., 2002; Kahn, Barczak & Moss, 2006].

In summary, effective portfolio management requires of three elements to be in place to work in harmony with one another [Cooper et al., 1997b]; the business strategy, the development process for new projects and the portfolio review with its various models and tools [Cauchick Miguel, 2008]

2.5.2 Implications of portfolio management to business’ strategy

Portfolio management is the manifestation of the business’s strategy [Cooper et al., 1997b, 2001]. Strategic alignment in a portfolio of projects requires general approaches such as including strategic criteria into project selection since portfolio components must compete for scarce resources, and they are selected or prioritized depending on their value to the business [Sanchez et al., 2008], i.e. incorporating numerous strategic criteria into the go/kill decisions by using prioritization models and applying top-down strategy models, i.e. budgeting funds for different types of projects [Cooper et al., 1997b]

Portfolio management is that of balance [Cooper et al., 1997a], a means by which a firm can achieve its financial objectives in a world of competing demands and incomplete information [Terwiesch & Ulrich, 2008]. This balance is defined by a mix of different project types, short and long term, risk level and a limited number to ensure that all can be resourced effectively, but sufficient to enable an adequate flow of projects and new product introductions [Cooper et al., 1997a, b; Cauchick Miguel, 2008; Killen et al., 2008; Sanchez et al., 2008].

Terwiesch & Ulrich [2008] defined that to complicate things more; a right balance between, using existing strategies to assess opportunities [top-down] and exploring the possibility that innovation can enable new opportunities and then redefine the strategy [bottom-up] should be selected. Therefore, any portfolio planning process will require some form of iteration since it is unlikely to find immediately the perfect balance between the competing demands. On the other hand, Sanchez et al [2008] argued that portfolio management should be complemented with a risk management approach to ensure the strategic alignment and the required balance of the portfolio and also increase the probability of achieving the strategic objectives and maximizing the portfolio’s value.
At a glance, firms should choose the right projects in order to have a viable portfolio of high value projects. Moreover, the portfolio should be properly balanced and, most importantly, it should support the business strategy. Hence the broad macro goals are the maximization of value, balance, and strategic direction [Callahan & Brooks, 2004; Cooper et al., 1997a; Kendall & Rollins, 2003].

Terwiesch & Ulrich indicated in their work that the portfolio planning process should be aimed to:

- Identify current gaps relative to business strategy that need to be assessed through innovation projects.
- Identify future gaps based on expected changes in the business environment or envision future gaps.
- Balance between strengthening your current strategic position and exploring future strategies by deciding on the extent how the firm wants to lead in the exploration of new markets or technologies.
- Create the innovation portfolio for each horizon or strategic bucket – This would mean creating a portfolio with the highest financial value based on low uncertainty and medium uncertainty opportunities but by also hedging against chances within firm's industry by setting also high uncertainty opportunities to strengthen firm's future position [Matheson & Matheson, 1998].
- Seek for opportunities to would need to redefine the strategy by exploring always the extent to which the firm can redefine the competition in its industry, i.e. the emergence of a disruptive new technology [Christensen, 1997, p. 15] or radical new business concepts [Hamel, 2000].

Fig 2-6 Portfolio planning process proposed by Terwiesch & Ulrich [2008]
2.5.3 Portfolio management process

As it has been defined, the main goals of portfolio management are maximization of value, balance and strategic fit; therefore the process of portfolio management is vital to achieve these goals. On the other hand, if the process of portfolio management is wrong, serious and negative consequences shall be expected from the total new product effort [Cooper & Kleinschmidt, 2007].

Miller [2002] indicated that these consequences could be presented as a large number of small, low-impact projects, low project prioritization, a high level of project failures, too many projects for the available resources, and the inability to reject them. Time-to market increment, starvation of good projects, selection of projects based on emotion or politics and lack of strategic direction are also expected consequences of an inefficient project portfolio management [Cooper et al., 2001].

Sanchez et al. [2008] identified that also the lack of a clear linkage between the processes performed during portfolio’s progress and its objectives generates also poor outcomes. Effective portfolio management for new product development is thus a major business challenge. So much that is right or wrong with a business’s new product efforts hinges on the project selection and portfolio choices that senior management make [Cooper et al., 2001]. Martinsuo & Lehtonen [2007] identified perceptions of portfolio management efficiency as a subjective culmination of portfolio-strategy alignment, knowledge of priorities, financial yield, realization of the strategy, and efficiency of managing the project entity [cited in Müller et al., 2008]

Many scholars argued that project alignment and portfolio balancing have been addressed through various project portfolio management processes [Callahan & Brooks, 2004; Cooper et al., 2001; Kendall & Rollins, 2003; Levine, 2005; Martinsuo & Lehtonen, 2007; Miller, 2002; Sanchez et al., 2008]; although they lack of uniformity in their propositions they suggested the same type of activities but using different terminologies and ways to grouping them. Table 2-3 synthesizes them using a framework developed by the Project Management Institute in 2006.
2.5.4 Methods and models

Different approaches in terms of methods and models have been defined to portray the process of portfolio management. The most popular are: financial methods, strategy methods, bubble diagrams or portfolio maps, scoring models and check lists [Cooper et al., 2001]. In the following sections each method is defined and explored.

2.5.4.1 Financial methods

Between the most used methods, the dominant are the financial approaches [Cooper et al., 2001; Killen et al., 2008]. These methods regularly include profitability and return metrics, such as NPV, RONA, ROI or payback period. Other financial method is the Expected Commercial Value or ECV approach. Figure 2-7 displays this approach.

According the results of the comprehensive research made by Cooper et al. [2001] the best performers in portfolio management rely much less on financial models and methods as the dominant portfolio tool than does the average business. In a similar research made in Australia; Killen et al. [2008] found that the use of financial methods is linked to good alignment of spending with strategy, but does not correlate to high value projects in the portfolio.
ECV = \[ NPV \times P_{cs} - C \times P_{es} - D \]

- ECV = Expected Commercial Value of the project
- $PV$ = Income stream from project (discounted to present)
- $SC$ = Commercialization costs (capital equipment & market launch)
- $SD$ = Development costs
- $Pts$ = Probability of technical success
- $Pes$ = Probability of commercial success (given technical success)

The ECV (Expected Commercial Value) is determined for each project, and divided by the constraining resource (e.g., by R&D cost per project). Projects are then rank-ordered according to this ECV/R&D index. See Cooper et al., 1997a and 1998a.

Fig 2-7 Rank ordered against Expected Commercial Value [ECV]. [Cooper et al., 1997a and 1998a]

Sanchez et al. [2008] also considers that the disadvantage of limiting the value to solely financial terms is that managers do not consider a portfolio’s strategic value, since they do not reflect strategic benefits or capabilities that an organization can obtain from projects and consequently, neither the organization’s long-term growth nor permanence is considered, thus implying a difficult maximization of real value. Cooper et al. [2001] suggests to avoid over-reliance on financial methods as the dominant method and explains that one reason is that the sophistication of financial tools often far exceed the quality of the data inputs because these are often based on “flimsy market and cost analyses”. A second reason is that the Go/Kill and prioritization decisions are made fairly early in the life of a project, precisely when the financial data are the least accurate. And a final reason is that financial projections could be easily “manipulated” consciously or unconsciously especially if it’s led by an over-zealous project team.

### 2.5.4.2 Strategy-based methods

Models that are based on the business strategy to select and allocate resources, is the second most popular approach. According to Cooper et al. [2001] one of the negative sides of poor portfolio management is the lack of strategic criteria in project selection. Strategic alignment in a portfolio of projects requires building strategic criteria into project selection [Cooper et al., 1997b; Cauchick Miguel, 2008]. Scholars have found, that the use of the business strategy for resource allocation correlates positively as an enabler of alignment to strategic objectives, enter to new markets, new technologies introductions, better portfolio balance, high value projects content and spending in line with the strategy [Cooper et al., 2001; Killen et al., 2008].
Strategic Buckets method: Based on the business's goals, vision and strategy, senior management makes forced splits of money across various dimensions (for example, by product line; by market; by project type, and so on). From these splits are created 6-10 buckets (only four are shown above). Projects are then sorted into buckets, and then rank-ordered within buckets until the spending limit is reached for each bucket. Ranking can be via a financial index, the ECV, or a scoring model. Using the Strategic Buckets approach, R&D spending is forced to mirror the business's strategy. See also Cooper et al., 1998a and 1999.

Fig. 2-8 The Strategic Buckets method [Cooper et al., 2001]

The Strategic Bucket approach is one of the proposed models to allocate the resources across different types of projects upon the business strategy definition; then the projects are ranked or rated within buckets [Cooper et al., 1997a, b; Graves et al., 2000; Terwiesch & Ulrich, 2008]. The method begins with the business's strategy and requires the senior management of the business to make forced choices along each of several dimensions like where to allocate the scarce money resources [Cooper et al., 1997b]. This methodology helps firms to find a balance between protection of their current position and the creation of future options [Terwiesch & Ulrich, 2008]. The basic steps of the strategic buckets methodology are outlined as follows:

1. Define a set of innovation domains or buckets, where each one has to contain a combination of market and technology novelty
2. Allocation of resources according importance to support business strategy across the buckets
3. Make a selection of the best opportunities

The main idea is to split the portfolio in different levels of risk into: existing innovations (low uncertainty), adjacent opportunities in relative markets and improved technologies (medium uncertainty) and new opportunities (high uncertainty). Figure 2-9 shows the strategic buckets portrayed established for an automotive company [Terwiesch & Ulrich, 2008].

Daniel Rodríguez Orozco 32
Strategic buckets once defined are filled with projects in terms of opportunities. But interdependencies between projects must be watched for: market cannibalization to avoid launching projects that might compete for the same market. And resources use and financial targets, since many opportunities may use the same resources, which could derive in delays [Cooper et al., 1997b; Terwiesch & Ulrich, 2008]

According to Terwiesch & Ulrich [2008], the strategic-bucket methodology has three strengths that will help the firm to achieve a better balance of protecting current strategic position and to allow create future options: The first, by mapping current innovation activities in a firm, obvious and common mistakes of either over focusing in “cool” future technologies or investing just in incremental and linear extensions and not taking enough bets for the future. Second, this methodology obliges a top-down approach, which will allow a better support to the strategy and will be based upon business’ strategic growth by sizing buckets accordingly with gaps in the innovation portfolio; and third by allowing a fair comparison between opportunities.

Cooper et al. [1997b] depicted that the major strengths of this model is that it truly links the spending with the firm’s strategy, since all projects must compete for the same resources but consider that the major weakness of this model is the time consuming and arduous exercises needed by senior management and suggest the use of the Strategic buckets approach to pre-allocate funds for projects.
but suggest also the use of a scoring model in order to drive on-strategy projects toward the top of the list.

2.5.4.3 Bubble diagrams or portfolio maps

Bubble diagrams is a more graphic model where projects are plotted on a X-Y plot or map in the form of bubbles or balloons, and are categorized according to a zone or quadrant and this favored the displaying of the balance in new-product project portfolios [Cooper et al., 1997b, Cauchick Miguel, 2008]. This categorization resembles the original categorization defined by Day [1977] where businesses were categorized in Stars, Cash cows, Dogs, etc. rather here, projects are categorized in terms of Pearls, Oysters, White elephants, and Bread and butter projects. Lately, this model has gained much hype and exposure [Cooper et al., 2001, 1998a; Matheson et al., 1994; Roussel et al., 1991].

To construct a bubble plot or portfolio map, first projects must be evaluated to assess its attractiveness using a scoring system against a number of dimensions such as projects' fit with business strategy, inventive merit and strategic importance, competitive advantage durability; rewards expected in financial terms, competitive impact of technology, expected rate of success, R&D expected cost for completion, time to market, capital investment and marketing investment to exploit the idea [Roussel et al., 1991, p. 96-97].

Killen et al. [2008] identified in their research that the use of portfolio maps correlate positively with four measures of performance of the portfolio management process; balancing the portfolio, developing existing technologies and technological competencies, alignment with the strategic objectives, and high value projects in the portfolio. Therefore, the use of portfolio mapping models result in a better balance in the portfolio. Nevertheless, Cooper et al. [1997b] identified a deficiency for portfolio mapping as the
large number of possible maps, where one is tempted to plot everything versus everything, and the permutation could be endless.

2.5.4.4 Scoring models and check lists

Scoring models are popular in practice because of their simplicity of formulation [Cooper et al., 1997b, 2001; Hall & Nauda, 1990], and as a technique for project selection has appeared in various forms in the literature since the 1950's [Henriksen & Traynor, 1999]. The most common approach is to rate potential projects against a set of a priori criteria and then to obtain a figure of merit for each proposal by combining the result of the ratings using some type of algorithm [Archer & Ghasemzadeh, 1999a, b; Cooper et al, 2001; Hall & Nauda, 1990; Henriksen & Traynor, 1999]. A rank-order scoring model is possible to be constructed consistent with forms of economic and constrained optimization selection models [Hall & Nauda, 1990], and this prioritization approach provides management with a "first cut" list of projects according to certain criteria to review and adjust the list as needed [Cooper et al., 2001]. Scoring models can accommodate non-quantitative criteria into the selection process; peer-review can be incorporated and it can be customized by an organization to articulate the characteristics it wishes to emphasize [Henriksen & Traynor, 1999].

Scoring models are highly suitable for project selection when exist a low interdependence between them, that is, when the activities and results of one project do not depend on the activities and results of a different project. It has distinct advantages over other project selection methods since it is quantitative enough to posses a certain degree of rigor, yet not so complex to mystify and discourage potential users [Henriksen & Traynor, 1999].

First step is to decide on the criteria; in an informal process or more formal method like Delphi or analytic hierarchy process; against which the proposed projects will be evaluated. An example for evaluation criteria could be the use of the four R's: relevance, risk, reasonableness, and return. Once the criteria have been determined, it must be weighted to reflect the preferred emphasis of the organization, which will also facilitate self-selection of the optimal projects portfolio. Weight can be selected either formally or informally [Henriksen & Traynor, 1999]

Check lists is a much simpler evaluation method; here projects are evaluated on a set of Yes/No questions, where each project must achieve either all Yes answers, or a certain number of Yes answers to proceed. The number of Yes's is used to determine if the project continues, is rejected or for prioritization decisions [Cooper et al., 1997b, 2001]
2.6 Integration Definition for Function Modeling (IDEF0)

IDEF0 (Integration DEFinition language 0) is based on SADT (Structured Analysis and Design Technique), developed by Douglas T. Ross and SofTech, Inc. In its original form, IDEF0 includes both a definition of a graphical modeling language (syntax and semantics) and a description of a comprehensive methodology for developing models [Processing Standards publication 183, 1993].

As a function modeling language, IDEF0 has the following characteristics:

1. It is comprehensive and expressive, capable of graphically representing a wide variety of business, manufacturing and other types of enterprise operations to any level of detail.
2. It is a coherent and simple language, providing for rigorous and precise expression, and promoting consistency of usage and interpretation.
3. It enhances communication between systems analysts, developers and users through ease of learning and its emphasis on hierarchical exposition of detail.
4. It is well-tested and proven, through many years of use in Air Force and other government development projects, and by private industry.
5. It can be generated by a variety of computer graphics tools; numerous commercial products specifically support development and analysis of IDEF0 diagrams and models.

2.6.1 Modeling concepts

IDEF0 is a modeling technique based on combined graphics and text that are presented in an organized and systematic way to gain understanding, support analysis, provide logic for potential changes, specify requirements, or support systems level design and integration activities. An IDEF0 model is composed of a hierarchical series of diagrams that gradually display increasing levels of detail describing functions and their interfaces within the context of a system. IDEF0 is an engineering technique for performing and managing needs analysis, benefits analysis, requirements definition, functional analysis, systems design, maintenance, and baselines for continuous improvement [Processing Standards publication 183, 1993].

The IDEF0 definition of a function is a set of activities that takes certain inputs and, using some mechanisms, and subject to certain controls, transforms those inputs into outputs [Rashid & Ismail, 2007].
1. **Inputs** represent the class of arrows that express IDEF0 Input, i.e., the data or objects that are transformed by the function into output. Input arrows are associated with the left side of an IDEF0 box.

2. **Controls** describe the class of arrows that express IDEF0 Control, i.e., conditions required to produce correct output. Data or objects modeled as controls may be transformed by the function, creating output. Control arrows are associated with the top side of an IDEF0 box. Every activity will have at least one control.

3. **Mechanisms** represent the class of arrows that express IDEF0 Mechanism, i.e., the means used to perform a function; includes the special case of Call Arrow. Mechanism arrows are associated with the bottom side of an IDEF0 box. Mechanisms are the people, skills, facilities, equipment and materials that are necessary to carry out the activity. The characteristics relate to the identification, availability, quality and management of these resources.

4. **Outputs** represent the class of arrows that express IDEF0 Output, i.e., the data or objects produced by a function and are the consequences of the activity. The output of one activity will often form part of the input to subsequent activities. The view is taken that high-quality output will result when the other characteristics, on which the output is dependent, are such as to promote effective execution of the activity. Output arrows are associated with the right side of an IDEF0 box. [Processing Standards publication 183, 1993; Müller & Fairlie, 2003; Rashid & Ismail, 2007]

The result of applying IDEF0 to a system is a model that consists of a hierarchical series of diagrams, text, and glossary cross-referenced to each other. IDEF0 models provide a "blueprint" of functions and their interfaces that must be captured and understood in order to make systems engineering decisions that are logical, affordable, integratable and achievable. The IDEF0 model reflects how system functions interrelate and operate just as the blueprint of a product reflects how the different pieces of a product fit together [Processing Standards publication 183, 1993]. See figure 2-12.
2.7 Discussion

In this chapter a review of the concepts of megatrends and how they affect societies and businesses and the implications that these impose over them and how they may respond in ways to address the changes arising from the driving forces were identified and depicted. There is not much literature on processes or methodologies about how to analyze megatrends and to scope society’s potential responses which later will be translated into a series of needs in the form of opportunities.

This research work found only one well-structured process developed by Sultan et al. [2008], which is being used by Delphi Corporation to assess its strategic planning process. This process attempts to capture and analyze the effects of megatrends to further scope of opportunities and threats.

A leading consulting firm identified that megatrends have increased in importance to executives on future business’ strategy and profitability, but exists a lack of skills regarding how to address megatrends. For this reason, foresight methodologies were also researched in order to define their potentiality and applicability in the analysis of megatrends. Scenario planning and Technology
Roadmapping were the two methods that resembled to be widely used to scope indirectly the effects of megatrends. The first, centered on the implications that scenarios derived from trends and uncertainties have on the strategic planning and policy development process and the latter on the development of technology, market and product roadmaps. Both techniques resulted to be complimentary to describe how technologies, market, products, and processes might unfold in the future.

The foresight section was primarily studied in order to understand how future opportunities and threats for the business can be scoped since it was identified that companies that will have a clear strategic vision of potential futures will be more ready to understand and respond to the potentialities that lie ahead, will have a lead-start to shape competitive advantage and its innovation efforts and investments will have strategic alignment. Therefore, foresight process will encourage the need to review and revisit the current business’ strategy and propose a strategic redefinition if the outcome of this process turns out to indicate the latter.

At the end of this research, the concepts of portfolio management were studied and depicted since whatsoever effort to address potential responses will need of the development of a list of innovation and new product development projects inside the firm. These portfolio of projects need to be aligned and must respond to the business’ strategy and be balanced in terms of risk and time scope; therefore a prioritization must be done in order to allocate firm’s scarce resources effectively to enhance its chances to maximize the value of the innovation and new product project portfolio that will be aimed to address to potential responses resulting from megatrends.

The author of this thesis sees an opportunity to connect the foresight process of megatrends exploration and analysis with the portfolio management techniques in order to construct a comprehensive methodology that will aid to analyze the effects of megatrends through foresight techniques like scenario planning and technology roadmapping, to scope potential responses which in turn will derive in a series of opportunities and threats that will have strategic implications on the current and future business’ competitive position, and the need to launch strategically managed innovation and new product development projects portfolio to address megatrends. Modeling techniques like IDEF0 could be used to design the activities of the proposed methodology.
Chapter 3

3. Methodology

3.1 Introduction

In the previous chapter the concepts of megatrends and how they impact our life and businesses were explained. Also some methodologies were studied to analyze megatrends as a source of opportunities for new businesses, markets, products or applications, like the Delphi’s MAPS [Sultan et al, 2008]. The use of foresight methodologies like scenario-planning and technology roadmaps were studied and its application to analyze megatrends were defined. Together in the literature review, the concepts surrounding new products developments portfolio management were studied, since the purpose of this research work is to link a way to breakdown global megatrends using foresight methodologies into the strategy redefinition that will drive opportunities into a best defined innovation and new products developments portfolio.

In this chapter a methodology is proposed to understand how megatrends may become sources of valuable information by decomposing them into strategic business’ criteria that will be useful to develop, prioritize, select, and define an innovation and new products development portfolio. The final purpose of the methodology is to enhance the technologic strategy planning process and thus to feed the innovation pipeline with well oriented projects that will seek to close gaps in the strategy to seize opportunities and to address threats.

3.2 Proposed methodology

It is the purpose of this thesis and research work to propose a methodology as a guiding tool for managers to define an innovation and new products development portfolio derived from the exploration and analysis of global megatrends, which affect with a more predictable way societies and businesses.

Addressing them in a profound, systematical and analytical fashion, the strategic innovation portfolio could be constructed in a balanced way, allocating economic and human resources strategically and achieving higher odds of maximizing value from innovation and new product development projects in the overall innovation pipeline.

The proposed methodology is presented in the Figure 3-1, and it is divided in three stages: 1) the Foresight stage, 2) the Strategic stage and 3) the Innovation stage. Each stage corresponds to a
process in which inputs are converted into outputs accordingly in which tools and resources used by the process are identified and proposed methods are shown as guides for developing activities inside each process. The stages are defined and explained in detail next.

For modeling purposes Integration Definition for Function Modeling or IDEF0 will be used as a tool to detail each of the processes of the methodology as it was referred in section 2.6 of chapter 2.
3.3 The Foresight stage

The Foresight stage is developed around a process which intends to explore, identify, analyze and break global megatrends down to the identification on how societies, industries, markets, governments or groups are reacting or are expected to react in terms of potential responses to address the driving forces behind global megatrends and related subtrends affected in the strategic areas of interest. The process includes the use of a scenario planning framework to foresight future pathways for the uncertainties derived from the analysis of the affecting trends at localized areas of interest and the remaining questions about how they could behave in the future. This particular process is called Megatrends breakdown process.

The main inputs for this process are the current business strategy definition and the global Megatrends information. The whole process is based on the exploration, search, analysis, prioritization and decomposition of key megatrends down to local or particular subtrends, identification of remaining uncertainties and scoping potential responses using scenarios to forecast pathways of development.

The ultimate goal is to identify those current and potential reactions in well defined areas of interest or concern and that will be used to evaluate business current and future strategic position against the outcome of the analysis and to redefine the business strategy in consequence to address current and future business gaps, environment, new opportunities and threats through an innovation and new products developments portfolio in a subsequent Strategic stage.

3.3.1 The Megatrends Breakdown process

As it has been explained before, the Megatrends Breakdown process is aimed to explore megatrends and decompose them to obtain sources of important links and information that would help to redefine the strategy in order to achieve well oriented innovation and new products developments portfolio. Figure 3-2 depicts the IDEF0 model level 0 of the Megatrends breakdown process.

This process takes as inputs the information available about megatrends and the current strategy. Controls for this process will be the megatrends definition and the impact to business. The mechanisms to run the process will be supported by the exploration, research resources, critical analysis and the planning team involved in the process. The expected output is the expected responses to megatrends or potential responses.
The process is divided in 3 main basic activities; and in turn each activity is divided in different steps to achieve the purpose intended. Figure 3-3 depicts the model decomposition of the process.
Define key megatrends and driving forces and its implications to business (A0-1)

The proposed methodology starts its operation by exploring in a pool of information, identifying and selecting those global megatrends that have a more profound impact on the business, and that somehow could imply a quicker or direct effect to the business current and future operation and strategy. Basic steps include searching in the pool of information composed by the Internet (www) through the use of search engines to look into databases, web pages and electronic libraries to search for reports, magazines, outlooks, forecasts, etc. Other sources of information include conferences, proceedings, government reports and expert panels. Although these sources are not exhaustive they tend to be the most accessible and popular for the general public. Then from megatrends definition of section 2.2; megatrends are identified, scoped and prioritized and driving forces fueling megatrends are unveiled.

The activity is subdivided in the following tasks or steps:

(A1-1) Explore for current Megatrends and list them
The main search for information about global megatrends is done through basic exploration using tools like the Internet to access to public reports mainly generated by government agencies, world organizations, academic institutions, proceedings from conferences, electronic magazines, expert panel reviews, etc. The intention is to detect which are the current global megatrends that affect societies and industries in a well defined pattern. During the exploration, megatrends must be indentified from the bulk of information and these must be listed for further classification and rank. This is done through basic research and by identifying all those trends that have global implications according the review of the literature obtained from the exploration.

(A1-2) Classify and rank megatrends
Once all global megatrends have been identified, then they must be classified by type according to the following classification: economic, societal, technologic, environmental or political. This classification will be helpful to prioritize megatrends according possible higher impact to business, since some might be more prone to affect the business environment with more intensity or in a faster pace.

(A1-3) Prioritize and select key megatrends for analysis according to business impact
Now Megatrends must be prioritized according its associated impact to the business. This step is aimed to decide whether a Megatrend deserves further analysis or not by the accompanying expected level of impact to the business, which could be ruled out as: high, medium or low. A
brief explanation about how a certain megatrend would affect or is expected to impact the business can be added. Megatrends that are expected to impose a high degree of impact must be analyzed first, followed by medium impact. These can now be called key business Megatrends. Low impact Megatrends are left behind for later further analysis or should be discarded at all.

(A1-4) Search for specific studies, outlooks, reports for selected Megatrends
Once key megatrends for study have been selected, a more profound exploration or research should be made in other to get access to all the data concerning those key megatrends. The same information used to identify current and future global megatrends could be used to go deeper into analysis.

(A1-5) Extract, review and collect relevant data
Extracting the data is a key to go further into the analysis. Here it is important to synthesize the information and summarize those key figures from the exploration effort. For example: projections and patterns, demographics, economic data, societal and environmental issues, geographic areas, technologic forecasts, etc. This data presents the core of the analysis since it represents the basic figures and preliminary trends that could be used to forecast future scenarios and address remaining uncertainties.

(A1-6) Identify the key driving forces
With all the information, a summary must be done to identify what are the driving forces behind the figures and information. Driving forces must be interpreted as: what are the reasons of why this megatrend is developing. This is important since an effort to assess a particular megatrend needs to indentify the stage of development of driving forces; since a strategy’s redefinition might arise accordingly later. For example; the increasing cost of energy (megatrend) is driven by the increasing demand and decreasing oil reserves (driving forces) and this trend seems to be ascending for the next 20 years [OECD/IEA Energy Outlook 2008]

At the end of this activity megatrends would have been explored and identified, a prioritization process would have been carried out according to possible impact to business; key figures and data collected and reviewed, and driving forces fueling megatrends disclosed. In the next activity this information will be helpful to define specific analysis in strategic business areas of interest and define the particular trends or subtrends and remaining uncertainties arising from megatrends.
Identify the subtrends and remaining uncertainties (A0-2)

As it was explained earlier, in this activity the particular trends or subtrends affecting strategic areas of interest derived from the effects of key global megatrends will be scoped and analyzed in detail in order to comprehend its relationship with driving forces. These subtrends have local effects and impact in focalized industries, markets, products, technologies, geographical regions, political environments, etc. After scoping and analyzing the subtrends, it is expected that a series of uncertainties appear and remain for further analysis since it is expected than not only one possible future for the development of these subtrends exist. These uncertainties arise when someone tries to foresight future development and further response of societies, markets, groups, economic entities, industries or governments to these developing trends due to the changing forces pushing from behind, making difficult to predict one possible response to address them and therefore is expected that multiple choices might exist. The activity is subdivided in the following steps:

(A2-1) Define areas of strategic interest (industries, markets, segments, geographic regions, etc)

In this step markets, industries or areas of interest for the business strategy must be defined to further search for a correlation for each megatrend/driving force according a degree of impact either in a positive or negative manner. For example, increasing environmental awareness (megatrend) derived from global warming (driving force) is directly related to the automotive industry (strategic market for magnet wire industry) since cars are a major source of air pollutants like CO$_2$; thus it is expected that automotive industry will respond with technological innovations to meet regulations intended to reduce CO$_2$ emissions by enhancing fuel efficiency for example, which would possibly impact magnet wire industry with newer requirements for wires used to wind coils in alternators, electric motors and sensors to manufacture high-efficient cars.

(A2-2) Search and explore for outlooks, reports, studies, technology roadmaps of specific areas of interest

Like in steps A1-1 and A1-4 of activity 1, exploration shall be made in order to gather particular information on regard selected area of interest. For example, if the interest is related to global energy trends a good idea is to search in documents released by the International Energy Agency or the US Department of Energy to cite some sources.
(A2-3) Extract the data
Same like in step A1-5 of activity 1, the concerned data shall be extracted with the difference that here the information has to be filtered thoroughly considering the relationship and impact to the business in terms of: projections, demographics, geographic distribution, regulations, volumes, investment rates, prices, costs, politic conditions, technologic advances, customers, competition, etc. For example, a magnet wire company interested in the energy market will be concerned of the projected electric power generation for the next 20 years in a region of the world where it competes; and the related technologies arising from particular trends for electric generators and transformers needed since it supplies wire for the coils, but it will not specifically be concerned about how many kilometers of new transmission cables are expected to be installed in regional electric grid in the same period of projection.

(A2-4) Assemble data collected around focused area and correlate it with driving forces
Once that relevant data has been gathered, it is important to use the key figures and trends to start envisioning pathways of development. For this to be done, it is necessary to understand which driving forces are fueling and correlate them with the trend and this is very important to define since this information will be used during the projection of scenarios to forecast possible pathways for the uncertainties that might appear. From the example cited in step (a), the driving force related with global warming correlates directly with the particular trend of making cars more fuel-efficient (compact, light-weighted, development of hybrid propulsion systems, use of other less pollutant fuels, etc.)

(A2-5) Identify the subtrends affecting strategic areas of interest
With data selected and assembled, now it is possible to identify the local trends or subtrends in effect in the particular area of study. These subtrends will now have a clear correlation with the driving forces behind megatrends, allowing a better position to the planning team to foresight the scenarios for the specific issue. Past example in step (d) remarks this concept.

(A2-6) Define what the remaining uncertainties are
Now that the subtrends for a particular area of strategic interest have been disclosed there might still exist uncertainties on regard what could be the future development of certain factors around the actual trends. Understanding and defining what these uncertainties are is crucial to develop a scenario framework and thus achieve higher odds of success while addressing them strategically. This step is designed to list all of the possible uncertainties arising from the analysis done on prior steps.
This whole activity process shall be carried out for each one of the strategic areas of interest and the outcomes shall be recorded and be analyzed separately.

At the end of this activity, strategically concerned areas of interest would have been studied and explored searching for pertaining data to identify the local trends or subtrends affecting them to find the link or correlation with key megatrends and driving forces. Uncertainties that remained after this exercise would have been defined for further analysis.

**Assess uncertainties through a scenario-planning framework (A0-3)**

In this activity a scenario-planning framework will be built to define possible pathways of development for the uncertainties remaining. The whole idea of this activity is to assess the implications that different courses of development could have on the strategy and future business development. In short, this activity is aimed to use the scenario-planning tool to capture the richness and range of possibilities, stimulating decision makers to consider changes that they would otherwise ignore [Schoemaker, 1995].

The author of this thesis considers that integrating this tool to the proposed methodology is very helpful since according to scenario planning literature review, companies can benefit from this tool when: uncertainty is high relative to managers' ability to predict or adjust, too many costly surprises have occurred in the past, the company does not perceive or generate new opportunities and when the quality of the strategic thinking is low (too routinized or bureaucratic). The proposed scenario planning framework is adapted from the methodologies reported in the literature review chapter (see section 2.4.2). The steps concerned with the construction of the scenario framework are explained and detailed in the following paragraphs and it consists of six sub-activities as follows:

1. **(A3-1) Classify and rank the uncertainties**
   From the list of uncertainties first they must be classified and ranked according to the relevance to the business strategy. Here the ranking must be done according the degree of expected impact and direct relationship to the current and future strategic position assigning a higher ranking to those which would have major implications to the business operation and strategy in a stronger fashion or that might develop in a quicker pace.

2. **(A3-2) Define a time frame for the analysis consistent with a selected planning period**
   A time frame must be now defined in order to establish the scope of planning. The selected time frame shall be selected in terms of products, markets, geographic areas, technologies, etc. The projection shall be consistent with the information obtained during the activity 2 when the local trends or subtrends were defined. For example, planning for a 5 year time frame will at
least require basis from projections made on key figures and subtrends in a particular area of interest with enough data to forecast possible scenarios.

**(A3-3) Define who are the stakeholders involved**
Define who are the primary actors involved in the development of the uncertainties and subtrends; who will be affected, who is influencing them and who have interests. Major stakeholders are customers, competitors, suppliers [both for materials, processes and technology], government and shareholders.

**(A3-4) Develop or explore and analyze possible scenarios for each uncertainty**
Now that the subtrends or local trends, key driving forces and uncertainties have been identified and disclosed, it is possible to build scenarios. There are two options to address this step: 1) Develop scenarios on own account, or 2) Explore on information databases for already developed useful scenarios.

**Option 1:**
Construct your own scenarios like a story telling, some researchers suggest that writing one or two pages is sufficient to depict a scenario. Exploring or developing technology roadmaps is a good alternative to foresight development pathways to describe markets, products, processes and technology evolution during the scenario scope. The author of this thesis recommends selecting for each uncertainty four possible futures or scenarios according to section 2.4.2 of previous chapter. Here driving forces come into function when with all the data gathered from previous activities is used as intelligence material to address different scenarios. Developing scenarios for each uncertainty will be like trying to find the link between uncertainties and trends in the form of story lines. Sometimes intuition will be helpful in constructing scenarios. Other authors recommend using heuristic methods like selecting the top two uncertainties and then cross them to contrast them each other and some other suggest a more statistical approach. The proposed approach is to define four possible scenarios, list the related uncertainties and form a matrix where correlation between scenarios and uncertainties is assessed.

**Option 2:**
Explore in the information databases (internet, industry's reports and outlooks, organizations, proceedings, etc.) for already developed scenarios with close relationship to the concerned strategic area of interest. Analyze the information and decide upon its usefulness to generate ideas to construct own scenarios or use them as they were conceived.

Daniel Rodriguez Orozco
The decision upon what option is going to be used will depend on the time and resources constraints that the organization confronts, or to the lack of the appropriate skills to develop scenarios of the planning team or organization.

(A3-5) Validate that scenarios are consistent and plausible
Scenarios must be validated in terms of consistency and plausibility; this would mean that they have to somehow make sense and have a certain degree of logic in the assumption made during its development. For example, expecting a high growing rate of the electric demand and expect a decrease in population of a region in the following ten years could be ruled out as implausible; validation process is done by reviewing each of the scenarios and discarding those that do not meet a degree of consistency and plausibility called by common sense. In case that option 2 was chosen and scenarios from third parties were researched, just double check that they match to the interest of the analysis.

(A3-6) Identify and define potential responses for each scenario outcome
Now that scenarios have been developed and validated, the potential responses to each of them have to be defined. For potential responses we must understand as how the market, industry, society, or governments are expected to respond to forces of change derived from megatrends, through driving forces, particular trends or subtrends and forecasted behavior of uncertainties. For example if global CO₂ levels in the atmosphere are expected to rise at higher rate than is forecasted, it is also expected that stricter environmental regulations would be proposed and approved thus affecting industries to adjust or develop products, technologies and processes to meet these regulations at a higher pace. Potential responses must be stated as a list of possible approaches to address driving forces and forecasted scenarios outcomes at each of the areas of concern related to the business.

At the end of this activity an envisioning process would have been done. By using a scenario-planning framework potential responses can be scoped and sources for opportunities but also for threats could be identified. Potential responses outing this activity will be used to define opportunities and threats, which will helpful to evaluate current and future strategic position, which in turn could derive into a business strategy redefinition that will drive the development, evaluation and management of the innovation and new products developments portfolio.

To summarize the outcome of the Foresight Stage the author proposes a report depicted by Table 3-1, which intends to organize the information and products of the Megatrends breakdown process. This table will serve as the roadmap for the next stage of the methodology.

Daniel Rodriguez Orozco

50
<table>
<thead>
<tr>
<th>Megatrend</th>
<th>Information sources</th>
<th>Classification</th>
<th>Business impact</th>
<th>Driving forces</th>
<th>Areas of interest</th>
<th>Subtrends</th>
<th>Uncertainties</th>
<th>Scenarios</th>
<th>Potential Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Megatrend 1</td>
<td>* Organization * Institution * Council * Industry * Government * etc</td>
<td>* Societal * Economical * Technological * Environmental * other</td>
<td>* High * Medium * Low</td>
<td>F1-1 F1-2 F1-3 ... F1-x</td>
<td>* Industry * Market * Segment * Geographic region * Technology * etc.</td>
<td>T1-1 T1-2 T1-3 ... T1-x</td>
<td>U1-1 U1-2 U1-3 ... U1-x</td>
<td>* Scenario 1-A * Scenario 1-B * Scenario 1-C * Scenario 1-D</td>
<td>R 1-1 R 1-2 R 1-3 ... R 1-x</td>
</tr>
<tr>
<td>Megatrend 2</td>
<td>* Organization * Institution * Council * Industry * Government * etc</td>
<td>* Societal * Economical * Technological * Environmental * other</td>
<td>* High * Medium * Low</td>
<td>F2-1 F2-2 F2-3 ... F2-x</td>
<td>* Industry * Market * Segment * Geographic region * Technology * etc.</td>
<td>T2-1 T2-2 T2-3 ... T2-x</td>
<td>U2-1 U2-2 U2-3 ... U2-x</td>
<td>* Scenario 2-A * Scenario 2-B * Scenario 2-C * Scenario 2-D</td>
<td>R 2-1 R 2-2 R 2-3 ... R 2-x</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Megatrend x</td>
<td>* Organization * Institution * Council * Industry * Government * etc</td>
<td>* Societal * Economical * Technological * Environmental * other</td>
<td>* High * Medium * Low</td>
<td>Fx-1 Fx-2 Fx-3 ... Fx-y</td>
<td>* Industry * Market * Segment * Geographic region * Technology * etc.</td>
<td>Tx-1 Tx-2 Tx-3 ... Tx-y</td>
<td>Ux-1 Ux-2 Ux-3 ... Ux-y</td>
<td>* Scenario x-A * Scenario x-B * Scenario x-C * Scenario x-D</td>
<td>R x-1 R x-2 R x-3 ... R x-y</td>
</tr>
</tbody>
</table>

Table 3-1 Foresight Stage report table
3.4 The Strategic stage

Next in the methodology is the Strategic stage, which comprehends the evaluation of the current and future business’ technologic and strategic position based upon the outcome of the Foresight stage in the form of potential responses to the driving forces that global megatrends impose over societies, industries, markets, governments and groups. These responses must now be translated into a series of strategic decisions in order to address them in a systemic fashion. The Strategic stage is precisely designed to assess this objective since it starts by identifying and scoping opportunities and threats derived from expected potential responses which in turn will drive a strategic evaluation in terms of current and future strategic position to face current and future strategic gaps and to assess upcoming changes derived from the effects of megatrends that might already had not been addressed by the strategy. A new strategic redefinition should be contemplated if the outcome of contrasting current definition of strategy against the result of the evaluation turns out to be necessary.

The newest strategic redefinition must be translated in terms of a series of projects, which through the Strategic Portfolio Management process will be translated into a well defined, balanced, and strategy oriented innovation and new products development portfolio. Portfolio management techniques are used to achieve this objective. In Figure 3-4 the process is depicted.

The ultimate purpose of this process is to increase the chances of the business to succeed in maximizing the value, balancing the projects in terms of time scope and risk, and to allocate efficiently resources throughout the list of projects. At the end, the final outcome of the process must respond to the business strategic redefinition which now will contain a bold reasoning on regard why current economic, market and technologic trends for example of a certain region, area or industry behave in the way they behave and what is its expected future behavior, and this is only achievable if we get to know what is behind fueling them in the form of driving forces arising from global megatrends.

The strategic stage proposed by this methodology is intended exclusively to help develop the innovation and technologic strategic planning of the business in terms of a projects portfolio containing new products, processes, markets, technologies, or even new businesses but it does not contemplate a complete strategic planning process for the whole business.

3.4.1 Strategic Portfolio Management process (A0)

The Strategic Portfolio management process is designed to use the input of potential responses and to end with an innovation and new products developments project portfolio. Current and future strategic
technological position is evaluated upon drivers of change imposed by megatrends in the form of potential responses and how the business is currently and will be in the future positioned to address them.

The Strategic stage is handled by following this process, which is divided in two folds. First part is called Strategic Position Mapping sub-process, which deals with the business strategy evaluation and strategic redefinition based upon its technologic position to address the current and future gaps arising from opportunities and threats scoped from potential responses by developing or exploring Technology Roadmaps. Second part is called Projects Portfolio Management sub-process and it deals with an ideation process to generate a primal list projects. This primal list is then scrutinized and evaluated by means of project portfolio management tools for further selection and composition of the innovation projects and new product development portfolio in order to achieve the fourth goals of portfolio management: maximize value, balance the mix of projects, appropriate resource allocation and strategic alignment.
3.4.1.1 Strategic Position Mapping sub-process (A0-1)

The idea is to define a current and future "map" of the business' strategic technological position by initially scoping a list of opportunities and threats, which are defined according the expected responses to driving forces/megatrends and related local subtrends in effect in the strategic areas of interest for the business. Opportunities like new markets, new customers, new products, processes and technologies are depicted. Also, current and future threats for the business can be drawn out in the form of obsolete products, markets, technologies and processes. Other threats like new competition, substitute products and services can also be scoped.

After opportunities and threats have been identified; the evaluation of current strategy must be done by means of comparing the current and future strategic position of the business against its ability to confront new opportunities and threats. Technology Roadmaps are developed as a tool to establish current and future gaps of the actual strategic technological definition by identifying pathways of development of technologies, products, markets and processes and then scoping needs, gaps, strengths and weaknesses. Strategic redefinition is then established to close and address the encountered gaps. This sub-process is subdivided in three steps, which are explained as follows:
Identify and scope opportunities and threats derived from potential responses (A1-1)

First step of the process is to translate the potential responses into a series of opportunities and threats for the business. This scoping process is done by depicting what are the unsatisfied needs that will have to be covered due to current or expected changes derived from the forces that drive the trends in areas of interest. These changes can be defined in terms of newer requirements for products, attributes, processes, markets and technologies whether as opportunities or as threats. This activity consists in two basic steps:

(A11-1) Classify each potential response as an opportunity or threat
This first step is aimed to determine the nature of each potential response in terms of the business strategic language; understanding as opportunity a chance for the business to seize a current or future need by addressing corresponding strategic decision-making, even new businesses can be identified; and for threat as a disadvantageous current or future position for the business to remain competitive that could also imply leaving or divesting current businesses. Nevertheless, can occur that a single potential response can be treated either as an opportunity or as a threat and it will dependant on the management team to define the most suitable classification. From the list of potential responses built at the end of the Foresight stage, a new column should be added to insert this classification.

(A11-2) Define and scope specific opportunities and threats
Now that potential responses have been classified as opportunities or threats, is necessary to define in detail the context for each of them. A small redaction can be written to portray in business terms the implications that each opportunity or threat represent to the current strategy (e.g. new and obsolete products, processes and technologies, new markets, segments, competition, substitute products and substitute technologies, etc.). Scenarios developed during the Foresight stage can help to address more easily this task.

Evaluate current and future strategic competitive position (A1-2)

Once the potential responses have been converted into opportunities and threats for the business the current technological strategic definition must be compared against the strategic implications that these may represent to it. In short, current strategic definition is put to the test in order to define if it still holds valid for the expected business technologic environment promoted by these opportunities and threats. If current strategic definition fails to address them, then a strategic gap has been found. These gaps can correspond to a current strategic gap when strategy does not include a current opportunity or threat in its definition; or to a future strategic gap when it does recognize that a future opportunity or threat has
not yet been included in the definition. The end purpose is to establish current and future competitive position of the business.

Developing or exploring Technology Roadmaps to identify the pathways of development of technologies, products, processes and markets are useful to identify gaps in the current and future technologic position of the company and thus strategically plan the required list of projects to meet the challenges that each opportunity or threat represent.

T-Plan approach proposed by Phaal et al. [2001] is a good option, although is time consuming and it could require a large amount of specialized personnel involved to develop the roadmaps. The author of this thesis recommend as an option, to explore and search for technology roadmaps already developed by industries, organizations, customers, etc. related within the strategic areas of interest for reference technology roadmaps (technologies, products, process and market development), and then extrapolate those maps into internal requirements that will help to map the organization. The steps of this activity are arranged as follows:

(A12-1) Aggregate opportunities and threats of common background
First from the list, all opportunities and threats of common background or pertaining to a single area of strategic interest must be aggregated in order to evaluate them conjointly in the same technology roadmap. In short, if opportunities and threats identified correspond to a same industry, market segment or product family, then they can be identified as part of the same strategic area of interest and thus evaluate the current and future position of the business to address encountered gaps. For example, for the a magnet wire business it could be of interest knowing how well positioned is to compete for all current and future opportunities and address new technological requirements in the industrial electric motors segment.

(A12-2) Develop or explore Technology Roadmaps
The development of technology roadmaps will be aimed to layout the development of pathways of technologies, products, markets and processes of respective strategic technological concern. Roadmaps can be constructed based on the literature review of section 2.4.3 of the previous chapter. But as it was mentioned earlier in this section, technology roadmapping tends to be a resource consuming approach. To mitigate and intent to overcome this situation the author of this thesis suggest to explore using the search tools used to gather information during the Foresight stage; to look for already developed technology roadmaps done by industries, organizations, competitors, suppliers, customers, etc. related with the strategic area of interest to search for reference technologies, products, process and market development, and then extrapolate those maps into technological, new product, market and process requirements for
The organization. The roadmap should also help to evaluate the product position, technologic position, market position, process position, access to knowledge and R&D capabilities of the organization. If the user considers necessary, a strategic positioning map can be additionally constructed to reflect the current and future competitive position upon other variables like: price, cost, market share, logistic capabilities, etc.

(A12-3) Identify current and future strategic gaps

Once roadmaps have been constructed or analyzed, a series of gaps will be identified. The next step is to define the degree and scope of each of them and determine their position in a time scale to figure out the relevancy to the strategy and if it deals as current or future technologic, product, process or market gap. A list must be constructed and an expected time frame selected. For example, a strategic gap found on regard the ability of a business to deliver a specific product performance for a specific market requirement that was foresighted to be applicable five years from now should be ruled out as a future gap.

Redefine the business strategy (A1-3)

Next activity of the methodology is to translate current and future strategic gaps into a new strategic definition that will be driven by the need of assessing and addressing the corresponding strategic activities to close them. Markides [1997] proposed five ways to define strategic innovation: 1) redefine the business, new ways of doing things, 2) redefine the who, in terms of customers, segments, etc., 3) redefine the what, like products, technologies, services, etc, 4) redefine the how in the form of what core competencies, processes or technologies must be leveraged, and 5) by starting the thinking process in different points, like identifying the unique capabilities that makes a business attractive to customers, instead of only identifying what customers want and how the business will fulfill them.

The strategic redefinition will have to contain the necessary arguments to address the identified gaps in a systemic manner. The strategy for each pertaining market, products, processes and technologies must be now defined. This must include also new business opportunities and obsolete businesses, models, products, technologies, etc.

This methodology does not detail the steps on how the technological strategy business redefinition must be done since it will be dependant on how each business manages its strategic planning process, which is not part of the scope of this research and work.
3.4.1.2 Portfolio Management sub-process (A0-2)

Transforming the strategic redefinition into a series of innovation and new products developments projects is the next step in the process. An ideation process is proposed to define a broad list of projects aimed to close the strategic gaps. First thing is to build the list or pool of projects by promoting and leveraging the ideas throughout the organization, and then a compilation must be done for further analysis. The present methodology does not explore in detail the ideation process, but suggests some methodologies to achieve this task.

After the ideation process is completed, a list is created with all the ideas that will compose the primal portfolio of projects. It is called primal portfolio because not all ideas or projects will have the potential to create value to the business; they may lack of the sufficient strategic arguments, may be too risky or too poor in value added terms, or consume scarce resources without a real and clear benefit for the business. According to section 2.5.2 and 2.5.3 of the literature review chapter, managing the portfolio of projects is in deed the manifestation of the business strategy. Thus, the importance of a good portfolio management process, which includes the strategic criteria to enrich the projects selection that will reflect the priorities, kill projects that resemble mediocre, focus on projects that really meet the strategic criteria, avoid the reluctance to kill bad projects, and enhance the selection with a formal method.

The sub-process is composed by fourth activities and they are explained below:

**Define a list or pool of innovation and new products development projects (A2-1)**

Now that the strategy of the business has been redefined, it has acquired a new vision by breaking global megatrends down to the strategic implications over the current and future business’ strategic technological position and it is time to set a primal list of projects. These projects will be the first approach to manifest the new business strategy. This primal portfolio must contain ideas for new products, markets, processes, technologies or even new businesses and services, as they must be oriented to close the strategic gaps and enhance the business competitive position.

To achieve this goal, it is necessary that the business organization help in the ideation process, but it is also highly advisable getting ideas from the outside. To accomplish this task is proposed the following steps and sources to achieve such goal:

a) Communicate the redefined strategy to the organization
b) Use current and future strategic gaps as drivers of innovation
c) Ask for ideas to the different areas of the organization such like R&D, sales and marketing, engineering, operations, etc.

d) Allow the sufficient mechanisms for ideas to flow through the organization; the use of an intranet as a medium is an example, and encourage personnel to participate with ideas

e) Propose ideation workshops and use of methodologies like DELPHI method, use Technology roadmaps for reference

f) Search for ideas outside by surveying customers and suppliers, use of QFD tool

g) Use technological exploration

The ideation effort must now be translated into a series of projects in raw, which will need to be scrutinized to leverage those with the potential to become part of the innovation and new products development portfolio. This selection of the projects is done in the following activities.

**Construct and evaluate the portfolio through Portfolio Management (A2-2)**

According the literature of portfolio management reviewed in the section 2.5.4 of chapter 2; different methods exist to perform the portfolio management; between the most common used are the financial and strategic models [Cooper et al., 1997, 2001]. Nevertheless, many scholars have warned about the over reliance on financial methods. On the other hand, strategy approaches correlates better with the alignment of the strategic definition. Nevertheless, the use of scoring models is simple to be formulated and they are popular in practice.

This methodology proposes to use a hybrid approach as evaluation model for the Portfolio Management process. The first part will use a scoring model approach to make a first-cut of projects based on selected strategic criteria, which will derive in a prioritized list. In second part, projects must be located in strategic buckets, defining *low risk - high certainty* projects, *medium risk - medium certainty* projects and *high risk - low certainty* projects for this purpose. Third part will be integrated by the financial method approach, which cannot be left behind since value maximization is one of the most important goals of portfolio management and estimating the financial value implication of projects is either as important to the management as strategic value. The steps of this process are depicted as follows:

(A22-1) Construct a scoring model and evaluate projects
First define the evaluation criteria for the model. For example: strategic relevance, risk, market size, market share, technologic challenge, resources, time frame, etc. Then assign a weight to each of the evaluating attributes. Evaluate projects and obtain weighted scores and prioritize projects accordingly.
(A22-2) Define strategic buckets and allocate projects
Define three strategic buckets according to the definition made earlier or classify them in: incremental, next generation and breakthrough projects. Allocation in each bucket shall be made upon the prioritization and classification made during the scoring approach. Use the business strategy to balance the portfolio across the buckets.

(A22-3) Evaluate financially projects
To evaluate financially projects, first marketing intelligence and some R&D and engineering data should be gathered to establish expected market volume, customers, prices, developing expenses, manufacturing costs and capital investment for each project. Then using classical project evaluation techniques like NPV and Internal Return Rate and payback period, projects are financially evaluated and prioritized. Nevertheless, it is important to keep strategic vision while evaluating financially projects since some of them may result financially unattractive at present time, but it may pose future strategic consequences if they are not addressed properly.

Define the innovation and new product development portfolio (A2-3)
Once the evaluation of the portfolio has been done, a refined portfolio of innovation and new product development projects shall be composed arising from the business' strategy redefinition. All those projects that did not make the cut can be positioned in a project backlog for further development if is considered necessary in the future. The remaining step is to communicate the portfolio definition to the organization to start further planning process of each the projects. The output of this stage will be the Innovation and new products development Portfolio.
3.5 Innovation stage

The Innovation stage is designed solely to classify the projects from the innovation and new product development portfolio in terms of development projects of products, applications and technologies. Needs for knowledge developments are identified and a further technologic exploration can be defined for further technologic knowledge requirements and to serve as a search engine of information on regard technologies, products, processes and techniques. At the end of the process a pipeline of engineering and R&D projects shall be defined with its corresponding stages and gates, which ultimately will be aligned with the strategic intend of the business.

3.5.1 Innovation management process

As it was already defined, the Innovation management process deals with the assembly of the feed of projects that will enrich or constitute the innovation pipeline. Here, projects are classified and ranked, specific technologies and new product developments are allocated to the correct and proper treatment is assigned as they get into the innovation pipeline. Fig 3-6 defines this process.

Fig 3-6 Innovation management process
The activities of this process are quite simple since it does not represent a complete technology management process, but it can be useful to depict in a simple way the nature of the projects by defining the scope of each of them.

The activities are then defined as follows:

1. **Classify each project in terms of new product or existing product**
   First every project from the portfolio must be scrutinized in order to establish if it is a new product or existing product already in the market but that needs to be internally developed. Current technologic and market knowledge are used to define the scope of the project.

2. **Define existing products that are intended for new applications**
   If the project deals with an existing product then must be defined if it is directed to fulfill a newer application. In case that the project has been identify as a current product and suitable for the application then the project must be handed to the sales or marketing department.
3. Identify if projects deals with new technology for further new product development
In case that the project has been identified as new product development then must be decided according to the technologic roadmaps if novelty technology must be developed or access to existing technology must be achieved. In case the project deals with existing technologies, it must be directly passed to the innovation pipeline to define if it deals as a R&D or engineering project.

4. Determine further knowledge requirements and gaps (technology roadmaps will guide this selection)
If project was identified with newer technology requirements, then first technologic knowledge requirements must be established according the technologic gaps found during the Strategic stage by employing the Technology roadmapping technique. In case that current technologic knowledge of the firm includes the required technical arguments to go forward, then the project must be moved directly to the innovation pipeline.

5. Define technologic exploration to bridge technologic knowledge gaps
If the project requires further technologic knowledge then an exploration effort can be started to research the current state-of-the-art on regard related technology or technologies and compile valuable information in a technologic exploration front which will be aimed to build a bridge between science and requirement, which further will prompt into an R&D project. This step can include to benchmark competitors against required technological capability and knowledge.

6. Establish the innovation pipeline with stages and gates
Establish the projects by classifying them as R&D or engineering projects and set the follow-up using the Stage-Gate methodology proposed by Cooper et al.
Chapter 4

4. Case of study

4.1 Introduction

This chapter deals with a case of study in which the proposed methodology was used to validate its usefulness and applicability as a tool for managers to define an innovation and new products development portfolio based on the analysis of megatrends and its related implications to the technological business' strategy when current and future gaps arise while scoping and fore sighting society's responses to address the effects of megatrends, and whereas by taking the appropriate managerial decision-making, the expected responses can be further translated into a strategy-oriented and financially evaluated portfolio of innovation projects to meet society's current and future needs.

As it was defined in the chapter 1 (Introduction) of this thesis, one of the drivers of why this methodology was developed is to help promote the construction of portfolio of innovation projects inside the Mexican magnet wire industry in order to leverage its competitiveness and to increase the chances to thrive in global economy by developing the technologies, products, processes and markets to address megatrends and related driving forces affecting in the form of subtrends in particular areas of strategic interest for this industry. For this reason and as part of the scope of this thesis, the proposed methodology was applied inside a Mexican magnet wire company, which for confidential purposes is going to be named "Company A" further on; to analyze the applicability of the tool to support its technological strategic planning process definition.

"Company A" competes in the different market segments of the wire and cable industry in North America (NAFTA market); between the most important segments are: energy, automotive and electric motors segments both nationally and internationally. Main competitors are US-based, although they have operations in Mexico and other parts of the world, making them leaders in the industry. In recent years European and Asian competitors have established operations in the NAFTA region to compete in the rectangular wire\(^1\) business, which has strengthen the competitive level lately for this type of product/market.

The main objectives of this case study are: 1) apply the proposed methodology inside "Company A" and identify its intended applicability inside an industry [Mexican magnet wire], by running two experiments;

\(^1\) Rectangular magnet wire is widely used in the fabrication of electric coils where high amperage is required such like in electric transformers, generators and in large traction electric motors.
2) evaluate the outcomes of the methodology in terms of the value of information obtained during the experimentation process, and 3) define modifications to the methodology needed in case they are found necessary.

4.2 Scope of the methodology demonstration

The scope to demonstrate the methodology usefulness was oriented to develop experiments by employing the first stage and partially second stage of the methodology since the main purpose is to validate that megatrends analysis and breakdown can be used as drivers to define the innovation effort of a company by developing new products, technologies, markets, applications and processes that would be strategically aligned to close current and future technological gaps that arise when needs develop to respond to megatrends. The author of this work played the roll of the planning team needed to assess the analysis based on an overall experience of more than thirteen years in the magnet wire industry.

4.3 Description of the experiments within the case of study

The experimentation of the proposed methodology was done in a theoretical representation using access to real information pertaining to "Company A", which at all moment is kept confidential, but that was used for the only purpose to direct the application of the methodology during the experiments defined and to demonstrate the usefulness of the methodology depicted by it. It is not the purpose of this thesis to define the technologic-strategic plan for "Company A" since is not part of the scope of this academic research. Nevertheless, by running experiments was expected to get pieces of information that anyhow might resembled useful for "Company A" for a further technologic-strategic planning process or by agreeing and full employing the proposed methodology as part of its regular technologic planning process.

The proposed experiments consisted in searching and exploring megatrends and define those which would have a degree of impact for the magnet wire company in two of its strategic markets (areas); being the first the Automotive market segment and the second the Energy market segment. These were chosen since they together represent almost the 50% of the sales of "Company A". The experiments were defined as follows:

Experiment #1: Megatrends breakdown process for the automotive market. In this experiment the first stage of the proposed methodology was used to identify global megatrends and then define how are impacting or expected to impact on the automotive market in terms of specific trends (subtrends).
and what is still uncertain and then assembling possible scenarios to arrive to potential responses from the stakeholders. The main purpose of this experiment was to test the first part of the methodology and validate its usefulness by following the steps and tools depicted by the methodology. The summary table proposed in Table 3-1 of chapter 3 was used to demonstrate the outcomes of the process.

Experiment #2: Megatrends and the strategic portfolio management process for the Energy market. This experiment describes how the strategic technologic evaluation and strategic gaps were defined for the energy market when megatrends are taken into consideration. Although this experiment did not cover the complete portfolio management process since it would have implied to compare current technological strategic definition of "Company A" against what was found to further redefine its strategy and creation of a particular portfolio of projects, which is not the purpose of this thesis; the author's intention was then to demonstrate the usefulness of the methodology to provide the tools to managers to define the innovation and new product development portfolio based on megatrends analysis.

4.4 Experiment #1: Megatrends breakdown process for the automotive market

As it was defined earlier in this chapter, experiment #1 deals with the demonstration of the first stage of the methodology (Foresight stage) by scoping, exploring and defining the global megatrends, where by further analysis are broke down to disclose the driving forces behind them and selecting those key megatrends that are expected to impact the business environment, and that are reflected as particular trends or subtrends in focalized areas such like industries, markets, regions, etc. Remaining uncertainties arising from the question "what will happen next?" are analyzed using the scenario planning framework proposed, which will help to scope potential responses.

This experiment was conducted based on the automotive industry, which requires magnet wire to make different electric and electronic components inside the cars, such like: alternators, engine starters, sensors, solenoids, and electric motors used in different systems of the car. Table 4-1 depicts the different electric motors that today's cars use in different systems and applications.

<table>
<thead>
<tr>
<th>Type of motor</th>
<th>Function</th>
<th>Motors per car</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjustable anchor motor</td>
<td>Adjusts a three-point seatbelt's shoulder position to fit the vehicle occupant's shoulder height</td>
<td>2</td>
</tr>
<tr>
<td>Adjustable pedal motor</td>
<td>Adjusts the position of the accelerator and brake pedals to suit the vehicle occupant</td>
<td>1</td>
</tr>
<tr>
<td>Antenna motor</td>
<td>Extends or retracts a rod antenna</td>
<td>1</td>
</tr>
<tr>
<td>Blower motor for air purifier</td>
<td>Drives a fan installed in an air purifier</td>
<td>1</td>
</tr>
<tr>
<td>Cooling fan motor</td>
<td>Fan for cooling radiator and condenser of air conditioner</td>
<td>2</td>
</tr>
<tr>
<td>Door closer motor</td>
<td>Both side door and sliding door will shut automatically if they are not completely latched. It also locks the rear door and boot.</td>
<td>2-5</td>
</tr>
<tr>
<td>Electric motor</td>
<td>Function</td>
<td></td>
</tr>
<tr>
<td>---------------</td>
<td>----------</td>
<td></td>
</tr>
<tr>
<td>Door mirror motor</td>
<td>Folds in a door mirror or adjusts its angle for a better view</td>
<td></td>
</tr>
<tr>
<td>Electric power steering motor</td>
<td>Assists steering wheel movements by the driver</td>
<td></td>
</tr>
<tr>
<td>Electric water pump</td>
<td>To maintain the heater function by circulating engine cooling water</td>
<td></td>
</tr>
<tr>
<td>Electronic stability control (ESC) motor</td>
<td>This drives a hydraulic pump which is used in the ESC brake system</td>
<td></td>
</tr>
<tr>
<td>Electronic throttle valve control motor</td>
<td>This is a system to control a throttle valve with an ECU and an electric motor instead of a cable or a link mechanism as found in conventional engines</td>
<td></td>
</tr>
<tr>
<td>Electronic variable gear-ratio steering motor</td>
<td>This is a motor equipped on an E-VGR system which continuously changes the ratio of the steering angle of front wheels to the rotation angle of the steering wheel</td>
<td></td>
</tr>
<tr>
<td>Motor for electric variable valve timing</td>
<td>Adopting an electric motor instead of an oil pump makes it possible to control valve timings at low and high rpm’s as well as at low and high temperatures</td>
<td></td>
</tr>
<tr>
<td>Motor for exhaust gas recirculation (EGR) system</td>
<td>Driving an EGR valve equipped on the exhaust side of the engine, it helps purify exhaust gas and improve fuel economy.</td>
<td></td>
</tr>
<tr>
<td>Power rear door motor</td>
<td>Open and closes the rear door automatically</td>
<td></td>
</tr>
<tr>
<td>Power slide door motor</td>
<td>Open and close the sliding door automatically</td>
<td></td>
</tr>
<tr>
<td>Rear wiper system</td>
<td>Motor to move the rear wiper arm and blade</td>
<td></td>
</tr>
<tr>
<td>Seat motor</td>
<td>Adjusts vehicle seating</td>
<td></td>
</tr>
<tr>
<td>Servo motor for air conditioner</td>
<td>The servo motor controls air conditioner temperature, switches air outlet and switches internal and external air.</td>
<td></td>
</tr>
<tr>
<td>Stepping motor for headlight levelling</td>
<td>A stepping motor to control the vertical orientation of headlight projection</td>
<td></td>
</tr>
<tr>
<td>Stepping motor for headlight swivel</td>
<td>A stepping motor to control the horizontal orientation of headlight projection according to the steering angle and vehicle speed</td>
<td></td>
</tr>
<tr>
<td>Sunroof motor</td>
<td>Opens and closes the sunroof</td>
<td></td>
</tr>
<tr>
<td>Telescopic steering column motor</td>
<td>Adjusts the position of the steering column to suit the vehicle occupant</td>
<td></td>
</tr>
<tr>
<td>Tilt steering column motor</td>
<td>Adjusts the height of a steering wheel</td>
<td></td>
</tr>
<tr>
<td>Variable nozzle turbo motor</td>
<td>Works as part of the turbocharger system to boost low-end torque and purify exhaust gas emissions</td>
<td></td>
</tr>
<tr>
<td>Washer system</td>
<td>Consists of a pump and nozzle for washer liquid application and a tank for storing washer liquid</td>
<td></td>
</tr>
</tbody>
</table>

**Table 4-1 Electric motors in today's automobiles.** [Source: Asmo Co Ltd cited in Just-Auto 2009]

Lately, magnet wire has being used in the manufacture of the electric motor inside HEV (Hybrid Electric Vehicles) and more recently in PHEV (Plug-in Hybrid Electric Vehicles) so as the electronic controllers used to synchronize the internal combustion engine and the electric motor. Figure 4-1 shows the use of magnet wire inside the electric motor in HEV’s cars.

![Magnet wire in HEV cars](source: Honda)
4.4.1 Definition of key megatrends and driving forces and its implications to business (A0-1)

First step of the methodology is to explore using exploration resources like the Internet through search engines to browse different databases in search of reports, outlooks, conference proceedings, and other pieces of information that would lead to identify megatrends. Then they classified and rank according and expected business impact to define the key megatrends and driving forces that effect or are expected to affect the business environment. Figure 4-2 shows the process decomposition in sub activities using IDEF0 (refer to section 3.3.1.1 of chapter 3).

- **Search and explore megatrends**
  
  First activity was aimed to search in the information pool that the cyberspace represents by using popular search engines on the world wide web; such like: Google, Yahoo, Bing and others. In this case the author also accessed to the ITESM’s Electronic library and database as a resource of exploration. Using the term “megatrends” or “global trends” as search keywords, the exploration was performed. From the broad amount of results the explorer or explorers need to use personal criteria to go exploring further on to the link of information that the results of the search engine displays, discarding and not wasting time with those links to sites that may not represent sources of credible and trustable information. For this reason, it is highly recommended to explore mostly in documents and web pages
of governmental councils and departments, world organizations, leading consulting firms surveys and reports, universities and colleges, trusted NGO’s, etc.

The exploration led to the following sources of information:

(a) US National Intelligence Council


(c) Ernst & Young consulting firm – Global megatrends 2009 [2009]

Other reports and outlooks were found, although they were not used to identify global trends since they were aimed to study particular trends or “megatrends” in particular areas such like health, energy, housing, etc. Megatrends were identified and listed; table 4-2 depicts the fifteen megatrends and each of them were scrutinized according megatrends definition of section 2-2 of the literature review chapter, to define if each is or not a megatrend.

<table>
<thead>
<tr>
<th>Megatrend</th>
<th>Affects at least one region of the world?</th>
<th>Already in motion?</th>
<th>Difficult to alter?</th>
<th>Affect all players?</th>
<th>Completely out of someone's control?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Increasing life expectancy and falling fertility rates</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>2. Aging population in developed countries</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>3. World population mostly increasing in developing countries</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>4. Urbanization - more than half of the world population will be urban</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>5. Cross-border migration</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>6. Globalization - growing interconnectedness in the form of increasing flows of information, technology, capital, goods, services and people throughout the world</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>7. Globalization of labor and talent markets</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>8. Constraining fresh water supply - half world’s population living in “water stressed” regions</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>9. Increasing demand of energy and commodities</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>10. Growing concerns about environmental issues - GHG emission control, climate change and global warming, soil and land degradation</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>11. Increasing pressure on corporate agenda on regard social responsibility</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>12. Faster pace of technological innovation</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>13. Rising of emerging markets</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>14. Changing financial landscape - increasing sophistication and connectedness of capital markets</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>15. New governance challenges - Globalization, dispersion of information technologies, growing relativism</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

Table 4-2 Megatrends list from exploration and search according megatrends definition

Daniel Rodríguez Orozco 69
- **Classify and rank megatrends**

From the list of megatrends, each was classified according its relevance in: economic, societal, political, technologic or environmental. Then they were ranked according the classification by grouping them accordingly. See table 4-3.

- **Prioritize and select key megatrends for analysis according to business impact**

As it was defined in the section 3.3.1 activity A1-3 a prioritization and selection of key megatrends needs to be done according the expected impact to the business. For case of the experiment the criteria employed to select the megatrends that could affect the magnet wire “Company A”, were selected upon the criteria and experience of the author of this thesis, who has worked in this industry for more than thirteen years and collaborated in different areas such like engineering, R&D and operations; so as in different projects involving sales, marketing, strategic planning and financial areas related to the Mexican magnet wire industry.

The selection for this experiment was carried out using the following criteria: High impact expected to the Mexican magnet wire industry and the implicit relationship impact to technological strategic needs. The summary of the selection and impact definition is shown also in table 4-3.

<table>
<thead>
<tr>
<th>Megatrend</th>
<th>Classification</th>
<th>Business Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urbanization - more than half of the world population will be urban. 400 million living in ten megacities in 2015</td>
<td>Societal</td>
<td>High - This trend is expected to derive in the increasing need of power generation and supply side needs, requiring technologic solutions to respond to spatial constraints, increasing need of services and transportation of growing urban zones and megacities</td>
</tr>
<tr>
<td>Increasing demand of energy and commodities</td>
<td>Economical / technologic</td>
<td>High - Increasing needs of energy are expected to drive most of the growing of the magnet wire business in the following years, together with increasing demands for energy efficiency advances in generation, distribution and end-use of energy are expected. Demand of commodities like copper and aluminum mostly from emerging economies like China and India are expected to push prices up of these metals adding pressure to constraint working capital resources in this industry</td>
</tr>
<tr>
<td>Growing concerns about environmental issues - GHG emission control, climate change and global warming, soil and land degradation, waste and pollution</td>
<td>Environmental</td>
<td>High - This is one of the trends that are expected to impact heavily magnet wire industry due to the needs to decrease CO2 emissions and pollutants in all sectors thus requiring technologic solutions to respond to increasing concerns and growing consensus about climate change. Increasing energy generation and use is expected to put a heavier burden on GHG emissions control</td>
</tr>
<tr>
<td>Faster pace of technological innovation - Biotech, IT technology, material sciences, nanotechnology</td>
<td>Technologic</td>
<td>High - Material sciences and nanotechnology could become the most important drivers of innovation in the industry</td>
</tr>
</tbody>
</table>

*Table 4-3 Magnet wire related high impact key megatrends*
- Search for specific studies, outlooks, reports for selected megatrends

For experiment purposes and because the automotive industry is the strategic area of concern for the magnet wire industry that ruled this study, only the one megatrend was studied in detail to follow further steps in the methodology. The selected megatrend was no.10: Growing concerns about environmental issues, mainly because automotive industry is directly related to the GHG (Greenhouse Gas) emissions.

For the case of the study the major references of information found from a further exploration and research were the following:

(a) World Business Council for Sustainable Development (WBCSD)
   i. Facts and trends to 2050 – Energy & Climate change [2004a]
   ii. Pathways to 2050 – Energy & climate change [2005]
   iii. Mobility to 2030: Meeting the challenges of sustainability [2004b]

(b) US Department of Energy - Energy Information Administration (US DOE – EIA)
   i. Annual Energy Outlook 2009 [March 2009]

(c) Organization for the Economic Cooperation and Development (OECD) and the International Energy Agency (IEA)
   i. World Energy Outlook 2008 – Global energy trends to 2030 [2008]

Although the megatrend of study was growing concerns about environmental issues, energy related reports and outlooks were found as the major sources of information on regard environmental issues with direct relationship to environmental matter since its profound correlation on regard GHG emissions.

- Extract, review and collect relevant data

An extensive review of the information was done to extract the relevant figures and data from the outlooks and reports regarding issues pertaining to the megatrend being studied. This activity is time-consuming and then must be performed to obtain just the key information and trends to help determine the drivers behind the megatrend and understand better what would happen next and how societies, industries or governments may respond to its effects. Information that may result non-critical during the first review can be further analyzed if it turns out to be necessary. For illustration purposes some key data and exhibits are presented below.

Daniel Rodríguez Orozco
"The IEA World Energy Outlook Reference Scenario (IEA 2004) projects a rise in global carbon emissions from 7.8 Gigatons of carbon (GtC) in 2002 to some 12 GtC by 2030. The IPCC scenarios used in Facts and Trends (WBCSD 2004a) indicated a rise to 15-16 GtC by 2050, if current trends are not altered. Such emissions profiles put the world on a trajectory towards an atmospheric CO2 concentration as high as 1,000 ppm, up from 370 ppm in 2000 and 280 ppm in pre-industrial times. The resulting temperature rise cannot be predicted with accuracy, but it might be as high as 3-4°C Celsius by 2100 and up to 6°C Celsius by 2300.

"Limiting atmospheric concentrations to around 550-ppm while still allowing carbon emissions to increase in the medium term requires a global downturn in emissions no later than 2030, followed by a continuing decline. By 2050, in contrast to a sharply rising demand for energy (at least double) over the same period, emissions must approximate today’s levels" [WBCSD, 2005]
- **Identify the key driving forces**

From the analysis made on key information and figure key driving forces were identified accordingly. In this case is clearly that the main driving forces behind this megatrend are:

i. Increasing concern about GHG’s emissions and its control

ii. Risk of a potential global warming scenario and climate change

These driving forces are expected to keep increasing its effects and keep fueling this megatrend, therefore it is expected that it will long affect societies thus needing to address the corresponding strategies to face with the challenges that it represents.

### 4.4.2 Identification of the subtrends and remaining uncertainties (A0-2)

Second part of the Megatrends Breakdown process is to identify the subtrends or local trends derived from the effects of megatrends. To perform this analysis, it was necessary to choose a strategic area of interest to the business; for the case of the experiment #1 the automotive industry was selected as body of study. Here the local effects and impacts of megatrends were disclosed and the remaining uncertainties identified. Figure 4-6 depicts the sub-activities decomposition using IDEF0 (refer to section 3.3.1.2 of chapter 3).
- **Define areas of strategic interest**

As it was explained earlier the automotive sector was chosen for this experiment, since it represents an important market for magnet wire business.

- **Search and explore for outlooks, reports, studies, technology roadmaps of specific areas of interest**

The exploration and search for information on particular data was done using the sources already found during the past activity (A0-1). In this case the outlooks and reports used were specifically:

(a) World Business Council for Sustainable Development (WBCSD)
   - i) Pathways to 2050 – Energy & climate change [2005]
   - ii) Mobility to 2030: Meeting the challenges of sustainability [2004b]

(b) Organization for the Economic Cooperation and Development (OECD)
   - i) Transport Outlook 2008 – Focusing on CO2 emissions from Road Vehicles (see Appendix I)

- **Extract the data**

The exploration in this particular case was aimed to find reports and data concerning automotive sector. The search was aimed to collect data, figures and trends that relate automotive sector with the megatrend of study. A vast amount of information was found and a thorough analysis was needed to select key figures and data from the large number of data handled by the outlooks and reports found. Only some excerpts from the research are shown in the following figures and exhibits since it would have required creating a full report, which is not the intention of the experiment. See Appendix I

**Fig 4-7 Projected growth in light duty vehicle (LDV) ownership [WBCSD, 2004a]**

**Today**

There are some 970 million vehicles on the road, the majority in North America and the EU. Higher fuel taxes and continued regulation in the EU, along with different consumer preferences, result in a higher proportion of smaller, lighter vehicles, which makes for a more energy efficient fleet than that in North America.

The world’s vehicle stock rises to over two billion units, with an almost proportionate rise in total passenger kilometers traveled. Developing countries in particular are expected to experience sharp rises in vehicle numbers as their economic development continues. [WBCSD 2004b, 2005]
- Assemble data collected around focused area and correlate it with driving forces

It was clear the correlation that driving forces: 1) *Increasing concern about GHG's emissions and its control*, and 2) *risk of a potential global warming scenario and climate change*, have with the data collected from the reports. According to the emissions scenarios of Fig 4-5 and the projected growth in light-duty vehicles in Fig 4-7, increasing efforts in the transportation (automotive) sector needs to be done to confront the rising in GHG's emissions forecasted due to the growing pattern in automobiles, and this trends are expected to be of present to least year 2030.

- Identify the subtrends affecting strategic areas

According to the correlation of data now it was clearer to identify what are the subtrends arising from the megatrend and driving forces. The following subtrends were identified accordingly:

1. Increasing fuel efficiencies technologies
2. Lighter more compact vehicles
3. Developing economies increasing its LDV\(^2\) fleet sharply

- Define what the remaining uncertainties are

This activity was aimed to define if uncertainties on regard the expected trends remained. From the literature read during this experiment, the author found that future development of these subtrends is still uncertain since there is not yet a complete consensus on regard the anthropogenic causes about climate change, which could lead to different scenarios on regard policies and regulations affecting future technologic developments in this industry. On the other hand, the roll of fossil fuel prices and technologic advances needed to increase fuel efficiencies and use of power propulsion alternatives are yet to be developed at a cost-effective basis. Table 4-4 summarizes the information that was obtained during the first two sections (main activities) of the Megatrends Breakdown process.

<table>
<thead>
<tr>
<th>Megatrends</th>
<th>Classification</th>
<th>Business Impact</th>
<th>Driving forces</th>
<th>Area of interest</th>
<th>Subtrends</th>
<th>Uncertainties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growing concerns about environmental issues - GHG emission control, climate change and global warming, soil and land degradation, waste and pollution</td>
<td>Environmental</td>
<td>high</td>
<td>(F1) Increasing concern about GHG’s emissions and its control</td>
<td>Automotive industry</td>
<td>(T1) Increasing fuel efficiency technologies (T2) Lighter more compact vehicles (T3) Emerging economies are increasing its cars fleet sharply</td>
<td>(U1) Full consensus about climate change (U2) Policies and regulations (U3) Price of fossil fuels (U4) Technologic advances to improve cost-effective use of alternative propulsion systems</td>
</tr>
</tbody>
</table>

LDV stands for Light-duty Vehicle according to the *WBCSD Mobility to 2030* [2004a] and includes mostly cars.

*Daniel Rodriguez Orozco*
4.4.3 Assessment of uncertainties through Scenario Planning (AO-3)

Third and last part of the Megatrends Breakdown process is to define how remaining uncertainties may unfold in different scenarios. This achieved by constructing own scenarios or relying on previous studies made by reliable organizations, such like the ones used to search and explore megatrends. The activity decomposition is shown in figure 4-8 using IDEF0 (refer to section 3.3.1.3 of chapter 3).

- Classify and rank the uncertainties

According to the outcome of the previous activity four uncertainties were defined. These uncertainties were ranked according possible impact to the business and its current strategy. Basically the uncertainty concerning the **technologic advance to improve cost-effective use of alternative propulsion systems** needs to be ranked number one, since it directly impact magnet wire industry because of the relationship to the market of HEV’s and PHEV’s cars, where magnet wire is used in the electric motor of these vehicles. The second is the issuing of **required policies and regulations** by governments to leverage the use of alternative propulsion systems in light-duty vehicles and to reduce emissions. This would lead to the need of foresight scenarios regarding on the **extent of the consensus of the anthropogenic causes of climate change** as third uncertainty. And fourth, the **prices behavior of fossil fuels** could alter the development of alternative propulsion systems. See Appendix II
- Define a timeframe for the analysis consistent with a selected planning period
  For experiment purposes, the timeframe chosen falls inside the projection span of the subtrends determined and therefore it was chosen a planning time of between fifteen and twenty years.

- Define who are the stakeholders involved
  The definition of the stakeholders concern all actors related with the matter. In this case, stakeholders are: governments, societies, industry leaders, and scientific community.

- Develop or explore and analyze possible scenarios for each uncertainty
  For the case of the experiment and since scenarios are preferable built using a panel of experts, the option 2 of the methodology was chosen, and the author explored in the databases to find already developed scenarios that could have a useful relationship with the foresight of the uncertainties future development. The research lead to the following source of information and related scenarios are shown in table 4-5:

  (a) Electric Power Research Institute (EPRI)
    i. Program on Technology Innovation: Electric Power Research Institute – Electric Power Industry Technology Scenarios

<table>
<thead>
<tr>
<th>Uncertainties</th>
<th>Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Digging in our Heels</td>
</tr>
<tr>
<td>U1 Technologic advance to improve cost-effective use of alternative propulsion systems</td>
<td>No extraordinary efforts to increase technologic fuel efficiencies</td>
</tr>
<tr>
<td>U2 Government policies and regulations</td>
<td>Governments against imposing high cost to economies to address unclear relationship between anthropogenic causes of climate change. Focused on wealth creation and poverty reduction.</td>
</tr>
<tr>
<td>U3 Consensus about climate change and environment</td>
<td>Not a clear relationship between human activity and climate change.</td>
</tr>
<tr>
<td>U4 Fossil fuels prices</td>
<td>Increasing prices driven by growth in demand and supply constraints.</td>
</tr>
</tbody>
</table>

Table 4-5 Scenarios development framework [adapted from EPRI, 2006]
Validate that scenarios are consistent and plausible
For the case of the scenarios that were used and the quality of the source of information, the scenarios were considered consistent and plausible at all time.

Identify and define potential responses for each scenario outcome
The four scenarios developed by the EPRI presented different pathways for the development of the technology needed to improve the cost-effectiveness of less pollutant alternative propulsion systems in the transportation sector, and more precisely in cars. Upon the various scenarios on regard the consensus about climate change and the government’s decision-making about policy and regulation to whether address or not the possibility of anthropogenic causes of climate change, technologies development in the automotive industry could be heavily supported to increase fuel-efficiencies and/or to leverage the development of alternative propulsion fuels like hydrogen; but on the other hand, could be less supported if the scenario points out to a less profound concern about climate change due to the uncertainty about a relationship between human activity and global weather.

According to the World Business Council for Sustainable Development (WBCSD), the potential responses to address increasing GHG’s emissions should be supported for the following pathways (see fig 4-9 and 4-10):

**Fig 4-9 Low carbon technologies in the road transport sector [Source: WBCSD, 2005]**

*Shifting towards low carbon technologies*

Possible low carbon technology options for the road transport sector include:

- **Biomass fuels**
  - Biomass fuels for transport can be derived from agricultural crops and crop waste and from other biomass such as harvested wood waste residuals.
  - Their conversion includes fermentation to produce ethanol and various processes to produce synthetic and bio diesels. These fuels become part of the short-term natural carbon cycle and can be carbon neutral when using appropriate harvesting techniques. For example, the use of sugar to produce ethanol via fermentation is already a large-scale industry in Brazil.

- **Hydrogen**
  - Hydrogen is an alternative energy carrier that is manufactured today from fossil fuels (principally natural gas). The carbon-free manufacture of hydrogen remains very expensive and involves energy transformation losses. In the longer term, innovative technologies (e.g. high temperature nuclear reactors or coal gasification with CCS) are needed. The hydrogen can then be consumed in a fuel cell producing electricity that then powers the vehicle.

- **Hybrids**
  - Hybrids use two power sources to operate the vehicle. The second source is a battery that recovers waste energy from vehicle operation and then powers the vehicle during periods of low demand. During these periods the main power source (typically an internal combustion engine) shuts down, thus saving fuel.

- **Diesel**
  - Although gasoline engines have improved, diesel remains more efficient due to the high compression ratios used within the engine. With the early issues around particulate emissions now being solved by new filters, and smoother operational performance, the technology has a great deal to offer in terms of efficiency gains. Europe for instance has embraced diesel over the last decade or so, a factor that has contributed to its relatively high vehicle fleet efficiency.
To finalize the Megatrends Breakdown process the report table depicted in the chapter 3 (see Table 3-1) was completed with all the data and information regarding the selected key megatrend. The breakdown process can be easily followed through the table 4-6. This process must be repeated as many times as necessary to analyze and break key megatrends down that are expected to have an important impact to the business. Now magnet wire industry's strategists, technologic and technical staff and business leaders must translate this potential responses into a series of opportunities and threats, which must be addressed by identifying the current and future strategic gaps and by deploying a series of innovation projects to respond in consequence with products and technologies to emerging needs in strategic markets or areas.

<table>
<thead>
<tr>
<th>Megatrends</th>
<th>Information sources</th>
<th>Classification</th>
<th>Business Impact</th>
<th>Driving forces</th>
<th>Area of interest</th>
<th>Subtrends</th>
<th>Uncertainties</th>
<th>Scenarios</th>
<th>Potential responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growing concerns about environmental issues—GHG emission control, climate change and global warming, soil and land degradation, waste and pollution</td>
<td>(a) US National Intelligence Council</td>
<td>Environmental</td>
<td>High</td>
<td>This is one of the trends that are expected to impact heavily magnet wire industry due to the needs to decrease CO2 emissions and pollutants in all sectors thus requiring technological solutions to respond to increasing concern and growing consensus about climate change. Increasing energy generation and use is expected to put a heavier burden on GHG emissions control.</td>
<td>(F1) Increasing concern about GHG's emissions and its control</td>
<td>Automotive industry</td>
<td>(U1) Full consensus about climate change</td>
<td>(R1) Digging in our Heels</td>
<td>(R2) Use of biofuels</td>
</tr>
<tr>
<td></td>
<td>(b) The McKinsey Quarterly</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(R3) Hybrid cars (HEV's, PHEV's)</td>
</tr>
<tr>
<td></td>
<td>(c) Ernst &amp; Young Consulting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(R4) Hydrogen both combustion and fuel-cell</td>
</tr>
<tr>
<td></td>
<td>(d) WBCSD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(R5) Diesel</td>
</tr>
<tr>
<td></td>
<td>(e) OECD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(U2) Policies and regulations</td>
</tr>
<tr>
<td></td>
<td>(f) US Dept. of Energy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(U3) Price of fossil fuels</td>
</tr>
<tr>
<td></td>
<td>(g) EPRI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(U4) Technologic advances to improve cost-effective use of alternative propulsion systems</td>
</tr>
</tbody>
</table>

Table 4-6 Experiment #1 report table

4.5 Experiment #2: Megatrends and the strategic portfolio management process for the Energy sector

The experiment #2 dealt with the demonstration of the Strategic Portfolio Management process; in this particular case the megatrends that were analyzed are concerning increasing demand of energy and commodities in combination with the previous megatrend: growing concerns about environment issues (GHG's emissions and climate change). Both combined contribute to a large list of potential responses that must be taken into consideration for the magnet wire industry as drivers of innovation projects in order to move at least at the same pace of the requirements or even better identifying future needs and thus developing technologic and technical solutions in advance and achieving a higher competitive position.
4.5.1 Assumptions of the experiment

Since the purpose of experiment #2 was to demonstrate partly the usefulness of Strategic Portfolio management process for the Energy sector as an important module of the proposed methodology, some assumptions were taken due to academic purposes and to ease its development since otherwise it would have been necessary to present a large amount of information. The following assumptions were taken as baseline for the experiment:

i. Data, current subtrends and potential responses in Energy sector were taken directly from the WBCSD Pathways to 2050 – Energy & climate change [2005]. Table 4-7 depicts this information.

ii. The outcomes of such study were considered that emerged from the two megatrends being analyzed since this document handled them in a similar way

iii. Electricity segment of the Energy sector was the only one analyzed. See Appendix III.

<table>
<thead>
<tr>
<th>WBCSD Power Generation [2005]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Today's subtrends</strong></td>
</tr>
<tr>
<td>In 2002, power and heat generation contributed around 40% of global CO2 emissions from fuel combustion, with coal-fired power generation responsible for about 70% of this. During 2005, China built one large conventional coal-fired power plant almost every two weeks. Expected future capacity additions for China are enormous;</td>
</tr>
<tr>
<td>Natural gas is only half as CO2 intensive as coal per unit of electricity generated. Continued high growth rates lead to increased import dependency for some countries and require the further development of capital-intensive infrastructure, such as liquid natural gas (LNG) terminals;</td>
</tr>
<tr>
<td>Nuclear power's safety record is improving, but concerns about weapons proliferation and issues with the public acceptance of waste disposal remain. Its capital costs can be particularly high in the case of uncertain regulatory outcomes;</td>
</tr>
<tr>
<td>Energy derived from biomass and waste represents a small but growing segment of the renewable fuels option. CO2 emissions from biomass-derived fuel combustion are classified as greenhouse gas neutral;</td>
</tr>
<tr>
<td>The economic viability of wind, wave or tidal as well as solar power capacity will continue to depend on consumer and government support for some time, even though wind is now nearing competitiveness in areas with favorable conditions. Generation from these sources can be unpredictable and intermittent, which typically demands extra investment in the transmission and distribution system, as well as backup or storage capacity.</td>
</tr>
<tr>
<td>The economic viability of wind, wave or tidal as well as solar power capacity will continue to depend on consumer and government support for some time, even though wind is now nearing competitiveness in areas with favorable conditions. Generation from these sources can be unpredictable and intermittent, which typically demands extra investment in the transmission and distribution system, as well as backup or storage capacity.</td>
</tr>
</tbody>
</table>

Table 4-7 Subtrends and potential responses for Energy power generation to 2050 [adapted from WBCSD, 2005]

Daniel Rodriguez Orozco
4.5.2 Strategic Position Mapping sub-process (A1)

This part of the experiment began by taking the potential responses that presumably arise from the increasing demand of energy and the growing concern on GHG’s emissions due to its possible implication with climate change. These responses are translated into a series of opportunities and threats for further strategic evaluation by using technology roadmaps in order to define current and future gaps in the current technological strategy. The Strategic Position Mapping sub-process was defined during chapter 3 to help assess this task and is the gate to the main process (Strategic Portfolio Management process). Figure 4-11 depicts the activities decomposition using IDEF0 (refer to section 3.4.2 of chapter 3)

4.5.2.1 Identification and scoping opportunities and threats derived from potential responses

This experiment was aimed to encounter potential opportunities and threats within the Energy sector, and with particular interest in electricity generation, which was defined as the strategic area of interest for the magnet wire industry. Nevertheless, the experiment was not aimed to identify projects with
particularity but to find areas of potential interest in order to assess them with strategic decision-making. For experiment purposes, two potential responses were analyzed through the methodology activities in order to test its usefulness.

The first particular selected potential response was the increasing use of renewable energy with more emphasis in wind energy generation, since according to the International Energy Agency's World Energy Outlook 2008 "Global output of wind power is projected to increase eleven-fold, becoming the second-largest source of renewable electricity after hydro by 2010. The largest increase is in the European Union, where the share of wind power reaches 14% in 2030, accounting for 60% of the increase in total EU electricity generation between 2006 and 2030 ".

The second, concerns directly to the increasing generation and demand of electricity (see Appendix III) where one threat but also an opportunity was found. In this case, High Temperature Superconductors (HTS) pose a threat to conventional magnet wires copper technology. According to US Department of Energy [2004], one of the enabling "critical" technologies to enhance electric power generation and transmission is based on the following: "advanced conductors are needed that are lighter weight, lower cost, and have higher current densities. High temperature superconducting (HTS) materials are needed that have low price-performance ratios compared to conventional conductors (such as copper) and that can be produced in sufficiently high volumes to meet the needs not only for power cables, but also for other grid electrical equipment including transformers, generators, synchronous condensers, fault current limiters, and other devices ".

- Classify each potential response as an opportunity or threat
  Wind energy generation - Is then considered an opportunity, since wind generation consume magnet wires to form the generator inside the hub and the increasing demand of "green" electricity and maturity of the wind generation technology are making it more cost competitive thus the large increase in this renewable form of energy generation.

  High Temperature Superconductors (HTS) – This technology can pose a threat to certain market niches for today’s copper magnet wires, such like power transformers, generators and industrial motors.

- Define and scope specific opportunities and threats
  Wind energy generation – To cope with increasing demand of renewable energy generation “Company A” must understand the scope of products, isolating materials and technologies behind the production of magnet wires used in the electric generator in wind turbines; understanding key parameters, and specific needs for this market segment to deploy projects aimed to enforce its current capabilities in address future or current requirements and compete in this sector.
High Temperature Superconductors (HTS) – Pose a future risk to current copper technology, mainly if HTS conductors technology progress sufficiently enough to compete in electric power components manufacturing such like large power transformers, generators and large industrial motors. For example: Potential applications of HTS conductors in the rotating dc field windings of synchronous machines include, a) Industrial motors at 1-10 MW, ~1800 rpm, b) Propulsion motors at 5 MW-30 MW, 100’s of rpm, c) Electrical generators at 100’s of MW, 3600 rpm, and d) Propulsion and distributed generation at few-30 MW, 3600 or higher rpm [Gouge et al., 2002]. Furthermore, “Company A” must consider analyze with more detail this emerging disruptive technology.

4.5.2.2 Evaluate current and future strategic competitive position

Once that opportunities and threats have been scoped and classified, next step was to evaluate the current technologic position of the company to assess both cases outlaid by the experiment. Nevertheless for confidentiality purposes, current technologic position at “Company A” was not disclosed, but for experiment purposes it was assumed that for both cases the technologic competitive evaluation was needed, since both represent a “new” opportunity or threat.

- Aggregate opportunities and threats of common background
In this case, although both cases are related to the electricity generation sector, they cannot be aggregated for its conjoint evaluation since each relates to different stages of technology and applications.

- Develop or explore Technology Roadmaps
For demonstration purposes, only one of the scoped issues was selected to develop or explore current technology roadmaps; for this case HTS conductors were selected, and the exploration mode was again used in order to search for already developed roadmaps since it is not the purpose of this thesis demonstrate how to build technology roadmaps but to used them as precursors to identify current and future technology strategic gaps. Figure 4-12 shows an approach for the development of HTS wire technology and applications.
Identify current and future strategic gaps

From the outcomes of this experiment, two possible technologic needs and possible technologic gaps were identified:

- First related to a current trend in the form of an increasing demand for "green" electricity generation such like wind energy generation and where "Company A" must evaluate if its current and future technologic strategy aims to develop technical and technological capabilities to attend a possible business opportunity as wind energy generation market surges as it was forecasted.

- Second, in the form of a future threat to current conventional magnet wire technology as HTS wires and cables develop and possibly replacing current magnet wires in power transformers, generators, and other electric equipment, as higher demand for electricity surges as it was forecasted. Therefore, "Company A" should analyze if its current technologic strategy address this technologic disruption and includes at least the surveillance and follow-up of this technology and/or further steps to incorporate projects to adopt it and become a future player.

4.5.2.3 Redefine the business strategy

This part of the experiment was not evaluated, since this activity concerned directly to the top management of "Company A", and the only purpose intended for this experiment was to demonstrate the operation of the proposed methodology.
Posterior steps of the methodology that include the Portfolio Management sub-process and the Innovation management process were not covered by this experiment since these activities are more corporate specific to each business, company, strategy, and management, and it was left for further individual evaluation of the companies that might adopt the full approach of the proposed methodology.

4.6 Summary of the experiments

In each case the experiments produced information for “Company A” that could be used to build a portfolio of projects. First experiment obtained important responses arising from the increasing concern of GHG’s emissions and climate change in the automotive industry. Further analysis could help to evaluate current technologic position of the company to assess the possible current and future requirements that these responses may represent.

Second experiment, was able to identified at least two sources of information that should be taken into consideration when the time to address the technologic strategy arrives for “Company A”; the first in the form of a big actual opportunity that today renewable wind energy represents for electricity generation and its forecasted increasing demand. The second, in the form of a future threat that could become a disruptive technology as it unfolds as the future nears. High temperature superconductors’ technology must at least be followed and watched for further decision-making approach.

At the end of these experiments, the summary pointed out to three possible courses of action in different markets, products and technologies for “Company A” that arose from no more than two megatrends that were analyzed. Further and comprehensive research and analysis of other megatrends and potential responses seemed to promise to provide a wider vision as the analysis unfolds.
Chapter 5

5. Results, conclusions and further research

5.1 Results and discussion

The following results were achieved during the development of this thesis:

- Understanding about megatrends was obtained; so as how they affect societies and businesses. A clear way to identify them was defined, although it does not exist a common definition, it was possible to arrange the concepts around them.

- During the literature review, it was explored that megatrends are taking relevance for corporate strategy definition in firms in last years, where from a global survey made by a leading consulting firm, seventy percent of managers consider them more relevant today than five years ago thus pointing out to a clear need for manufacturing firms to incorporate megatrends in their strategy.

- Frameworks and methodologies to analyze megatrends were researched and only one structured methodology was found, Delphi's MAPS

- Foresight methodologies were studied during the literature review. Scenario planning and technology roadmapping were found useful techniques to foresight futures of trends and uncertainties in technologies, products, markets and processes and they were proposed as part of the tools of the proposed methodology as both techniques resulted to be complimentary to describe how technologies, market, products, and processes might unfold in the future together with megatrends.

- Project portfolio management models were studied and its applicability and incorporation in the proposed methodology were found useful since they help managers to define better risk-balanced, strategically aligned, better resource allocated and value maximized project portfolio.

- A comprehensive methodology to define strategic innovation projects and new product development portfolio using megatrends exploration and foresight methodologies was defined and adapted upon the literature review of this research.
• Modeling technique IDEFO was found useful to design and graphically depict the proposed methodology.

• A case study containing two experiments described in Chapter 4 was developed to demonstrate the usefulness of the proposed methodology by applying such experiments in a Mexican magnet wire company ("Company A"). First experiment validated the concepts of the first stage of the methodology, resulting useful to identify potential responses for the automotive industry - defined as a strategic market - when one selected megatrend was analyzed and broke down. Second experiment partially validated the strategic stage proposed by the methodology when two selected megatrends affecting energy sector were analyzed and broke down and assumed potential responses derived into strategic gaps for the company analyzed.

5.2 Conclusions

During the development of this thesis, understanding about megatrends was obtained; so as a clear way to identify them was defined. On the other hand, a common definition of what is a megatrend could not be defined, although it was possible to identify from some author’s pieces of the definition and thus was also possible to arrange concepts around it and define its characteristics which helped to identify when a trend is a “megatrend” and when is just a regional, market or local trend.

It was explored and found that many institutions, governmental dependencies, world organizations and leading firms try to identify and study megatrends to take them into consideration attempting to address them with the required planning and decision making process to come up with the required actions arising from their effects over societies, industries and businesses.

Nevertheless, it was also found that although an increasing number of company’s managers recognize that megatrends incorporation into the business’ strategy is more important than some years ago, most of them lack of the needed skills and resources to respond to them.

During the literature review it was found that very few structured methodologies to analyze and incorporate megatrends into business strategy have been developed, which could be a reason why managers lack of sufficient skills to address them; only one methodology was identified. This process is the Megatrends Analysis and Portfolio Strategy (MAPS) developed by Sultan et al. at Delphi Corporation and published in 2008. This proposed methodology seemed a well-structured process to analyze megatrends as a source of strategies for innovative projects and products portfolio; nevertheless the specific steps to develop this methodology are not detailed and its operation requires...
the use of large expert panels to operate. On the other hand, foresight methodologies like scenarios and technology roadmapping were briefly defined as inputs of the MAPS process; but this process did not defined clearly how they must operate in the methodology. For this reason, a research was done to explore further on the applicability of these foresight methodologies and the way to incorporate and adapt them into the methodology was done and its usefulness was validated.

The MAPS process does not include also further steps to determine which projects of the portfolio arising from the megatrends analysis needed to be prioritized based upon strategic, financial criteria and scoring models depicted by project portfolio management techniques to increase the chances of the firm to define a risk-balanced, strategically aligned resource allocation and value maximized portfolio of projects. For this reason, project portfolio management was studied and its implications and models were identified during the literature review chapter and the author of this thesis saw an opportunity to incorporate project portfolio management techniques to enrich the proposed methodology.

From the above, a methodology was adapted and proposed composing of three stages. The proposal here defined, differs from the MAPS methodology in one important aspect since the latter is based on information generated by large expert panels and the proposed methodology in this thesis uses the concept of "exploration" by using current IT resources like the Internet and the search engines, which allows to almost anyone with sufficient research capabilities to explore and analyze megatrends.

Also the proposed methodology was built by first incorporating the baseline of the MAPS process to analyze megatrends, but defining a clear pathway and steps using foresight methodologies to foresee societal, economic, technologic, political and environmental potential responses to megatrends and its related subtrends and uncertainties. Then, further steps led to the strategic stage designed to identified current and future opportunities and threats to the firm and identifying current and future strategic gaps and further strategic technological redefinition, which is then decomposed into a series of projects that are scrutinized and evaluated through project portfolio management models to define the innovation and new product development portfolio. Last stage define the innovation pipeline by breaking down projects into new products, new technologies and new application projects, so as needs for further technologic knowledge and exploration were identified. The overall result is an enriched methodology.

To help visualize and to enhance comprehension of the methodology, modeling techniques like IDEF0 were explored and used to define the steps and activities. By this mean, identifying clearly the inputs, outputs, mechanisms and controls for each of the activities, it was possible to design the stages of the methodology and easily follow the process flow during its conception so as during the case study development used to analyze the usefulness of the proposed methodology.
A case study was applied in a magnet wire company “Company A” by running two experiments in two of its strategic markets: automotive and energy sectors. First experiment clearly proved the usefulness of the first stage of the proposed methodology, since it demonstrated that a manager interested to know more about megatrends can easily follow the steps proposed and arrive to useful conclusions about how are expected that societies and businesses will react to the effects of megatrends. Two shortcomings were found: First, is that is a highly time-consuming activity and could be problematic to busy managers to accomplish. And second, at least some expertise and skills regarding exploration using the web and search engines is needed, so as to have a well-established criteria to “filter” search results that may content non-accurate information and select those of trusted information.

In the second experiment, the proposed steps to identify opportunities or threats and then convert them into current and future technologic strategic gaps, was proven. Although, this experiment did not included the complete stage validation, the results obtained turned out to be useful by defining one possible current opportunity and one possible threat to the magnet wire business while the experiment was developed. One possible shortcoming found during this experiment process, was that this part of the methodology requires of a broad vision coming from different perspectives and angles of an organization in order to convert potential responses into opportunities and threats. For this reason, it is recommended that the evaluation gets done by a well-managed planning team with sufficient technical and technological background in order to manage specialized language and knowledge when handling technology roadmaps for example.

5.3 Further research and future work

The author of this thesis recommends continuing further research to define a universal concept about megatrends. Also more methodologies and frameworks are needed to be developed in order to increase the options to managers in different industries and sectors that are eager to understand how megatrends may play a key role to their business’ environment and strategy.

Further work must also be aimed to encourage industry leaders to use more foresight methodologies conjointly with megatrends since they have proven to be a useful tool to manage a wider business vision and thus resulting in better outcomes for companies who are willing to place a bet on the future.

As part of further research, one pending task is the comprehension and definition of the megatrends lifecycle. Although the proposed methodology includes in part of its development to analyze the current state of megatrends and driving forces by identifying if their effects are increasing, declining or being stable; a broader research should be made to establish the mechanisms to define the stages of their lifecycle. This further study could be useful to define the planning time horizons according to the
expected scope of the megatrends effects in a time scale and to define how often should they be revisited and followed-up.

Although this work was based on large companies, small and medium enterprises (SME's) can also benefit from the use of this methodology. As it was concluded in this work, by having access to the Internet, use of search engines and some exploration skills, SME's could reach megatrends understating and how they could have effects on their businesses, either as opportunities or threats. The author recommends as future work to research and adapt the proposed methodology for SME's by defining what steps should be skipped and what others should be modified or added.

During the experiments development, a large amount of information was found and became a bit harder to manage. Knowledge management methodologies integrated to the methodology could be a good solution to solve this problem.

One of the pending tasks of this work was also the designing of the implementation process for methodologies and frameworks to analyze megatrends in terms of organizational structures. As it was explained earlier, analyzing megatrends is a time consuming activity, therefore further work shall be aimed also to establish the organizational resources and structure needed to accomplish this goal in a cost-effective basis.

As of the methodology validation, the author of this thesis proposes that the steps that were not validated become so, or further adaptations or modifications be made by applying a broader case of study using the complete tools and methods proposed by this methodology using more profound data, inviting more people to participate and if possible using specific and wider case information to help define the strategic technology definition in a company.
References


Callahan, K. and Brooks, L. (2004), Essentials of strategic project management, John Wiley and Sons; New Jersey, USA


Daniel Rodríguez Orozco


Cooper, R.; Edgett, S. and Kleinschmidt, E. (1998a). Portfolio Management for New Products; Addison-Wesley; Reading, MA USA


Daniel Rodríguez Orozco 94


Miller, J. (2002)."A proven project portfolio management process", Proceedings of the Project Management Institute Annual Seminars and Symposium; Oct 3-10; pp. 347-352, San Antonio, TX USA


Daniel Rodríguez Orozco


WBCSD World Business Council for Sustainable Development (2005), *Pathways to 2050 – Energy and climate change*; Switzerland: Author


WBCSD World Business Council for Sustainable Development (2004b), *Mobility to 2030: Meeting the challenges of sustainability*; Switzerland: Author

Appendix I

Emissions scenarios for the Transport sector 2008

- In the Business as Usual Scenario, CO2-emissions from the transport sector are expected to grow by 120% by 2050 compared to 2000 levels. Emissions from light-duty vehicles grow more slowly, but will still be 90% higher in 2050 than in 2000.
- Sensitivity analysis on the light-duty vehicle module of the Business as Usual baseline suggests that emissions may grow faster than in the standard BAU. The main reason is the growth of traffic in emerging economies. Using income elasticities for vehicle use similar to those observed in the USA over the past 40 years implies faster growth than assumed in the Business as Usual Scenario.
- The projections illustrate "where demand would like to go", in the sense that it is assumed that sufficient energy supplies are available to meet demand without sharply rising prices. It is not straightforward that this indeed will be the case.
- Rapid improvements of the fuel economy of light-duty vehicles and freight trucks by about 30% would reduce emissions and may even stabilize them for these modes over the next two decades. This approach is particularly powerful when implemented on a global scale, not just in the OECD.
- In the longer run the expected growth in vehicle fleets and usage outstrips these fuel economy improvements, leading to rapid growth of emissions. Stabilizing emissions from light-duty vehicles over this horizon would require fuel economy levels of around 3.5l/100km (roughly 67 mpg or 80 gCO2/km) by 2050, around the world.
- It is sometimes argued that improving fuel economy by about 30% would be cost-effective, though it does require government intervention to shape consumer choice and manage risk for industry investment decisions. The projections suggest that ambitious targets, like stabilizing emissions from cars through 2050, require further technological change that could entail significant economic cost. The task for research is to direct policies to promoting the most cost-effective ways of reaching ambitious targets.
- Fast improvements of fuel economy may stabilize emissions over the next two decades. Such results may induce complacency, which the long run analysis shows would be misplaced if a goal of stabilizing vehicle emissions were to be adopted. For this, long run emissions standards would need to be established soon, in order to facilitate the more costly switch to low-carbon technologies and provide the certainty required for industry to make the necessary investments.

Fig A-1 Emissions scenario for the transport sector
Transport Outlook 2008 – Focusing on CO2 emissions from Road Vehicles
Source: OECD

Daniel Rodriguez Orozco 100
Appendix II

Hybrid Electric Vehicles trends

<table>
<thead>
<tr>
<th>Box 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybrid and electric vehicle markets until 2015</td>
</tr>
</tbody>
</table>

**Hybrid Electric Vehicles (HEVs)**

The worldwide HEV share in new vehicle sales is expected to continue its growth. However, the total production volume might be insufficient to meet demand, due to practical restrictions such as a limited production volume of batteries.

By 2012, the global sales figure for hybrid vehicles may have tripled to 2.2 million units. The share of hybrid cars in 2015 new car sales is expected to be below 10%.

**Electric Vehicles (EVs)**

The share of electric cars in new car sales in 2015 is expected to be well below the share of HEVs at that time.

Electric bicycles are expected to remain the dominant EV category. If current trends continue, the worldwide electric bicycle fleet will be well over 100 million units in 2015.

<table>
<thead>
<tr>
<th>Box 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plug-in Hybrid Electric Vehicles</td>
</tr>
</tbody>
</table>

A plug-in hybrid electric vehicle (PHEV) is essentially a hybrid electric vehicle (HEV) with additional batteries and a plug, giving the vehicle an ability to use electricity from the grid to move the vehicle. While the charge of the PHEV’s larger battery pack is depleted, some PHEVs may operate all-electrically, while others may use both battery electric and internal combustion engine mechanical power to move the vehicle. A variety of design options for PHEVs are possible, but all will use electricity from the grid to replace liquid fuels used by internal combustion engines in vehicles.

One of the advantages of PHEVs is a potential increase in energy efficiency. This could then result in a reduction of greenhouse gas emissions, fuel consumption and dependency on fossil fuels. However, the full energy cycle result is highly dependent on the type of electricity generation capacity (solar, wind, coal, etc.), which varies greatly in IA-HEV member countries. Also, the time of charging can influence the source of the additional electricity needed to power PHEVs.

Fig A-2 HEV’s trends and forecasts
Source: OECD International Energy Agency 2009  

Daniel Rodríguez Orozco
Appendix III

Electricity power generation growing trends

Fig A-3 Electricity trends