Engineering Work Breakdown and Assignment for Global Product Development

by

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Submitted to the Systems Design and Management Program
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Abstract

Companies are always looking for ways to reduce their costs, cost reductions which allow companies to increase their overall profits. There are various cost reductions strategies, such as: change materials and/or design of the products, change suppliers, and offshore engineering. This last strategy, offshore engineering, is a common practice in today's global industries. This thesis applies the cost-reduction strategy of offshore engineering to the automotive industry. Specifically, this thesis presents an analysis of the Seat Subsystem, which assists the corporation in selecting which components of the subsystem are optimal to be offshored. Based on product architecture design structure matrices, this analysis identifies clusters of components within the Seat Subsystem which are highly interrelated. After adding three variables: experience needed to develop each of the components, current experience of the offshore office, and supplier location of these components, a proposal of which components should be offshored is presented. Further, in this thesis a Process/Organization DSM is used to identify when in the seat development process the Seat Engineers have closer relations with other departments within the organization. The results of this Process/Organization DSM will assist the company in creating travel plans for the engineers.

After establishing which components of the seat should be offshored, an additional analysis is presented which assists the organization in determining where to offshore these components. This analysis is based on three frameworks: CAGE, ADDING, and Porter's and virtual diamond. A summary of the results of this analysis presents a quantitative evaluation of three offshoring options: China, India, and Mexico.

In addition, in this thesis an analysis is presented to determine how the Seat Organization Architecture needs to be adapted in order to support the Offshore Strategy. This organization transformation is based on three methodologies: Enterprise Architecture Sequence Model, 4P's of Strategy, and Seven Strategy Questions. At the end of this thesis, a six-step process is presented to assist other organizations when an offshore strategy is needed to breakdown the development of a product or system and determine where to offshore each of the components.

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Two years have gone so fast; many papers written, books read, and presentations done. All of this may sound like these two years were tedious, but it was exactly the opposite. These two years were amazing because they allowed me to learn a lot, meet great people and see the world from a system perspective. Today, while I am writing these last pages, these remarkable two years come to their end, but all of this would not have been possible if I would have tried to do it by myself. This experience was only possible because I was blessed to have the support of several amazing people whom I would like to thank.

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Abbreviations & Acronyms

BE – Body Exterior

C&A – Carpets and Acoustics

CC – Climate Control

CCS –Climate Control System

CES – Complex Engineering Systems

Elec. – Electrical

FSS – Full Service Supplier

fo – Foam

GPD – Global Product Development

gs – Guide Sleeves

HL- Head Liner

hr – Head Restraint

IP – Instrument Panel

IP- Intellectual Property

lu - Lumbar

MFG – Manufacturing

MKTG – Marketing

NAFTA – North American Free Trade Agreement

OCS – Occupant Classification System

OEM – Original Equipment Manufacturer

PDP – Product Development Process

pl - Plastics

PT – Power Train

R/1000 – repairs per every 1000 vehicles

re - Recliners

ri - Risers

SAB – Side Air Bag

sc – Seat Complete

st – Structure

sw – Switches

SWOT – Strengths, Weaknesses, Opportunities and Threats

sy – Systems (Seat Systems)

TGW – Things Gone Wrong

tc – Trim Cover

tr – Tracks

Purch. - Purchasing

VEV – Vehicle Evaluation and Verification

1 Introduction

1a. Problem description, Research Questions and Hypothesis

Throughout the years, there have been different financial crisis around the world; these situations affect industries all over the globe in a variety of ways. The global financial crisis which started in 2008 was not the exception. This financial crisis hit a myriad of industries, one of which was the automotive industry. After the housing and finance markets the impact was most severe for the automotive industry than any other. (Sturgeon & Van Biesebrock, 2010) This is due to the following rationale:

1. *"Huge debt loads, high fixed-capital costs, high labor costs, and immense pension and health care commitments to retirees"* (Sturgeon & Van Biesebrock, 2010)
2. *"High costs and growing longevity of motor vehicles prompted buyers to postpone purchases"* (Sturgeon & Van Biesebrock, 2010)

In North America, these two reasons were truth. The 2008 crisis had a direct effect on vehicle sales, and the fixed costs of the car companies were high. The decrease of vehicles sales was a result of high unemployment in the country and the increase on the fuel prices. Customers did not have money to spend on a new car, but were compelled to spend it in their basics needs. The few customers that bought cars wanted smaller and more efficient vehicles, and the automakers did not have these options.

As shown on the following charts, some of the Big 3 automotive companies in North America were close to bankruptcy with stock prices close to zero, and the sales keep decreasing year by year. The United States Congress offered several waves of bailouts, which led GM and Chrysler filing for Chapter 11 bankruptcy and to the CEO of GM resigning. (Sturgeon & Van Biesebrock, 2010)

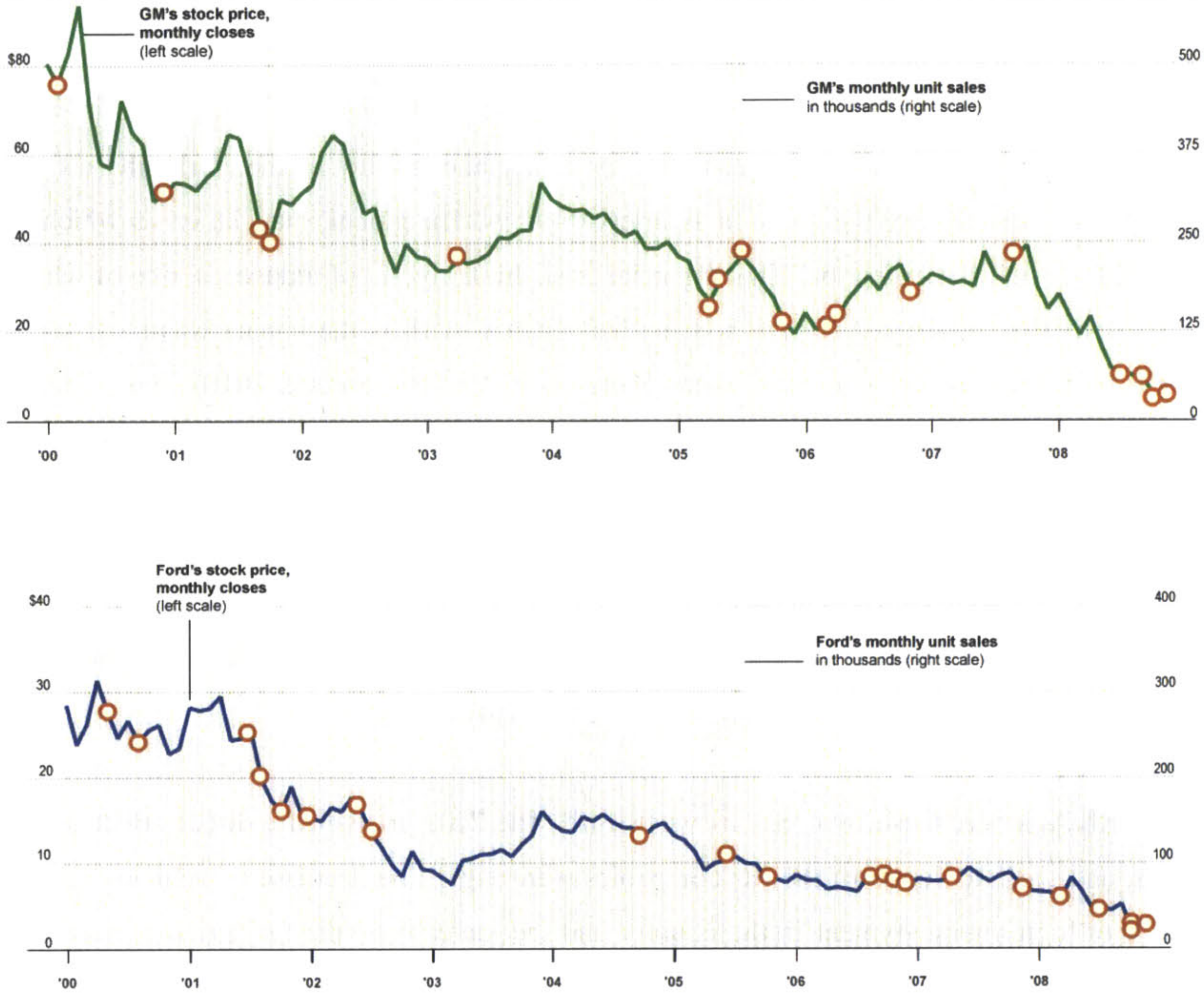


Figure 1 – Automotive Stock Prices and Sales (Dow Jones & Company, 2008)

This catastrophe demanded an urgent change of strategy. In order to have cash flow, some of the companies started selling or closing part of their business; Ford Motor Company sold Aston Martin, Jaguar, Land Rover and Volvo, and with a similar strategy GM closed its Oldsmobile brand. These actions let these automotive companies have money to invest in the development of new products.

Another action of this strategy was that some of these companies turned to investigate the utilization of low cost countries as a feasible way of reducing the product development costs. This was a new way of seeing these countries because up until this time they were usually taken into account just for manufacturing. These low cost countries, such as China, India, Mexico and

Turkey, are known for having a cheap labor force but now they were given with the opportunity of not just assembling the vehicles but also to develop them.

This innovative strategy came with a variety of benefits and risks; the obvious benefit is the lower wages in these countries. However, some of the risks were the lack of engineering experience, beginning remote PD work, which meant various time zones and cultural differences among the new global PD locations.

The real challenge here was not just reducing the product development costs; the goal was to reduce product development costs while at the same time getting equal or better quality in the final product along with improving product development timing. With this challenge in mind, the automotive companies had the task to determine what can be resourced offshore. Dr. Steven D. Eppinger and Anil R. Chitkara defined offshore as having Product Development resources located in another country, generally a low cost country. (Eppinger & Chitkara, 2006) With this definition of "offshore", the next question is how to decide which part of the product is best one outsourced to this offshore office, which brings the first research question for this thesis

Q1: What part of the product architecture can be designed efficiently offshore?

I currently work for a North American automotive company in the Product Development office. More specifically, I am part of the Seats Area which develops seats for different programs or vehicles designed in the company. This company also felt the consequences of the financial crisis, and like many other companies is looking for more efficient ways of designing and developing seats. With this goal in mind, I will endeavor to determine the most efficient way to meet this objective. This target brings us to the second research question.

Q2: Which components of the Seat Subsystem architecture can be designed in an office offshore?

The seat subsystem is probably one of the most complex systems within a vehicle. It is integrated with more than 200 parts, which need to interact among them. Because of this interaction a seat development office as many other offices, is usually divided in two internal areas: Core Engineering and Integration.

Within the core engineering area there is an engineer responsible to develop and perform component testing for each of the components of a seat. Some examples of these components are recliners, latches, head restraints, and foam among others. Listed below are some of the numerous parts which integrate within a seat.

PART DESCRIPTION	PART DESCRIPTION
HEAD REST	ADJUSTER
HEADREST FOAM & FRAME ASY	2 WAY MAN ADJ PASS W/ BUCKLE BRACKETS
INSERT EPP CORE	CAT 3 2 WAY MANUAL TRACKS
ARMATURE HEAD REST TUBE	BRKT BUCKLE I/B RH (BUCKLES CAN BE SERVICED INDIVIDUALY AS WELL)
SOFT PAD DIE CUT INSERT - COMFORT	BRKT BUCKLE O/B RH (BUCKLES CAN BE SERVICED INDIVIDUALY AS WELL)
RET FRT ST HD/RES GUIDE-MASTER	6 WAY PWR ADJ PASS W/ BUCKLE BRACKETS
SLV FRT ST HD/RES GUIDE-SLAVE	CAT 3 6 WAY PWR ADJ PASS
HEADREST ASSY LEATHER - PREMIUM	BRKT BUCKLE I/B RH (BUCKLES CAN BE SERVICED INDIVIDUALY AS WELL)
TRIM COVER HEADREST LEATHER - PREMIUM	Buckle BRKT O/B RH (BUCKLES CAN BE SERVICED INDIVIDUALY AS WELL)
FRAME ASY-FSB	RISER FT O/B PASS
FRAME ASY-FSB	RISER REAR I/B PASS
PAD F/S/B RH w/CCS	COVER REAR TRACK RISER I/B DRIVER
MANIFOLD INSERT FSB	COVER ASM FRONT TRACK RISER O/B PASSENGER
CAT 3 POWER RECLINER ASSEMBLY	COVER ASM REAR TRACK RISER O/B PASSENGER
POWER RECLINER MECH. (MOTOR SIDE)	COVER REAR TRACK RISER O/B PASSENGER
POWER DRIVEN RECLINER MECH. (OPPOSITE MOTOR SIDE)	Cover/TRIM
TORQUE ROD RECLINER POWER LH/RH	COVER ASSY ST BACK PERF LEATHER W/SAB LH CCS PREMIUM
SERVICE ONLY RECLINER MOTOR + BOLT	COVER ASSY ST BACK PERF LEATHER W/SAB RH CCS PREMIUM
RECLINER MOTOR	COVER ASSY ST BACK PERF LEATHER W/SAB LH CCS MIKO SUEDE
BOLT - M6 (TORX HEAD) RECLINER MOTOR	COVER ASSY ST BACK PERF LEATHER W/SAB RH CCS MIKO SUEDE
BOLT - M6 (TORX HEAD) RECLINER MOTOR	COVER ASSY ST BACK LH CLOTH 2 LESS MAP POCKET
BRKT ST BK SAB RH	COVER ASSY ST BACK RH LEATHER ST
MOD ASY FRT ST SD AIRBAG RH	COVER ASSY ST BACK LH CLOTH 3
LEAD WIRE SAB LH/RH	COVER ASSY ST BACK LH LEATHER -VOGA
RH - FSB JUMPER / PWR LUMBAR / PWR RECLINE / CCS SEAT	COVER ASSY ST BACK RH LEATHER
LUMBAR ASSY - POWER	COVER ASSY CUSHION LH PERF LEATHER CASHMERE
SINUOUS SUSPENSION WIRE - FSB	COVER ASSY CUSHION LH CLOTH HEV
BRACKET MTM BACK	COVER ASSY CUSHION LH LEATHER ST
CCS MTM BACK ASSY - ASSEMBLY FOR LEAR TO ORDER ONLY	COVER ASSY CUSHION LH CLOTH FORD ST
BLOWER ASM - MTM FRT ST BACK	COVER ASSY ST CUSH LH CLOTH 3
EXHAUST DUCT	COVER ASSY ST CUSH LH LEATHER
CUSHION	COVER ASSY ST CUSH RH CLOTH 3
FRAME ASY-FSC RH	NUT - LOCK HEX FLANGE NUT M6 (SAB BRKT TO BACK FRAME)
CAT 3 FRAME WITHOUT WIRES 2/6 WAY PASS/DRIVER	BOLT M6 (THREADED) - SAB TO BRKT
WIRE - STRUCTURAL, OUTBOARD RH	WELD NUT FOR AIR BAG BRKTS
RETAINER TRIM	PUSH PINS - TRIM GUSSET RETENTION AROUND RECLINER
RH SERVICE ONLY CCS >PAD F/S/C RH CCS + MANIFOLD + DIE CUT INSERT (2)	
PAD F/S/C RH CCS	
CCS DIE CUT INSERT (FRONT CUSHION FRONT INSERT) PEEL & STICK	
CCS DIE CUT INSERT (FRONT CUSHION REAR INSERT) PEEL & STICK	
MANIFOLD INSERT FSC	
SHIELD ASSY F/S/C 10-WAY PWR RH	
KNOB - BENCH SWITCH	
KNOB - RECLINER SWITCH	
KNOB - LUMBAR SWITCH	
SWITCH ASSY 10-WAY PASS	
CCS MTM CUSHION ASSY	
FILTER CCS BLOWER CUSHION--SERVICE ONLY	
DSCM MODULE (CCS ONTROL MODULE)	
HARNESS-RH LINC HEAT/COOL, 8 WAY PWR PS, PWR LUMBAR	
HARNESS-PASSENGER OCS WEIGHT SENSOR - LHS SEAT RAIL	
HARNESS-PASSENGER OCS WEIGHT SENSOR - RHS SEAT RAIL	

Figure 2 - Seat Components

Once these parts are designed and the component design verification test is successfully passed, there is an Integration Engineer that puts together all of these parts and performs the complete seat system level testing. This process is part of the INCOSE Vee Model illustrated in figure 3. The left side of the Vee shows how component level development and testing is done (going down the Vee). Then, the right side (going up the Vee) shows the same development and testing, but now at a system level.

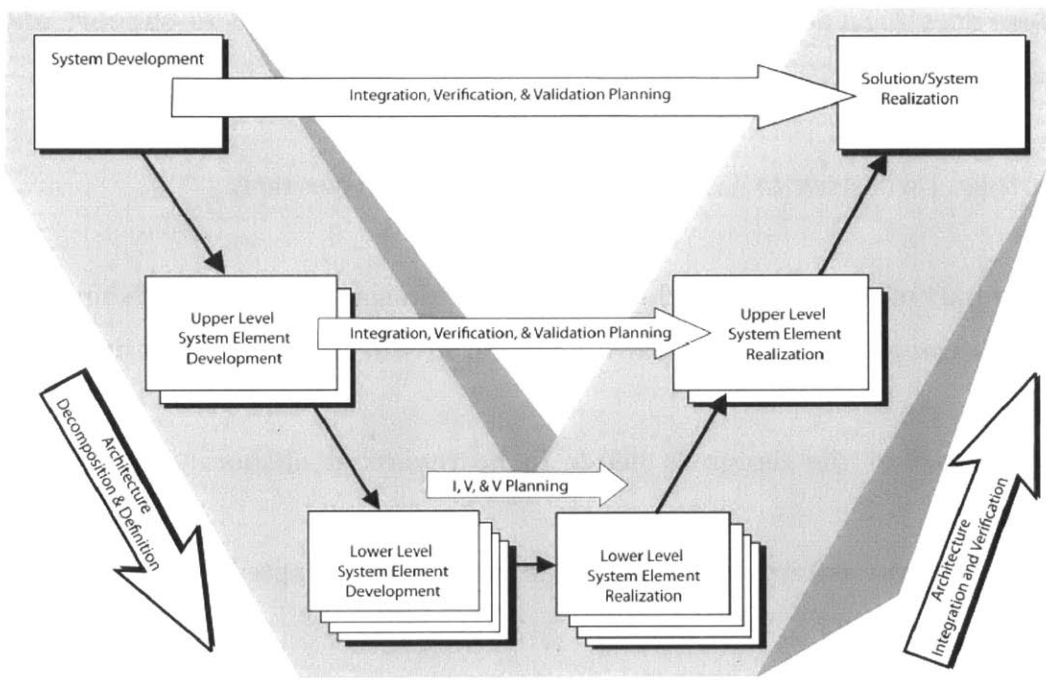


Figure 3 - Vee Model (INCOSE, 2011)

The Core Engineers are in charge of doing the left side of the Vee (component level) and the Seat Integrators are responsible of the right side (Seat System).These different areas of a Seat Development office bring another variable to the table, which elicits the next research question:

Q3: What phase of the design process is better to be resourced offshore: Core Engineering or Integration?

Having more than one office developing a product is an immense challenge for both the headquarters and the offshore office. The challenge is working together despite different time zones, culture or language. So, once it is determined which components and processes can be developed in an offshore PD office, this office will need to be organized in such a way that communication among the PD offices around the world does not affect the timing or quality of the final product. Because of this goal the fourth research question evolves:

Q4: How does the enterprise organization need to be adapted to support and enhance offshore development?

Summarizing, I will strive to answer these four main search questions:

Q1: What part of the product architecture can be designed efficiently offshore?
Q2: Which components of the Seat Subsystem architecture can be designed in an office offshore?
Q3: What part of the design is better to be resourced offshore: Core Engineering or Integration?
Q4: How does the enterprise organization need to be adapted to support and enhance offshore development?

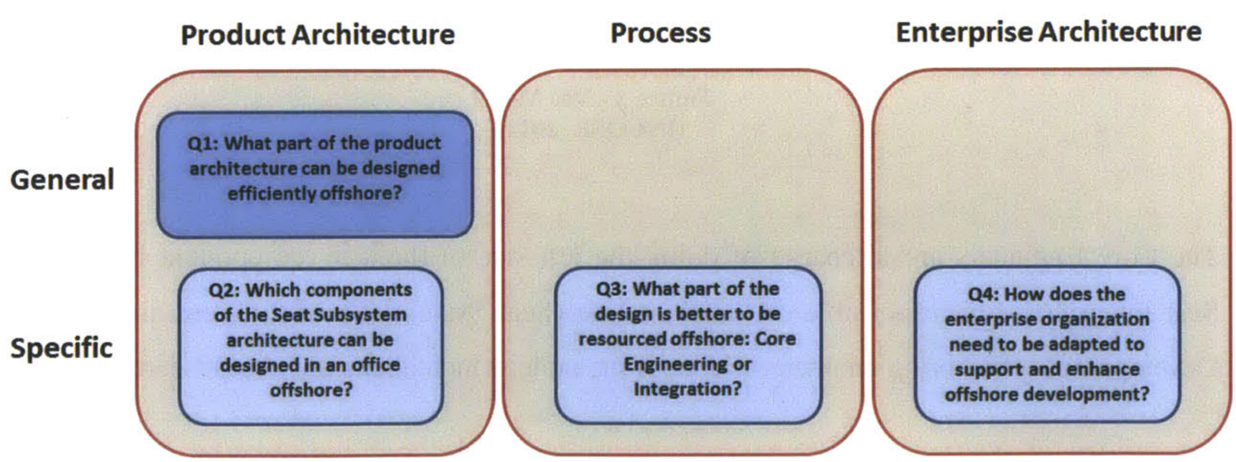


Figure 4 - Research Questions

During the next section I will explain the approach taken to answer the four questions raised above.

1b. Research Methodology

Now let me explain the process followed during this thesis in order to solve the hypotheses exposed previously. The first step was to search for available information related to this topic. This search was not limited to the auto industry; it covered any industry in which a study was performed to determine how to resource tasks to another location. This can be a physical task such an assembly, a service or any step of a process.

Which kind of process a study was based on did not matter because I wanted to identify which methods were used. All of these processes at the end can be analyzed as a system, and the methods used can be applied to any other system.

After this information search I performed interviews to identify the baseline of how decisions are currently made within the company. My goal was to identify and understand how companies choose which part of the system can be developed offshore.

Once it was understood how this decision is currently made; I used DSMs to find the relationships between the tasks and the components of the system in order to determine which can be resourced offshore.

The next step was to know how the organization needs to be reconfigured in order to support this new strategy and be able to grow or change according to the needs of the company.

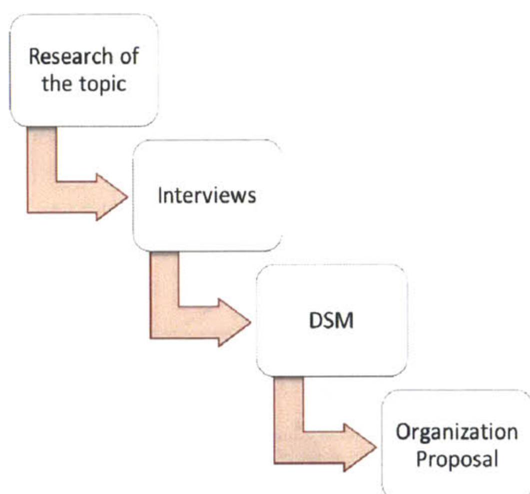


Figure 5 - Research Methodology

2 Current available information about the topic

As mentioned, I researched to find material related to the topic of this thesis, which is how to determine what part of a process or product can be done offshore. I found two particular publications. The first one is Dr. Anshuman Tripathy's thesis presented to obtain his PhD in Management at MIT called *Work Distribution in Global Product Development Organizations*. The second one is a paper by Dr. Steven Eppinger and Anil R. Chitkara called *The New Practice of Global Product Development.*

2a *Work Distribution in Global Product Development Organizations* (Tripathy, 2010)

Dr. Tripathy researched how to organize GPD for CES, and in his thesis he shows how different companies around the world have faced this challenge. He analyses the product architecture or task structure depending on the objective of each of these companies.

In chapter two he presents the common offshoring difficulties a company faces dependent on the interrelationships among the components. The following figure shows how if a component has a mayor interaction with another component, it will be difficult to offshore just one of these components. On the other hand if the company plans to offshore both it will be easier. Because less coordination across locations will be required. These options can be classified into two types: Component Offshoring or Sub-system Offshoring. The third and easiest option presented is the case where each component is independent of the rest of the components. This component can be easily offshored because there will be no coordination needed between locations.

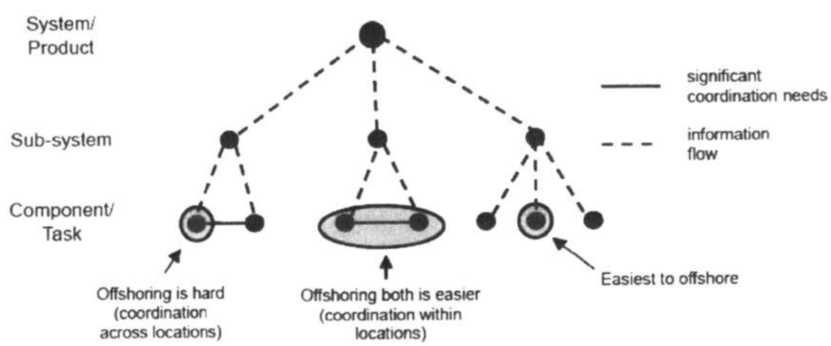


**Figure 6 - Offshoring Difficulties
(Tripathy, 2010)**

Figure 7 - GPD Architecture
(Tripathy, 2010)

Dr. Tripathy also presents various case studies with different approaches to offshoring as well as the reasons of why each company started the offshoring process. Such rationale can be competence seeking, cost saving or capacity. He presents a summary of these case studies in the following figure.

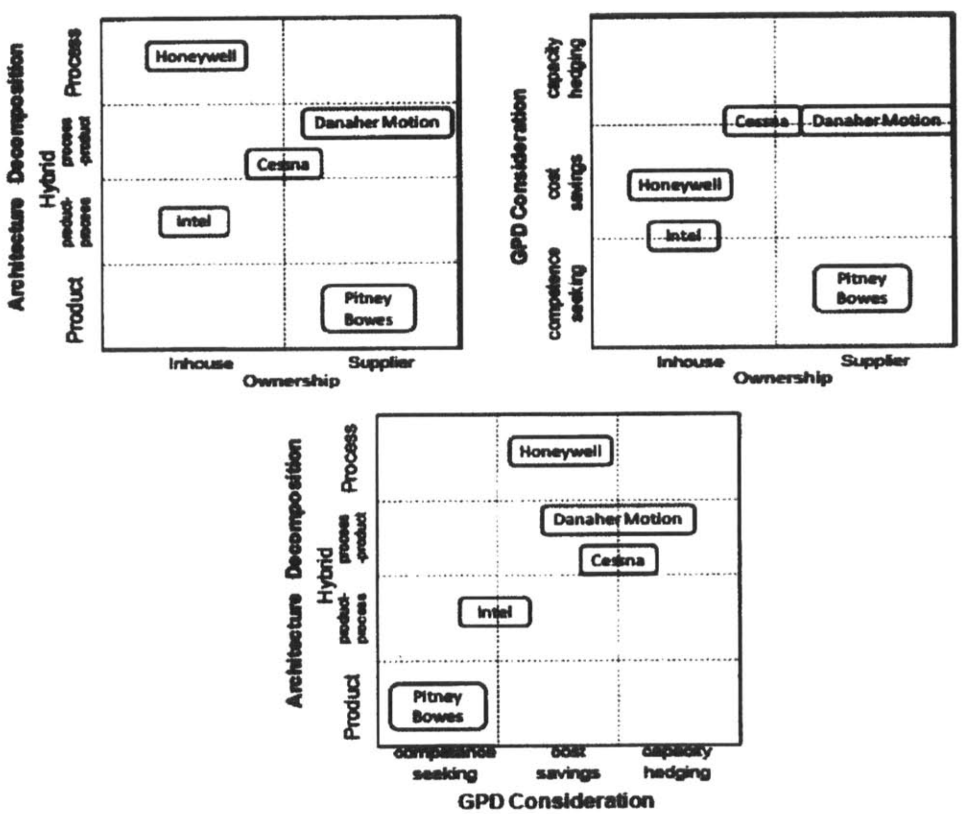


Figure 8 - Summary Observations of Case Studies
(Tripathy, 2010)

This summary shows how each of the companies approached the offshoring process related to the architecture decomposition and the rationale to offshore. For example, Honeywell started GPD to pursue cost savings, so they based their strategy in process architecture decomposition.

Since Honeywell-Aerospace Division and its Advanced Manufacturing Engineering area explored offshoring options based on cost reductions, and their investigation and case study are similar to the situation presented in this thesis, I further scrutinized their research and offshore options for cost reduction. They basically had three different options: to offshore local, to a medium cost or a low cost location.

They pursued the following steps to make this decision:

1. Identify the tasks that cannot be offshored from a list of the complete tasks performed, and then identify the ones that can be offshored as a group or bundle.
2. Use a Design Structure Matrix to identify the interaction during each of the tasks in the three different scenarios.
3. Determine the hours needed for coordination among different locations for each of the tasks.
4. Translate the hours spent for coordination into costs.
5. Optimize the costs based on the previous results.

After analyzing the five case studies presented in Figure 8, Dr. Tripathy concludes the following:

- *"Firms should prioritize their offshoring content to develop the knowledge and skill set at the GPD location (long term benefits), rather than prioritizing offshoring content based on index of modularity (short term benefits). The choice of subsequent offshoring content should consider the benefits from the existing knowledge and skill set at the GPD location, and also enhancing the same so that further offshoring efforts gain (path dependence)."* (A. Tripathy, 2010)

- *"Firms should prioritize efforts to reduce the efficiency gap in the coordination time between tasks that are at different locations before addressing the gap between tasks that are at the GPD location."* (A. Tripathy, 2010)

- *"In the face of uncertainty, the risk averse firm exerts higher initial efforts to support the offshoring efforts. This approach helps to minimize the efficiency challenges and develop the knowledge base at the GPD location faster, thus negating any adverse volatility in various exogenous factors."* (A. Tripathy, 2010)

Then Dr. Tripathy summarizes the process a firm can follow to establish a Global Product Development (Tripathy, 2010):

1. Determine the reason to offshore or establish a GPD
   a. Meet Market needs
      Unique content will be designed and developed in an alternate location
   b. Competence Seeking
      Defined content that will be designed and developed in an alternate location by a supplier.
   c. Cost Savings or Capacity
      List and analyze all process product combinations and with the help of a DSM determine which ones can be offshored and/or outsourced.

He also presented in his thesis the following figure that summarizes these steps

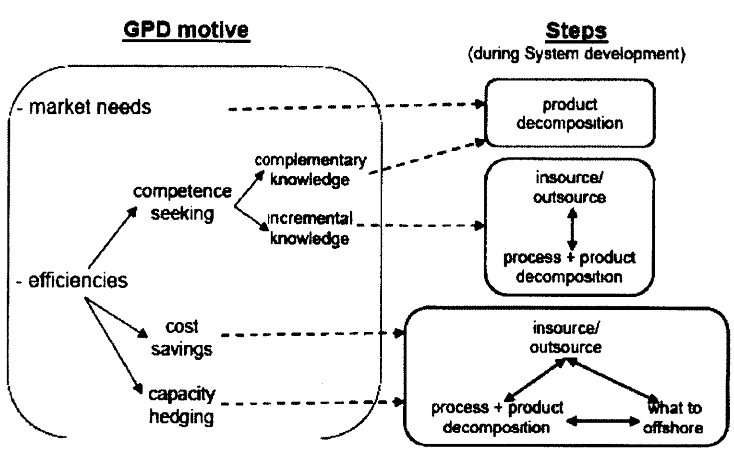


Figure 9 - Distribution Steps for GPD content (Tripathy, 2010)

2b *The New Practice of Global Product Development* (Eppinger & Chitkara, 2006)

The authors of this paper begin by describing how Global Product Development is growing around the world. They present the results of research done in 2003 by Deloitte of North American and Western European manufacturers. Their research found that "48% of the surveyed companies had set up engineering operations outside of their home region" and that "22% of the North American manufacturers already had located engineering functions in China, as did 14% of the Western European manufacturers polled" (Eppinger & Chitkara, 2006) Then they show the different reasons or purposes for a company to start developing a GPD. Some examples of these purposes are: facilitating the collaboration among different teams, having a better understanding of the needs of a distant market, testing, and prototyping among others.

They also provide a description of the benefits of having a GPD:

- Greater engineering efficiency (Lower costs)
- Access to technical expertise
- More global designs
- Flexible PD resource allocation

Additionally the authors presented a list of the reasons of why a company starts GPD:

- Lower Cost – Offshoring to lower cost countries (China, India, Vietnam)
- Improved Process – Having the manufacturing and engineering team in the same site
- Global Growth – Better understanding of the local needs and usage of local connections
- Technology Access – Access to new technologies developed in specific regions.

On this paper, the authors also mention that specific regions were adopting a GPD strategy more than others, which is sometimes related to the country's culture. They present as an example how the German and Japanese cultures are not aligned with the GPD strategy. On the other hand there are a large number of companies working with this approach. Hyundai Motors is used as an example. This company established Product Development Offices in numerous parts of the world. In this company's case, GPD was used for the advantage of obtaining technology and knowledge of the customers in a specific region. Because of this strategy, Hyundai has operations in Michigan (engine calibration and testing), Southern California (vehicle styling), California desert (high temperature testing), and Frankfurt (research).

In the next section of their paper, the authors propose that there are four modes to approach GPD based on the ownership and location of the resources. However, before they go further, they define the difference between outsourcing and offshoring. Offshoring is defined as "the location of those resources" while outsourcing is "the PD resources owned by a third party" (Eppinger & Chitkara, 2006).

The four modes mentioned before are as follows:

- Centralized

  PD resources are within a company and at onshore locations. The company can have different headquarters in different countries.
- Local Offshoring

  Local contractors or companies help with specific tasks or phases of the development.
- Captive Offshoring

  A company starts a new PD office in a foreign country.
- Global Outsourcing

  Contractors in another country will help with the development process. This is sometimes the first step before a Captive Offshoring approach.

They summarize these modes in the following figure:

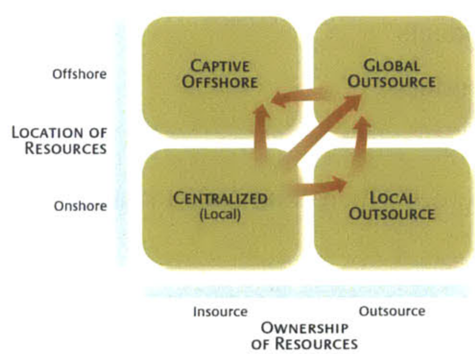


Figure 10 Modes of GPD
(Eppinger & Chitkara, 2006)

According to Dr. Eppinger and A. Chitkara the benefits of choosing the offshore mode are:

- *"The work product contains intellectual property related to product or processes that provide valuable differentiation"* (Eppinger & Chitkara, 2006)
- *"The skills and expertise that will be developed in the center relate to a core competence for the company"* (Eppinger & Chitkara, 2006)
- *"The center will provide a basis for understanding local markets and designing products based on that understanding"* (Eppinger & Chitkara, 2006)

Furthermore, three various approaches and processes of how to deploy or establish a GDP over time are given.

1. Process Outsourcing
    a) Outsource simple tasks to a third party. At the beginning these task should be almost independent of each other so they can be easily outsource; and,
    b) Outsource integrated tasks.
2. Component Outsourcing - Once the product is decomposed into components and modules
    a) Outsource simple components
    b) Outsource integrated components
    c) A third party develops complete modules
3. Captive Design Center – Investment needed
    a) Develops simple tasks or components
    b) Integrated tasks or components
    c) Complete modules or subsystems
    d) Derivative products
    e) New global products

At the end, the authors list factors which contribute to having a successful GPD:

1. Management Priority – Investment of resources
2. Process/Product Modularity – Ability to split the process/product into various elements that will be almost independently performed and/or developed in different locations.

3. Core Competence – Develop core competency in all locations
4. Intellectual Property – Share internal technologies while protecting the IP
5. Data Quality – Easy access to the data from all locations
6. Infrastructure – Same level of technologies, tools and systems in all locations.
7. Governance and Project Management – Capability to coordinate and monitor global teams.
8. Collaborative Culture – No barriers among locations, including language and process.
9. Organization Change Management – To plan and deploy necessary training for key members of the global team.

3 Industry, Organization and Product Description

3a.0 Industry

In the North American market, there are three American automotive companies better known as the Big Three: Ford Motor Company, General Motors, and Chrysler. In the past, the market was basically divided among these three companies. However, the market is now shared with Asian and European vehicles.

Also in North America, there are three main Seat Suppliers: Lear Corporation, Johnson Controls, and Magna International. These suppliers have most of the seating business of the Big Three American companies. These suppliers do the assembly of the seat and/or the design of seat. These two aspects will be reviewed in more detail in the next two sections.

3a.1.1 Seats Design and Development Industry

Vehicle development has been done only in a few countries around the world within select PD Offices. (Sturgeon & Van Biesebrock, 2010) Seat development is not the exception; this subsystem has developing centers in a small number of countries. The development of vehicle seats has been done by the suppliers and/or by automotive companies, depending on the total development costs. This means that sometimes the design of the seats is performed within the automotive company or in other words, it is done "in-house." In this case, the suppliers will do just the assembly of the seat, also known as build to print. Other times seat development is performed by the supplier (Full Service Supplier), and the Seat systems portion is performed by an engineer from the OEM.

Through the years the seat development phase has switched back and forth from the suppliers to the automotive company. This shift in development goes from an "In-house" to a "FSS" design of the seat. How this happens is illustrated in the following casual loop diagram in Figure 11.

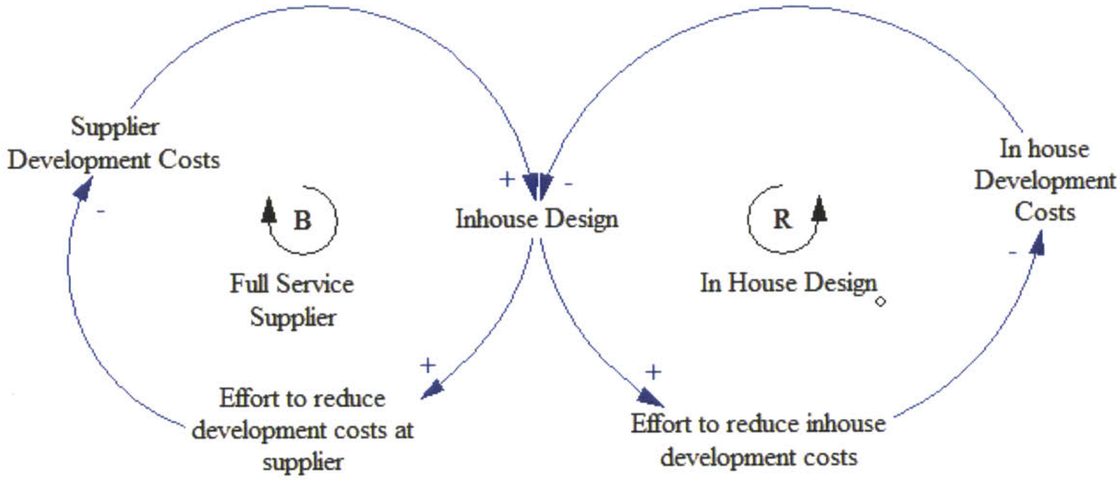


Figure 11 - Causal Loop In-house Design

This diagram shows that the In-House Design depends on the two main loops which I called Full Service Supplier and In-House Design loops. The first loop is a Balancing Loop because if there is more in-house design there will be more effort from the supplier to reduce its development costs. This means that the supplier's development costs will decrease, and as a consequence of this the in-house design will decrease as well.

The right hand loop shown in the diagram (In-House Design loop) is a reinforcement loop, which is because if there is more in-house design, the company will keep increasing their efforts to reduce costs. This effort will reduce the total development costs and will cause and increase of more in-house design.

The above causal loop diagram shows that in-house development depends on the effort spent to reduce costs at the supplier and within the company. The behavior of this phenomenon will be a cycle, which means that development will be transferring from the supplier to the company over time. The following figure shows a representation of these cycles obtained from an interview with a Seat Manager of an OEM.

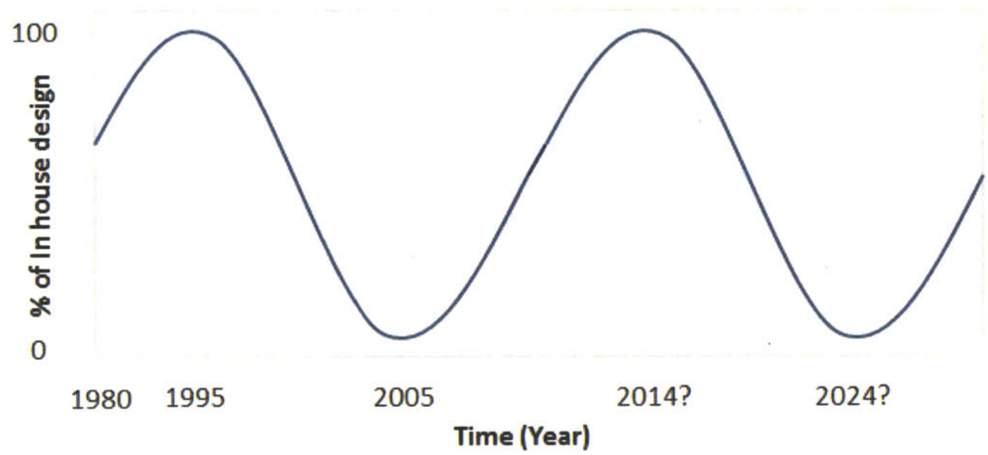


Figure 12 - In-house Design Cycles Representation
(Nunez, 2012)

The period of time it takes to go from one stage to another (FSS to In-House) depends on the expertise of the engineers on each side. For example, if the automotive company does not have the expertise to develop the seat, it will need to obtain this capability by hiring engineers from the supplier or by developing the knowledge within the company. The first option is the quickest approach to obtain the desired level of shill, but there is also the option of doing both at the same time.

As it was shown on the causal loop diagram, the two main loops depend on the effort to reduce development costs at the supplier and OEM, so the amplitude of the cycle can be increasing along the time. (McLoughlin, 2012)

3a.1.2 Seats Design and Development Process

A product development process is normally an integration of numerous steps or phases. The design and development process of the seat subsystem is not the exception and can be analyzed as a general Product Development Process. There can be specific phases on the seat design and development process, such as the comfort target definition; however, for this thesis I will use a general PDP.

This general process is one described by Professor Ulrich and Dr. Eppinger in their book *Product Design and Development*. They divided this process into six phases which are shown in the figure below:

Figure 13 - Product Design and Development Process (Eppinger & Ulrich, Product Design and Development, 2004)

In order to better understand each of these phases, main objective as well as a brief description of each phase presented by Dr. Eppinger and Professor Ulrich in their book are given below; this based on what Dr. Eppinger and Professor Ulrich presented on their book. (Eppinger & Ulrich, Product Design and Development, 2004)

Phase 0 – Planning

This phase is when the team performs research on the market for different technologies based on corporate strategy. At the end of this phase, the team will develop the project mission in order to start the development process.

Phase 1 – Concept Development

During this phase, the team identifies needs to be satisfied with the project in order to generate different alternatives or concepts. Once these concepts are generated, the team should perform a comparison with the competition as well as analyze the costs of each of the proposals.

Phase 2 – System-Level Design

At the end of this phase, the team will have a defined product architecture, including the components of the final product, their specification, as well as a flow diagram to assemble them.

Phase 3 – Detail Design

The detail design phase is when the team develops specifications for the unique parts for this product and a list of needed standard parts. It is also during this phase when the process plan is determined and tooling is designed. The purpose of this phase is to deliver control documents, such as drawings for the components and tooling. These control documents are used to assess the production costs.

Phase 4 – Testing and Refinement

Alpha prototypes which reflect the production intent are built during this phase to perform the testing. The results of these tests will determine if the design is satisfying the needs of the customer and if the performance of the product is as expected. After this testing, Beta prototypes are built which are made of production parts, but sometimes not assembled through the production process. These prototypes, similar to the alpha ones are also tested, but this time the test attempts to simulate customer usage in order to determine the prototype's performance and reliability.

Phase 5 – Production Ramp Up

During this phase, the work force is trained on the production process, and the process and tooling are evaluated for any needed minor changes. The production of the new product starts in this phase and as the name indicates, production volume gradually increases until it reaches 100% of capacity.

3a.1.3 Seat Manufacturing

Vehicle assembly or manufacturing is usually organized regionally or nationally with the suppliers of big systems, such as the seats, located close to the assembly plant. Lighter or generic parts are brought from centralized global suppliers, usually located in low cost countries, to take advantage of the economies of scale and low labor costs. (Sturgeon & Van Biesebrock, 2010)

The manufacturing phase of seats has been done by the supplier, so it does not matter if development follows a FSS or an In-house strategy. The three main suppliers mentioned before (Lear Corporation, Magna International and Johnson Controls) have assembly facilities all around the world, sometimes owned by them or as a joint venture. Seats manufacturing facilities are commonly located near the OEM assembly plant because this commodity is mostly handled as a just-in-time delivery to the plant. The following matrix shows the assembly locations each of these suppliers have around the world as obtained from the Industry and Trade Summary.

Company	Ownership	Foreign assembly location	Principal customers
Johnson Controls (Milwaukee, WI)	Public	Canada Mexico Brazil Australia South Africa Belgium France Germany Italy Netherlands Portugal Spain United Kingdom Czech Republic	General Motors Ford DaimlerChrysler AG BMW Mercedes-Benz Volkswagen Honda Nissan Toyota
Lear (South Field, MI)	Private	Canada Mexico Argentina Brazil Venezuela Turkey Russia China Thailand India Australia South Africa Austria Belgium France Germany Italy Portugal Spain Sweden United Kingdom Czech Republic Hungary Poland	General Motors Ford DaimlerChrysler AG BMW Fiat Volvo Mazda
Magna International (Aurora, ON)	Private	EU United States Mexico Brazil Korea China	General Motors Ford DaimlerChrysler AG BMW/Rover VW Group Mercedes

Figure 14 – Seats Suppliers Assembly Plants Locations
(USITC, 2001)

3b.0 Seat Organization

3b.1 Seats within the Organization and Architecture

The company is a global enterprise with offices in Asia, South America, Europe and North America, and each of these regions have their own seat organization which is part of the Product Development Office. The next figure shows where the seat organization is positioned within the company.

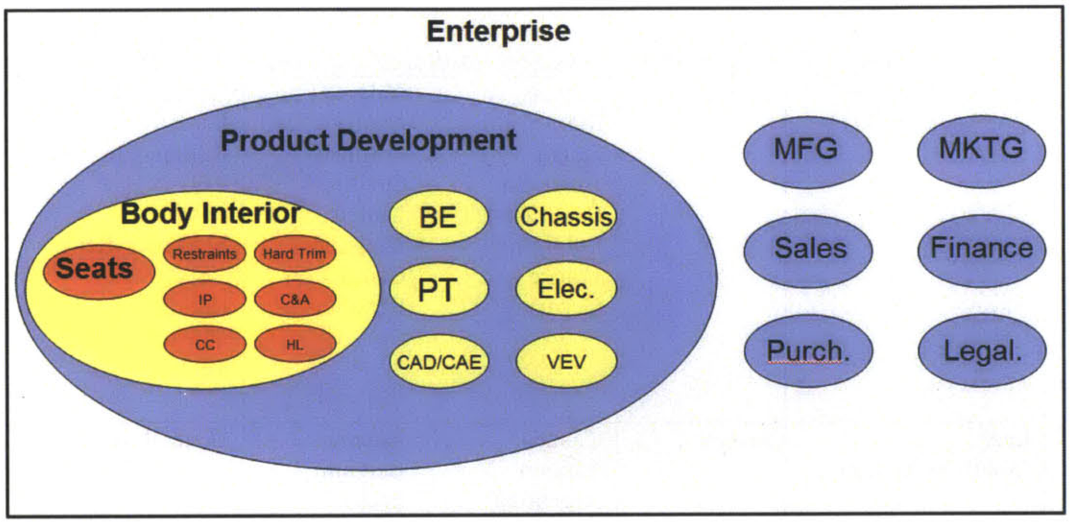


Figure 15 - Seat Organization within the Enterprise

This seat organization has a specific architecture, which I will define by using Professor Robert Simons Five Archetypes of Unit Structure. (Simons, Unit Structure - Defining a Primary Customer as a Basis for Organizational Architecture, 2007) Professor Simons says that the architecture of an organization is based on one or a combination of the following archetypes:

Low Price Configuration

The Upper management has target consumers whose principal objective is product price. Some examples of companies with this architecture are: Wal-Mart, TJ Maxx and Dell. The control of all resources is under the Operating Managers in order to use the economies of scale strategy. Units are grouped by function, and the distribution networks are usually regional.

Local Value Creation Configuration

Procter and Gamble is an example of such an organization because its strategy is to compete by satisfying the regional customers' specific necessities. This may mean that the company will need to offer the same product in different regions, but with small changes to adapt the product to the regional's wants. Each of these regions has their own R&D, manufacturing and marketing areas, which mean that these functions are duplicated within the company.

Global Standard of Excellence Configuration

These companies usually choose to compete by offering products with unique features which are difficult to copy. Perfection and differentiation of the product are priorities; thus, design, technology or brand attributes is at the core of the strategy. These enterprises are organized by global family products. PD and marketing are centralized globally, which allows the company to take advantage of economies of scale in these areas. Nokia and Gillette are some of the companies using this type of architecture.

Dedicated Service Relationship Configuration

To offer a long-term service relationship is the main objective of these companies. The relationship with the customer does not finish upon completion of the sale; this is just the starting point for these companies, such as IBM who created separate units for each key customer.

Expert Knowledge Configuration

This configuration is similar to the Low Price Configuration previously explained. The difference between the two is that in this case the architecture is divided by knowledge specialty. This type of configuration *"encourages the specialization and technical excellence"* in the product (Simons, Unit Structure - Defining a Primary Customer as a Basis for Organizational Architecture, 2007). Most of universities (Harvard Business School and MIT) and pharmaceutical companies have this sort of architecture. Also, Product Development offices on the automotive companies follow this configuration.

In order to understand the architecture of the Seat Organization, I will first explain its history. In the past, most automotive companies individually developed their product in each regional PD office. This means that a similar product was designed in each of these offices to satisfy their local customers. In other words, the PD offices were working independently of each other. This translated as a waste of valuable resources: money, workforce and time. Bryce G. Hoffman illustrates this issue in his book when he describes an anecdote from 2007 of the CEO of Ford Motor Company: *"In an early meeting with reporters, Mulally was asked if he was interested in a merger. 'Yes!' he exclaimed with a big grin as we all whipped open our notebooks. 'We're going to merge with ourselves.'"* (Hoffman, 2012)

Applying Five archetypes from Professor Simons, at that time the architecture of the seat organization was a hybrid of Local Value Creation and Expert Knowledge Unit structures. Within each of the Product Development Offices around the world, they were organized as Expert Knowledge Configurations such as Structures, Plastics, Foam, Trim Cover, etc; but, organized as Local Value Creation among them. With this organization architecture, positions were duplicated in each of the regions. This duplicity of positions was with the assumption that each region needed different products in order to satisfy the needs of its primary customers, and resources were allocated to meet these needs. Figure 16 further explains the former architecture.

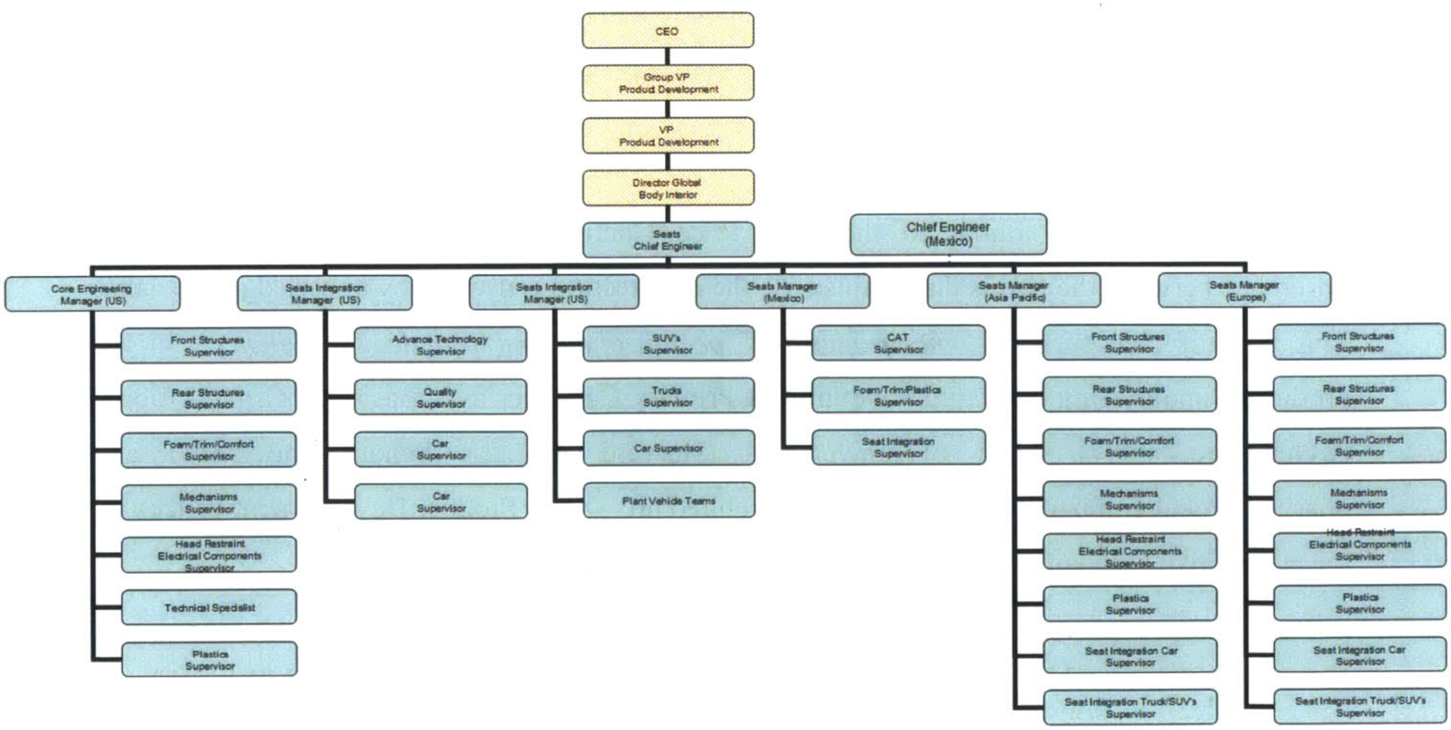
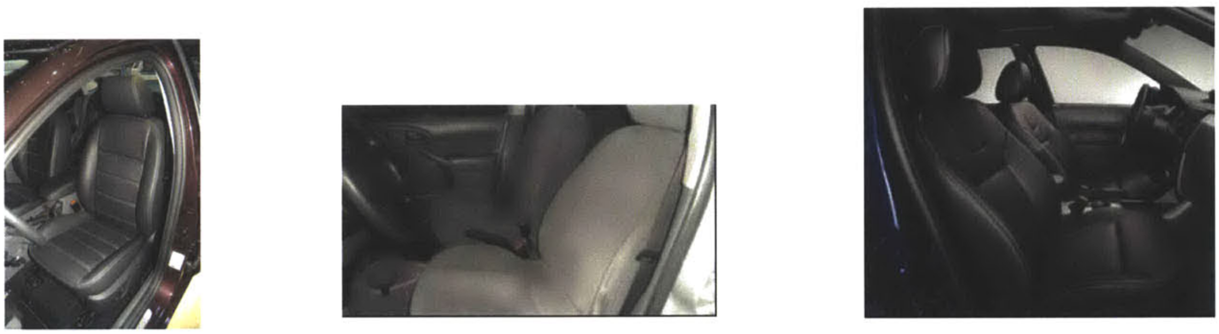


Figure 16 - Prior Seats Organization Architecture

The Big Three automobile companies had similar strategies; they duplicated positions because of close proximity to the customer and the needs of the customer. This strategy produced good results, but it was not cost effective because resources were wasted. Since this thesis is specific to the Seat Subsytem, and in order to have a better understanding of these wasted resources, consider the seats of a mid-size vehicle from one of the Big Three. In 2008, there were three different seats for the Ford Focus around the world. A completely different and unique seat had been developed and produced for this same vehicle in three separate global regions. The pictures below show these various designs



Europe South America North America

(Inc, 2012)

Figure 17 – 2008 Ford Focus in Different Markets with Different Seat Design

Once the automotive companies started working as global entities, the architecture needed to be adapted to this new strategy. However before suggesting a new architecture, an analysis of which components should be developed in each office was needed. This analysis will be presented in Chapter 4 of this thesis.

3b.2 4P's of Strategy

In order to better comprehend the seat organization architecture, I am going to use the *4P's of Strategy* from Professor Robert Simons. He defines these 4P's as follows (Simons, 2000):

Strategy as Perspective – Creating a Mission

- Mission refers to the broad purpose, or reason, that a business exists.
- Good missions supply both inspiration and a sense of direction for the future
- A mission statement communicates the core value of the business

- Its purpose is to motivate, instill pride, and give an overarching sense of direction and perspective to employees at all levels of the business

Strategy as Position – Choosing how to compete

- How do we create value for our customers?
- How do we differentiate our products and services from those of our competitors?

Strategy as Plan – Setting Performance Goals

- The preparation of plans and goals represents the formal means by which managers
    - Communicate a business' strategy to the organization; and, coordinate the internal resources to ensure that the strategy can be achieved.
- Goals, as reflected in profit plans and operating plans, are the end or results that management desires to achieve in implementing business strategy.

Strategy as Patterns in Action – Feedback and Adjustment

- Managers must have their eyes focused on customers and competitors, while at the same time keep their ears to the ground.
- Managers must listen and learn.
- Managers must encourage employees to experiment and constantly challenge subordinates to share their ideas and success so over time this information can be used to realign strategy.

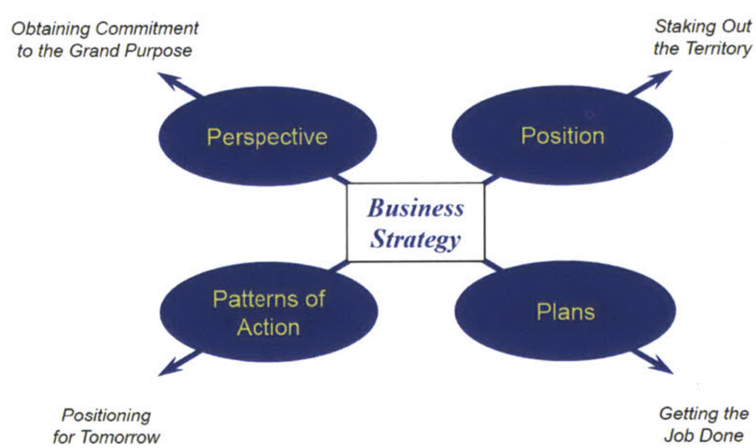


Figure 18 - 4P's
(Simons, Spring Term Lecture Designing Winning Organizations, 2012)

Now with this understanding of the 4P's of Strategy, allow me to apply them to describe the Seats Organization:

Strategy as Perspective – Creating a Mission

Harnessing diverse global talents to develop world class products that excite the customer, leveraging scale while meeting individual customer needs

Strategy as Position – Choosing how to compete

To have Global:

- Seats Structure platform
- Comfort DNA
- Materials Specifications
- Design Rules

Strategy as Plan – Setting Performance Goals

The strategy is cascaded throughout the whole organization starting with the objectives' score card of the company (CEO) until it reaches the individual objectives of each of the engineers within the Seats Organization.

Strategy as Patterns in Action – Feedback and Adjustment

The above "strategy as plan" ensures that the objectives of each of the engineers are aligned with the strategy of the company, but then how to ensure that the engineers are achieving these objectives? With "Strategy as Patterns in Action" the objectives of each of the members of the organization are reviewed twice a year with their direct supervisors. It is during the midyear review where some of the objectives can change in order to reflect the real needs of the organization.

3b.3 Stakeholders

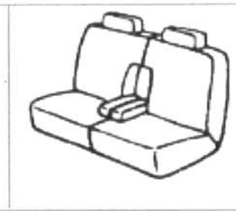
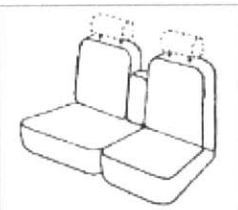
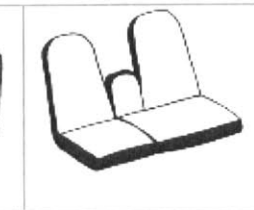
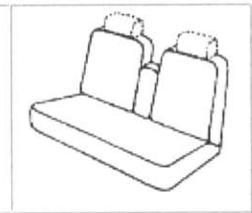
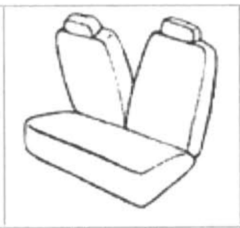
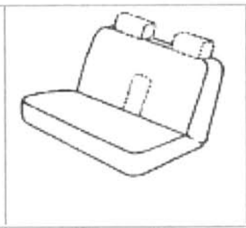
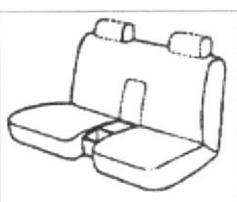
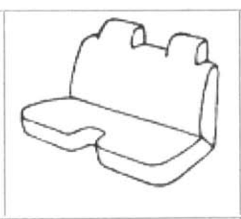
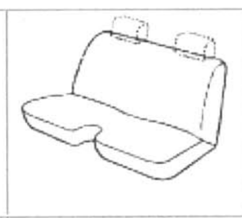
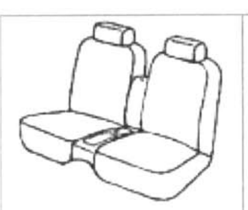
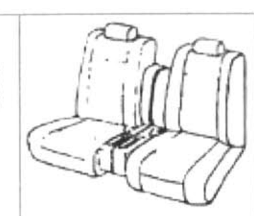
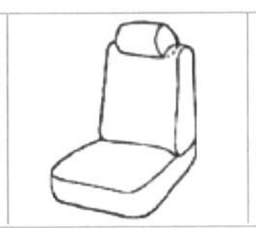
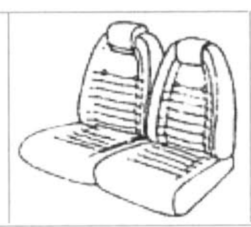
The following Figure explains the stakeholders and needs:

Stakeholder	Needs
Program	On-time delivery of seats Cost effective designs Reliability
Suppliers	Specifications Timing
Purchasing	Cost-effective designs Specifications
Assembly Plant	Easy to assemble On time delivery of seats
Studio	Engineering feasibility Product to support their surfaces
Marketing	Features Appearance
Final Customer	Comfort Safety Appearance Features Reliability
Regulatory Agencies	Regulations compliance
Employees	Challenges Training Working tools Professional development Safe and healthy work environment Recognition
Other Subsystems	No interferences

Figure 19 - Seat Organization Stakeholders & Needs

3c. Product Description

The products of this organization are the seats for various programs/vehicles. The seats can be classified by rows within a vehicle such as 1^{st}, 2^{nd} and 3^{rd} row. This classification will depend on the type of vehicle in which seats are going to be used. Then, after classifying the seats by which row they are placed in the vehicles, the seats can be categorized by type which depends on the seat architecture. The following figure summarizes these categorizations:

				
Type 1 Low back bucket seat with or without armrests or headrests	**Type 2** High back bucket seat with integral headrest	**Type 3** 45/45 low back seats with dual armrests and headrests	**Type 4** 45/45 high back seats with dual armrests	**Type 5** 50/50 low back seats with dual armrests and headrests
				
Type 6 Low back bucket seat 60% passenger 40% driver with or without headrests	**Type 6HB** High back 40/60 The smaller seat is the driver seat and the larger is the passenger seat. With or without armrest or console lid	**Type 7** Low back bucket 40% passenger 60% driver with or without headrests	**Type 7HB** High back 60% driver 40% passenger. With or without armrest or console lid	**Type 8** Solid bench, split back with single armrest and headrest
				
Type 9 High back bench seats, split back with integral headrests	**Type 10** Low back solid bench - split back with or without headrest	**Type 11** Solid bench back & seat with or without armrests or headrests	**Type 12** Solid high back bench	**Type 13** Solid high back bench with split seat and center tray or console
				
Type 14 Bench back, split seat with tray or console, with or without armrest or headrest	**Type 15** Integrated high back bench with gearshift cutout (i.e. Toyota)	**Type 16** Truck Bench with gearshift cutout	**Type 17** Integrated spit high back with solid bench seat	**Type 18** Notchback bench - seats move on single frame, with or without headrests
				

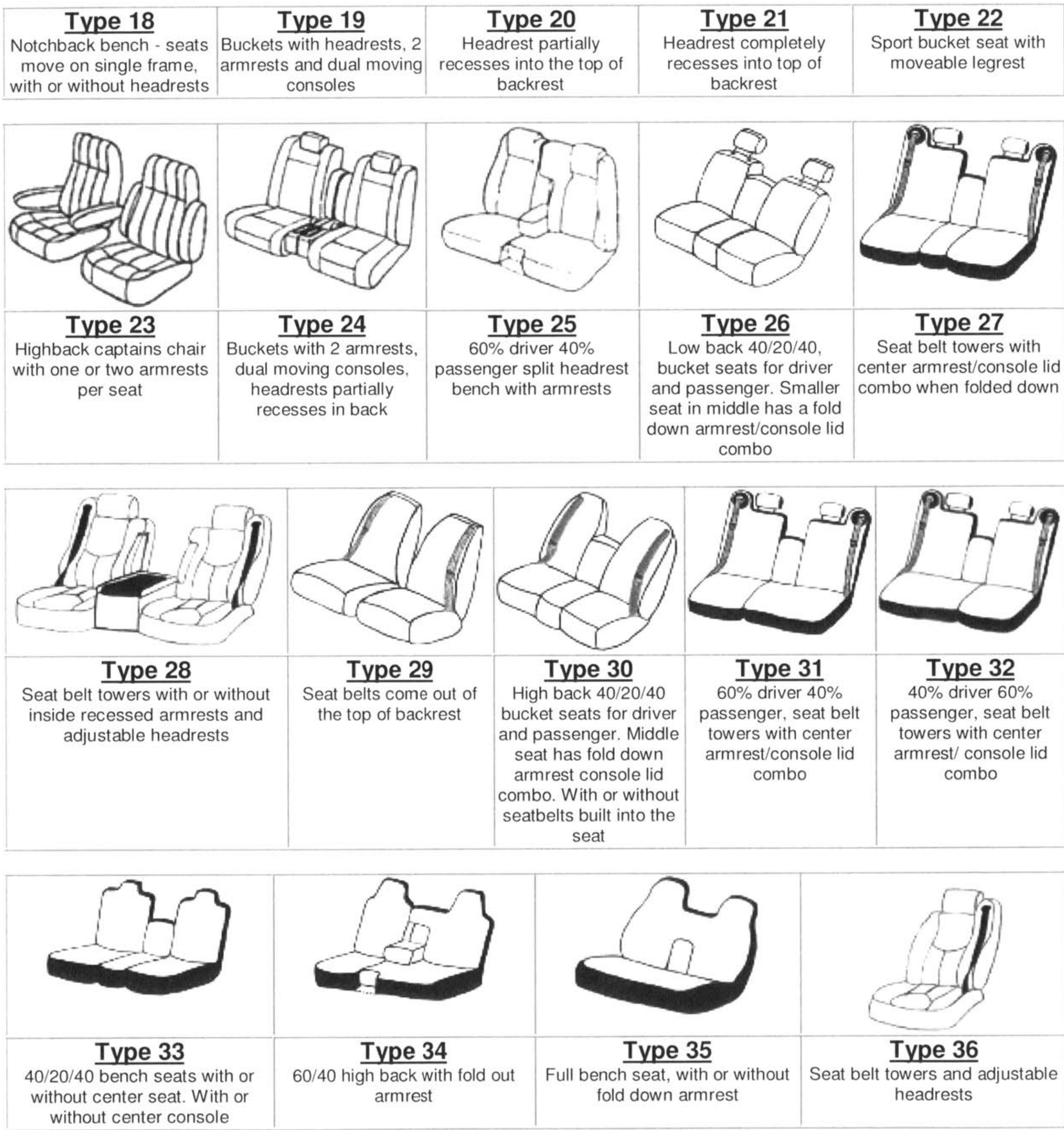
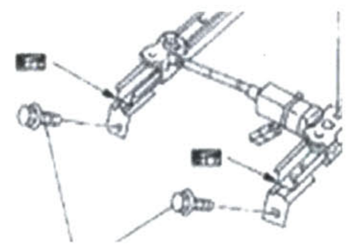
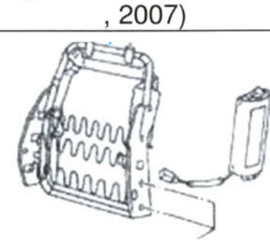
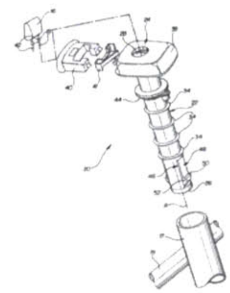
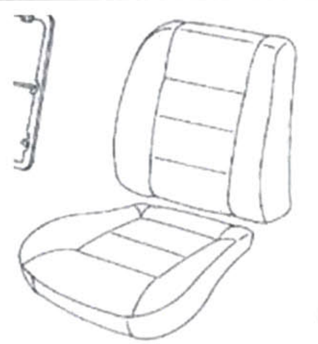
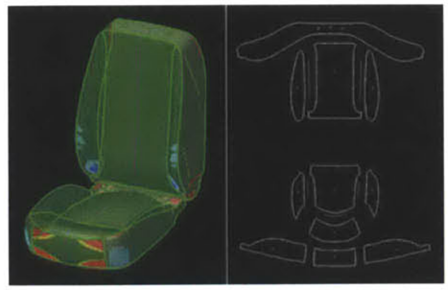


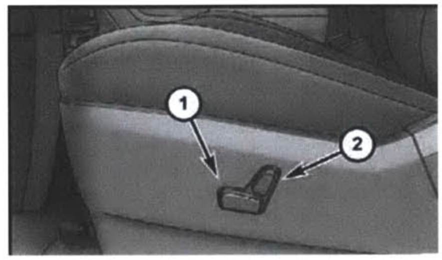
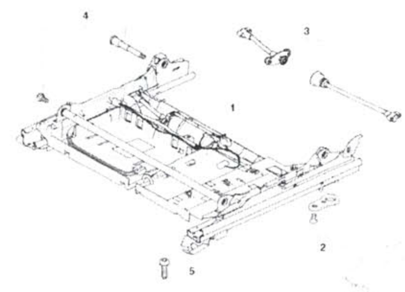
Figure 20 - Seat Categorization According to Architecture (Superlamb, 1995)

During this thesis, I will use a type 1 seat (low back bucket seat with adjustable head restraint and without armrest) which shares most of the same components as the other seat types. This type of seat is integrated by a variety of components; below is a list and description of these components.

Component	Description	Example
OCS	Measures the weight of a passenger to determine his/her size. This information is used by the air bag system	 **Figure 21 - Delphi Passive Occupant Detection System - B** (Delphi Coporation, 2012)
Risers	Attaches and locates the seat in the vehicle	 **Figure 22 - Risers** (G20, 2012)
Lumbar	Supports lower back of the occupant	 **Figure 23 - Lumbar Systems** (Kongsberg Automotive Lumbar Systems , 2007)
SAB	Deploys to prevent injuries during a side impacts	 **Figure 24 - Side Air Bag** (G20, 2012)

CCS	Allows the occupant to increase or decrease surface temperature of the seat	 **Figure 25 - Climate Seats** (Gentherm, 2012)
Guide Sleeves	Seat appearance and lets the occupant adjust (up/down) the position of the head restraint as well as serves to house the head restraint's tubes	 **Figure 26 - Head Restraint Guide Sleeve** (Ford, 2002)
Foam	Gives support and comfort to the occupant and houses the SAB	 **Figure 27 - Foam Pads** (G20, 2012)

Trim Cover	Gives finished appearance to the seat.	 **Figure 28 - Trim Cover** (VISTAGY, 2012)
Head Restraint	Comfort and prevents injuries to the occupant during a rear impact	 **Figure 29- BMW Head Restraint** (OEM, 2012)
Recliners	Mechanism that lets the occupant adjust the seat back angle	 **Figure 30 - MAGNA Recliner** (MAGNA International , 2012)

Switches	Control device that lets the occupant operate the functions of the seat	 **Figure 31 - Switches** (Chrysler, 2012)
Tracks	Lets the occupant adjust the location of the seat (Up/down, fore/aft)	 **Figure 32 - BMW Front Seat Track** (OEM, Real OEM Front Seat Rail, 2012)
Plastics	Appearance of the seat as well as covers sharp edges of the seat structure	 **Figure 33 - Seat Plastic Side Shield** (Parks Off Road, 2012)

Structures	Gives the seat stiffness to support the occupant.	 **Figure 34 - E325i BMW Structure** (Real OEM, 2012)

3d.Baseline – How decisions currently are made

As mentioned in section 1b, the plan was to perform interviews to obtain a baseline of how the company makes the decision to send development offshore. I had the opportunity to talk with the person that manages the headcount for North America as well as with the Global Seats Chief Engineer with experience in Asia Pacific region. Based in this experience he gave me the insight of how the decision is taken in that region as well as Europe. With his current role in North America he confirmed that the information got from the head count manager of North American was accurate, this information is presented below.

They explained that currently the decision to send the development of different subsystems of the vehicle is based on the knowledge of the offshore office. This is because not all the product develop offices has the same expertise level. For example, there are three main offices: Europe, North America and Asia-Pacific, these main offices have a high expertise level on the development of seats. On the other hand there are four support offices or offshore options with a lower level of expertise. This example shows the importance of knowing the expertise level of each of the PD Offices, and is because of this is why the company has a system to measure and monitored the expertise of their engineers so they know what the level of experience is for each of them. (Oden, 2012) (McLoughlin, 2012)

It is common in some companies that different offshore offices develop a specific expertise. This can be based on the product architecture, such as a modular design. With this plan, each office will develop a module that will be integrated at a later time.

The case been studied in this thesis, the company did not decide to offshore modules; it started off shoring subsystems that required a lower level of expertise or that experience could be acquired in a relatively short period of time due to the low complexity of the system. With this method of choosing what is going to be off shored based on complexity in mind, I prepared the following graph which represents all the vehicle's interior systems ranked by complexity. However let me first define "complexity" according to the Merriam Webster Dictionary. Complex is *"a whole made up of complicated or interrelated parts"* (Merriam-Webster Incorporated, 2012). Based on this definition, I can conclude the following: the greater the number of components and interrelationships among them in a system, the more complex the system will be.

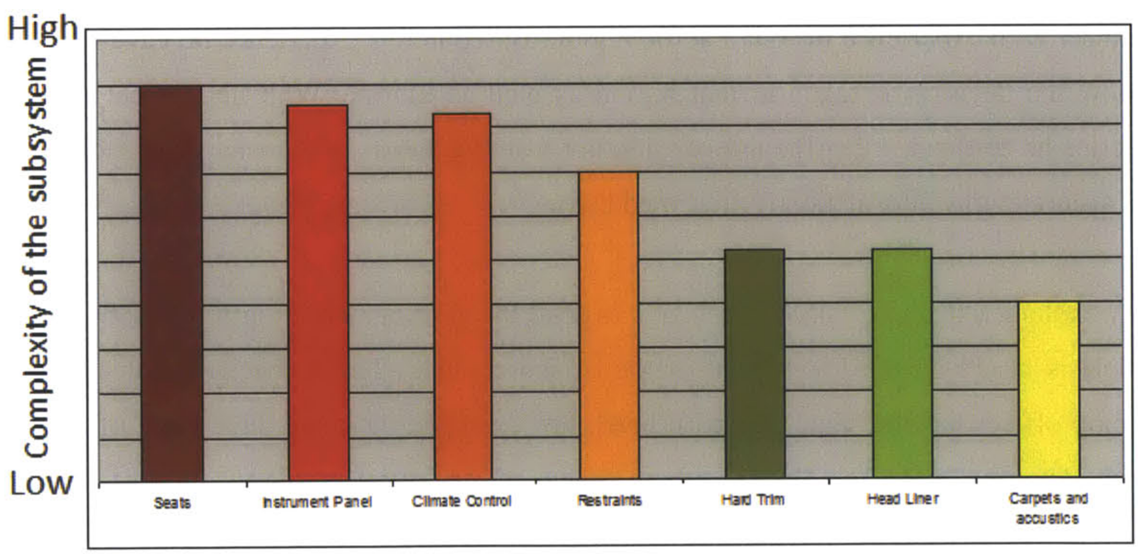


Figure 35 - Interior Subsystems Ranked by Complexity
(Nunez & Zamora, Complexity of Interior Subsystems, 2012)

An example of one of these subsystems offshored to another PD Office is the Hard Trim Subsystem. This is possible because the expertise required to develop this subsystem is low due to the low complexity of the system.

Summarizing, currently the decision to send a subsystem offshore is basically dependent on the complexity of the subsystem and the experience of the engineers in the offshore office. Because of this, the company has created a tool to grade and monitor the expertise of the engineers. This tool is updated and reviewed twice a year by the engineer with his/her supervisor. In this way, each of the offices has a measured overall expertise level which is shared with the company headquarters. The following matrix summarizes the current decision making process.

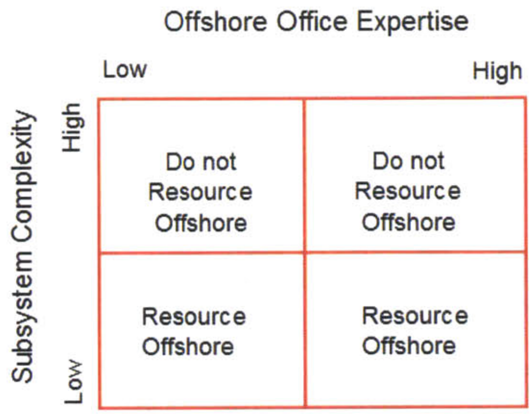


Figure 36 - Offshoring Decision Matrix

Based on the above matrix, the development of the seat subsystem should remain in the headquarters. This conclusion is true if we think about developing all the components of the seat. Yet, this decision can change if the analysis is done at a lower level of the system. This level, represented as level three in the following graph, includes the components of the seat.

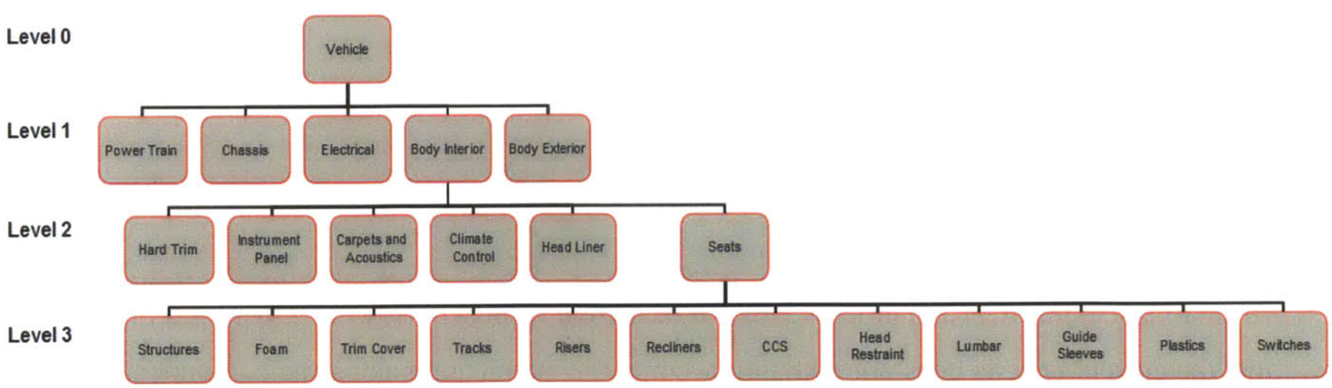


Figure 37 - Vehicle System Levels

Next, these twelve components in level three of the system were organized by degree of complexity. To simplify the analysis the components of the subsystem were organized based only on the number of unique parts without taking into account their interactions.

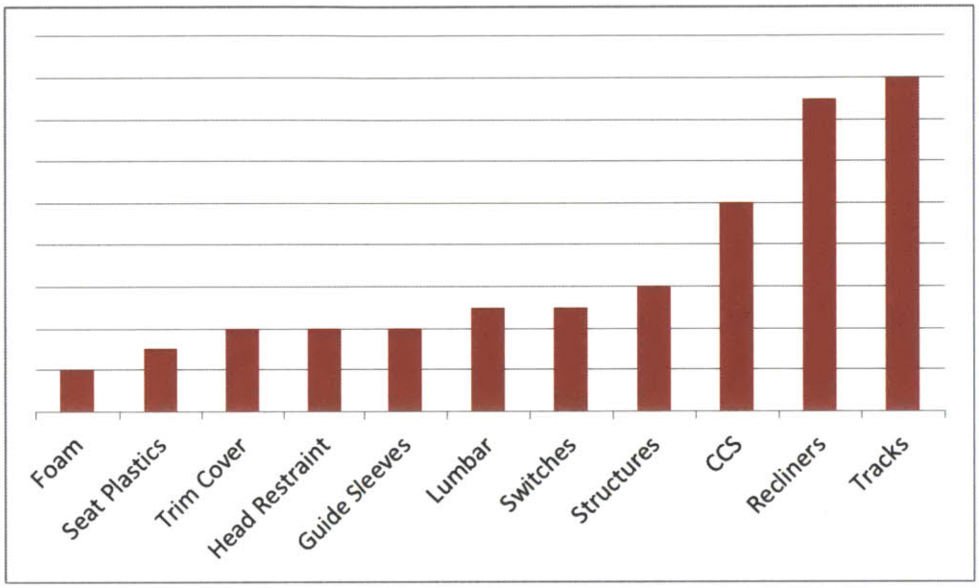


Figure 38 - Seat Subsystem Components Organized by Complexity

By analyzing the complexity of each of the components in level three and applying the current decision criteria, we can conclude that the seat components which should be developed offshore are:

- Seat Plastics
- Trim Covers
- Foam

At first glance, this decision process looks to be a good approach. However, there is a problem in that the current criteria does not take into account the interaction among the components, which also is directly related to necessary communication among the engineers. This high interaction among components may let the company to offshore these groups of components, so the engineers developing these components can have a better communication among them, which will be reflected as a better developing timing. Because of this, in the next chapter I will show an analysis of the relationship among the components of the seat using Design Structure Matrices.

4 Data Collection & Analysis

4a.0 DSM Analysis

This chapter will show the analysis of the seat subsystem as a product, an organization and a process as well as their interactions. The best way to represent this is by using DSMs. A Design Structure Matrix is a tool which assists in a better understanding of the interaction among the components of a system, this can be steps of a process or physical components of a product. Compared with a flow diagram, this tool also gives a graphical representation of these interactions, and makes them easier to understand. There are several definitions for DSM in the literature, however, in this thesis I will reference two:

1. According to Dr. Eppinger and Dr. Browning, *"The DSM is a network modeling tool used to represent the elements comprising a system and their interactions, thereby highlighting the system's architecture"* (Eppinger & Browning, Design structure Matrix Methods and Applications, 2012)

2. Another definition is *"A Design Structure Matrix (DSM) is a two-dimensional matrix representation of the structural or functional relationships of objects, variables, tasks or teams."* (de Weck & Lyneis, 2011)

Different authors define the number of DSM types, but I will use Dr. Eppinger and Dr. Browing classification (Eppinger & Browning, Design structure Matrix Methods and Applications, 2012):

- Static Architecture
  - Product Architecture (Subsystems, Components or Functions)
  - Organization Architecture (Departments, Teams or Individuals)
- Temporal Flow

    - Process Architecture (Sub-processes, Activities or Parameters)
- Multi-Domain
    - Product + Organization + Process

The use of DSMs provides several advantages such as (Eppinger & Browning, Design Structure Matrix Methods and Applications, 2012):

- Conciseness – Large systems can be represented in a small matrix
- Visualization – This matrix gives a system view of the process, organization or product, and highlights the relationship patterns.
- Intuitive Understanding – This visual tool gives a representation that aids in the understanding of the hierarchy and complexity of the system.
- Analysis – DSM makes it easier to identify modules, iterations and relationships, which allow the user to implement other analytical tools.
- Flexibility – This matrix can be adapted according to the necessities of the analysis.

Now that the advantages of the DSM and their types have been clarified, I will use this tool to analyze the Seat Subsystem.

4a.1 Product Analysis

Beginning with an analysis of the Product Architecture, I will be able to identify which are the components with a higher interrelationship among them. As mentioned in Section 3c, during this analysis I am using a low back bucket passenger seat with adjustable head restraint and without an armrest. The components of this seat are listed below:

- Structures
- Foam
- Trim Covers
- Tracks
- Risers

- Recliners
- CCS
- Head Restraint
- Lumbar
- Guide Sleeves
- Plastics
- Switches
- SAB
- OCS
- Seat Complete
- Systems

Using these components, the following DSM was built. This matrix was based on my experience in the Seat Subsystem and on the following Boundary Diagram.

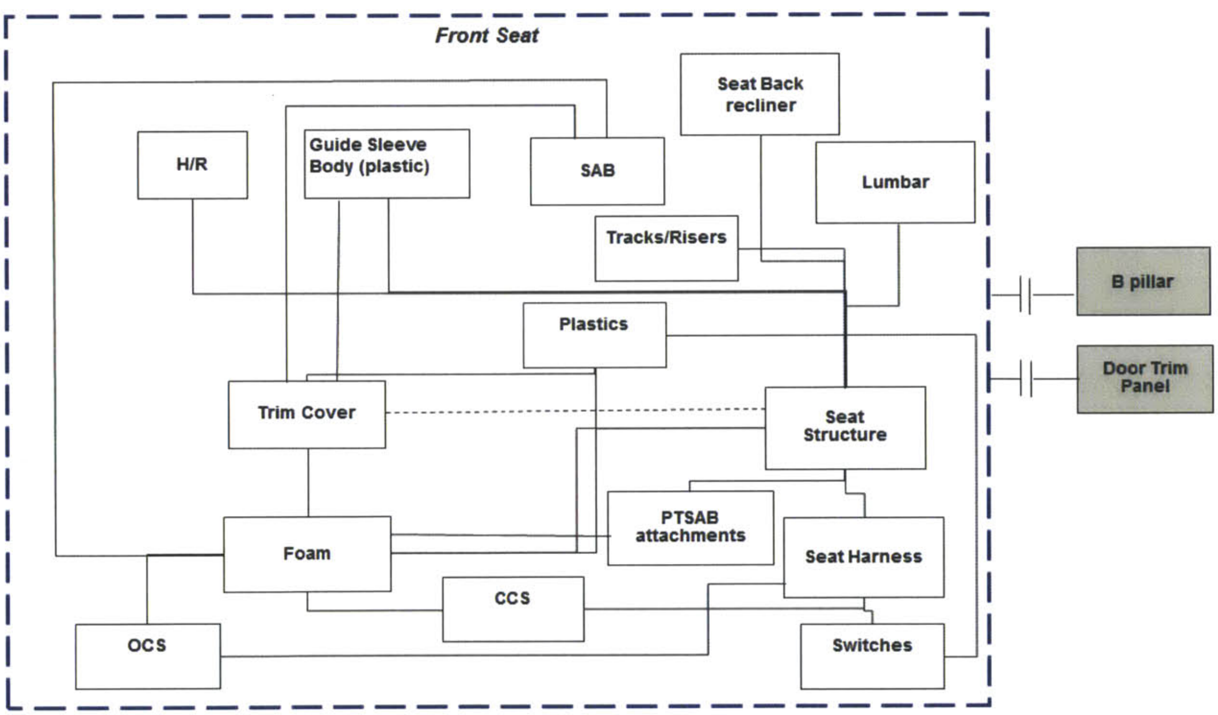


Figure 39 - Front Seat Boundary Diagram

The diagram presented in Figure 40 helped to identify interactions among the components. This diagram also highlights one of the benefits of using DSM, this benefit was to have a graphic representation of the interactions, which is now easier to understand and read. The DSM showing these interactions is given below.

	Structures	Foam	Trim Covers	Tracks	Risers	Recliners	CCS	Head Restraint	Lumbar	Guide Sleeves	Plastics	Switches	SAB	OCS	Seat Complete	Systems
Structures	st	X	X	X		X		x	X	X	X		X	x	X	X
Foam	X	fo	X			x	X	x	X		X		X		X	X
Trim Cover	X	X	tc				X	x		X	X		X		X	X
Tracks	X			tr	X							x		X	X	X
Risers				X	ri						X				X	X
Recliners	X	x				re					X	x			X	X
CCS		X	X				ccs					x			X	X
Head Restraint	x	x	x					hr		X					X	X
Lumbar	X	X							lu			x			X	X
Guide Sleeves	X		X					X		gs					X	X
Plastics	X	X	X		X	X					pl	X			X	X
Switches				x		x	x		x		X	sw			X	X
SAB	X	X	X										sab		X	X
OCS	x			X										ocs	X	X
Seat Complete	X	X	X	X	X	X	X	X	X	X	X	X	X	X	sc	X
Systems	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	sy

Figure 40 - Seat Subsystem Product Architecture DSM

This matrix was built using two levels of interactions: strong and weak. A strong interaction was represented with a capital "X", while a small case "x" was used for a weak interaction. The center of this matrix shows the interactions among the components of the seat. A close relationship between the foam pads and trim covers as well as between the tracks and risers of the seat are easily identified with this matrix. Also, after conferring with Dr. Eppinger, I added the Seat Complete and Systems Functions to the product architecture with the thought that even though these are not actual components, these two functions are significant during the development of the subsystem. (Eppinger, Thesis Review, 2012). The matrix illustrates how these two functions interact with all of the components of the seat during the development process; identified by the marks along the columns and rows for each of these two functions. Although the matrix supports a better understanding of the relationships among the seat components, a reorganization of the matrix will identify the clusters of components which have a higher level of interaction.

The matrix shown in Figure 39 was reorganized based on my experience and knowledge of the seat subsystem and by trying to move the marks or interactions of the components near to the diagonal in order to create blocks or clusters. This reorganization prioritized the strong over weak interactions.

	Risers	Tracks	Structures	Recliners	Head Restraint	Guide Sleeves	Trim Covers	Foam	SAB	Lumbar	CCS	Switches	Plastics	OCS	Seat Complete	Systems
Risers	ri	X											X		X	X
Tracks	X	tr	X									x		X	X	X
Structures		X	st	X	x	X	X	X	X	X			X	x	X	X
Recliners			X	re				x				x	X		X	X
Head Restraint			x		hr	X	x	x							X	X
Guide Sleeves			X		X	gs	X								X	X
Trim Cover			X		x	X	tc	X	X		X		X		X	X
Foam			X	x	x		X	fo	X	X	X		X		X	X
SAB			X				X	X	sab						X	X
Lumbar			X					X		lu		x			X	X
CCS							X	X			ccs	x			X	X
Switches		x		x						x	x	sw	X		X	X
Plastics	X		X	X			X	X				X	pl		X	X
OCS		X	x											ocs	X	X
Seat Complete	X	X	X	X	X	X	X	X	X	X	X	X	X	X	sc	X
Systems	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	sy

Figure 41 – Re-organized Seat Subsystem Product Architecture DSM

With the reorganized DSM, it is easier to identify the "modules" that can be created within the seat architecture. In the matrix shown in Figure 41 the clusters were identified with different colors. The clusters highlighted in this matrix are the following:

Structural Module – Orange Cluster

Integrated by: Structures, recliners, risers and tracks

By the interaction of these components, the seat gets stiffness and structure as well as attachment to the floor sheet metal, and the tracks provide linkage to the cushion pan.

Head Restraint - Green Cluster

Integrated by: Guide Sleeves and Head Restraint

This group shows a physical interaction between these two components. This is because the guide sleeves houses the rods of the head restraint structure.

Appearance -Yellow Cluster

Integrated by: Trim Cover, Foam and SAB

These components also have a physical interaction among them. The foam houses the side air bag and the trim covers the foam for appearance. There is also a relationship between the SAB and trim cover because the air bag deploys through one of the seams of the trim cover. This deployment through the seam gives the air bag direction.

Sideshield – Brown Cluster

Integrated by: Switches and Plastics

The plastic side shield sustains and locates the switches used by the customer to function the features of the seat.

Function – Blue Cluster

Integrated by: Seat Systems and Seat Complete

These two functions are the integration portion of the development process, which means that they need to interact with all components of the seat.

As previously stated, currently the decision of offshoring the development of some of these components is based on the experience of the remote PD Office. This is why I took the advice of my thesis advisor and used a five dimensional DSM to represent the three characteristics that were identified as important to the performance of an office during the development of a product. (Eppinger & Zamora, Thesis Review, 2012)

These variables are:

- Level of Expertise the Engineers Require to Develop the Subsystem – Based on the complexity of the component
- Supplier Available in Alternative Location – Having the supplier near the PD Office gives better opportunity for communication as well as involvement of the PD engineer with the supplier process.
- Engineers' Expertise in Alternative Location – It will be easier to develop a product if the engineers in the offshore office have the knowledge needed. This will also ensures a better quality and reliability of the final product

The levels used for each of these variables are:
Level of Expertise Required – Low (L), Medium (M) and High (H)
Supplier Available in Alternative Location – Yes (Y) and No (N)
Engineers Expertise in Alternative Location - Low (L), Medium (M) and High (H)

With these clusters and variables identified, I will use as an example the office in Mexico to show which group of components or clusters are good candidates to be offshored. The levels of the variables were determined and reviewed based on this specific seat PD Office in Mexico. (Nunez & Zamora, Variable Levels Based on Mexico's Seat Organization, 2012)

	Level of Expertise Required L/M/H	Supplier Available in Alternative Location	Engineers Expertise in Alternative Location	Risers	Tracks	Structures	Recliners	Head Restraint	Guide Sleeves	Trim Covers	Foam	SAB	Lumbar	CCS	Switches	Plastics	OCS	Seat Complete	Systems
Risers	H	Y	L	ri	X											X		X	X
Tracks	H	Y	L	X	tr	X									x		X	X	X
Structures	H	Y	L		X	st	X	x	X	X	X	X	X			X	x	X	X
Recliners	H	Y	L			X	re				x				x	X		X	X
Head Restraint	M	N	H			x		hr	X	x	x							X	X
Guide Sleeves	L	Y	M			X		X	gs	X								X	X
Trim Cover	L	Y	M			X		x	X	tc	X	X		X		X		X	X
Foam	L	Y	H			X	x	x		X	fo	X	X	X		X		X	X
SAB	H	Y	M			X				X	X	sab						X	X
Lumbar	L	N	L			X					X		lu		x			X	X
CCS	M	Y	L							X	X			ccs	x			X	X
Plastics	L	Y	H	X		X	X			X	X				X	pl		X	X
Switches	M	N	L		x		x						x	x	sw	X		X	X
OCS	M	N	H		X	x											ocs	X	X
Seat Complete	M	N/A	H	X	X	X	X	X	X	X	X	X	X	X	X	X	X	sc	X
Systems	M	N/A	L	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	sy

Figure 42 - DSM Based on Mexico's Seat Organization

After adding these three variables, I used them to identify the clusters that can be developed offshore. The optimal situation will be a low expertise required to develop that specific component, a supplier located near the offshore office, and that the expertise of the engineers of this office is high. With this approach, the components highlighted in green in the first column in Figure 42 are the ones that were identified that can be immediately offshored. (Nunez & Zamora, Variable Levels Based on Mexico's Seat Organization, 2012) I split into two phases the offshoring process for this Mexican Office:

Phase 1

The Green Square shows a cluster of the components that give the appearance to the seat. By offshoring these components, there will be a closer relation among the engineers developing each component. Since the Mexican office already has expertise with the Seat Complete and Plastic development, it is suggested that they can be offshored during this phase.

Phase 2

The components highlighted in blue in the first column of the matrix in Figure 42 are the components with which this alternate office needs to invest more resources in order to obtain the needed expertise required to develop these specific components in order to be able to develop these components. These components were also chosen because it was determined that the needed time to acquire this expertise is relatively short. (Nunez & Zamora, Variable Levels Based on Mexico's Seat Organization, 2012)

Once the needed expertise is achieved, the cluster within the red square can be offshored to this alternate PD office. This cluster, in conjunction with the one included in the green square, integrates the "Seat Top-Hat" cluster. I gave this cluster this name because when a Top Hat needs to be developed, it is commonly the components included in this group need to be redesigned. This gives a different appearance to the seat compared with the original or initial seat design.

Assuming that during phase 1 the plastics were already offshored, phase 2 will include the action of offshoring the switches to this office due to the medium expertise needed to develop switches and the relationship with plastics.

I believe that during this phase the development of the Seat Systems function should begin in this offshore office. Because the Seat System Engineer needs to interact with all the components of the subsystem. In addition, if this new office needs to develop a Top Hat, it will be necessary that for the System Engineer to help manage the team. This will result of having the Function Cluster in the new PD office.

4a.2 Process/Organization Analysis

Assuming that the clusters defined above can be developed offshore, an analysis of the interactions between Seats Engineers and the rest of the organization is needed. This analysis will allow us to understand in which phases of the development process there are more interactions with the areas that are not going to be located in the alternate office.

Like in the product architecture DSM, let me first identify which are the areas within the corporation which have more interactions with the Seat organization (Nunez, Seats Manager, 2012):

- Electrical
- Interior Hard Trim
- Interior Soft Trim
- Restraints
- Safety
- Seats
- Sheet Metal (floor)
- Studio
- VO

These elements are now included in the following DSM:

	Electrical	Interior Hard Trim	Interior Soft Trim	Restraints	Safety	Seats	Sheet Metal (Floor)	Studio	VO
Electrical	el	x	x	x	x	x	x		x
Interior Hard Trim	x	iht	x	x	x		x	x	x
Interior Soft Trim	x	x	ist			x	x	x	x
Restraints	x	x		re	x	x	x		x
Safety	x	x		x	sa	x	x		x
Seats	x		x	x	x	st	x	x	x
Sheet Metal (Floor)	x	x	x	x	x	x	sm		x
Studio		x	x			x		sd	
VO	x	x	x	x	x	x	x		vo

Figure 43 - Seat Organization interactions with other Areas DSM

With this matrix, it is easy to identify the close relationship among the Restraints, Safety and Seats areas. These areas need to work closely for various reasons, for example, they need to work together in order to develop a seat which meets SAB performance requirements. This performance requirement involves deployment time and location within specifications. However, in order to identify other interrelations, a reorganization of the matrix is needed. The reorganization followed the same steps used with the Product Architecture DSM. The results of these steps are shown in the next figure:

	Restraints	Electrical	Safety	Seats	Studio	Sheet Metal (Floor)	Interior Soft Trim	VO	Interior Hard Trim
Restraints	re	x	x	x		x		x	x
Electrical	x	el	x	x		x	x	x	x
Safety	x	x	sa	x		x		x	x
Seats	x	x	x	st	x	x	x	x	
Studio				x	sd		x		x
Sheet Metal (Floor)	x	x	x	x		sm	x	x	x
Interior Soft Trim		x		x	x	x	ist	x	x
VO	x	x	x	x		x	x	vo	x
Interior Hard Trim	x	x	x		x	x	x	x	iht

Figure 44 - Reorganized Seat Organization Relationship with other Areas DSM

This reorganized matrix shows that the previous assumption, that close relationships existed just among Safety, Restraints and Seats area was not the complete picture. This cluster also needs to include the Electrical team, which is highlighted in green in Figure 44.

Within the DSM, the red square highlights another group of departments that must work together to develop a seat. These interactions are not as close as the ones included in the green cluster, but one must be mindful that the Seat engineers will need to interact with all of the departments included within the red square. Two other clusters were identified in this matrix, the blue and the shaded one. However, since the purpose of this analysis is focused on the Seat Subsystem, these two clusters will not be analyzed.

So far, the DSMs have shown which components of the seat can be developed in an alternate location and which areas within PD this new location will need to work. The next step is to determine in which phases of the PDP the seat engineers interact more with other areas of PD. This information will help the offshore office to plan needed trips to Headquarters.

My first approach was to use a Domain Mapping Matrix which is a tool that relates two DSM's to identify their relationships (Danilovic & Browning, 2007). I had planned to include the organization DSM from Figure 44 and relate it with the Product Development milestones. After reviewing this with Dr. Eppinger, he suggested that this would be too complicated and that there should be an easier way to represent these interactions. Then, he had the idea of using a heat map to represent the quality of the relationship. A heat map is defined as a "*chart which represents data in a tubular format with user-defined color ranges like low, average, and high.*" (Charts, 2012) The cells of the Seat Organization in the DSM from Figure 44 would be split and separated into cells which represent each of the steps of the PDP. Next, by using a color representation show the strength of the relationship between the seats area and each of the other organizations in each specific step of the PDP (Eppinger & Zamora, 2012).

In this case, the color/number definitions used are the following:

Red 3 – Strong relationship
Pink 2 – Medium relationship
Yellow 1 – Low relationship
White 0 – No relationship

	PDP Phase	PDP Step	Restraints	Electrical	Safety	Seats	Studio	Sheet Metal (Floor)	Interior Soft Trim	VO	Interior Hard Trim
Restraints			re	x	x	x		x		x	x
Electrical			x	el	x	x		x	x	x	x
Safety			x	x	sa	x		x		x	x
Seats	0	1	0	0	0	0	0	0	0	0	0
		2	0	0	0	0	0	0	0	0	0
	1	3	0	0	0	1	1	0	0	0	0
		4	1	1	0	2	2	1	1	0	0
		5	1	1	0	2	2	1	1	1	0
		6	0	0	0	2	0	0	0	2	0
		7	2	2	0	2	0	2	2	2	0
		8	2	2	0	3	3	2	2	2	0
		9	1	1	0	2	0	1	1	1	0
		10	2	2	0	3	3	2	2	2	0
		11	3	3	0	3	3	3	3	3	0
	2	12	0	0	0	1	0	0	0	0	0
		13	0	0	0	3	3	0	0	0	0
		14	0	0	1	2	0	0	0	3	0
		15	0	0	0	3	3	0	0	0	0
	3	16	0	0	0	0	0	0	0	3	0
		17	0	0	0	3	0	0	0	0	0
		18	0	0	0	3	3	0	0	0	0
		19	0	0	3	3	1	0	0	1	0
	4	20	2	2	3	3	0	2	2	3	1
		21	3	3	3	3	0	1	0	0	0
		22	3	3	3	3	0	1	0	0	0
	5	23	0	0	0	3	0	0	0	3	0
		24	0	1	0	3	0	1	1	3	0
		25	0	0	0	3	0	0	0	3	0
		26	0	1	0	3	0	1	1	3	0
		27	0	0	0	3	0	1	1	3	0
		28	0	0	0	3	0	0	0	3	0
		29	0	0	0	3	0	0	0	3	0
		30	0	0	0	2	0	0	0	2	0
		31	0	0	0	0	0	0	0	0	0
Studio						x	sd		x		x
Sheet Metal (Floor)			x	x	x	x		sm	x	x	x
Interior Soft Trim				x		x	x	x	ist	x	x
VO			x	x	x	x		x	x	iht	x
Interior Hard Trim			x	x	x		x	x	x	x	vo

Figure 45 - Seats organization Interaction with other Areas

This new matrix makes it easier to visually identify when the seat engineers will be working closely to each of the other areas within the PD organization. In the following chapter, I will summarize the results of the three DSM's analyzed during this chapter.

4b.0 Choosing an Offshore Office

The analysis performed in Chapter 4 showed the components/functions that can be offshored to an alternate office. In this section I will use three different tools that help choose the best option for the offshore offices location. Then, I will apply these three tools to determine where to offshore the Seat Components between the PD offices in: China, India and Mexico.

4b.1 CAGE Framework (Ghemawat, 2007)

The name of this framework is an acronym for the four "distances" it measures. These distances are: Cultural, Administrative, Geographic, and Economic. The purpose of this framework is to show the distance for each of the four attributes in order to have a better understanding of which option is the best. These attributes are explained below:

Cultural Distance – *"the attributes of a society that are sustained mainly by interactions among people, rather than by the state"* (Ghemawat, 2007) e.g.: language, ethnicities, religion, values

Administrative Distance – Attributes mandated by goverments such as laws and policies. e.g.: currency, trades, weak institutions

Geographic Distance – Attributes derived from the physical location. e.g. physical distance, common boarder, ocean access, time zones, climates, transportation

Economic Distance- *"differences that affect cross-border ecomonic activity through economic mechanisms distinct from the cultural, administrative, or geographic"* (Ghemawat, 2007) e.g.: natural resources, financial resources, infraestructure, knowledge.

Below is the result of applying this framework to this specific case (Modified from Badin, Beristain, & Zamora, 2012)

Country	Cultural Distance	Administrative Distance	Geographic Distance	Economic Distance
United States	☑ Same country ☑ Same language	☑ Same country	☑ Same country	☒ Higher wages
China	☒ Different language ☒ Different work culture ☒ Different values and dispositions	☒ Low IP protection ☒ Unfavorable government regulations	☒ Farther ☒ 12 hours of difference	☑ Lower wages
Mexico	☒ Different language ☑ Similar work culture ☑ Similar values and dispositions	☑ NAFTA work visas ☑ Mexican Government covers part of Engineering expenses in the country ☑ Several automotive suppliers in the country	☑ Close ☑ 1 hour of difference	☑ Low wages
India	☑ Same language ☒ Different values and dispositions ☑ Similar work culture	☑ Other industries have started PD centers in this country	☒ Far ☒ 9 hours of difference	☑ Low wages

Figure 46 - CAGE Framework for Offshore Office

4b.2 ADDING Framework (Ghemawat, 2007)

This frame work helps the company to assess the option of going global by the usage of a value scorecard which evaluates six different aspects: *"adding volume, decreasing costs, differentiating, improving industry attractiveness, normalizing risks, and generating and deploying knowledge."* (Ghemawat, 2007)

Adding Volume

Sales will not be affected by offshoring the development of some of the seat components to an offshore office. However, in regards to China if the PD office designs vehicles for its own market, it may increase company sales. The increase is due to the large potential market in this country and the specific demand for the product.

Decrease Costs

By offshoring development to China, India or Mexico, the company will be significantly reducing costs due to lower wages in these three countries. Among them, China has the cheapest labor costs. Although since China is farther from the United States, travel expenses will be higher. Mexico would be a better option when comparing travel costs to Headquarters due to its geographical proximity to the United States.

Differentiating

By decreasing total engineering costs, the company will be able to develop more Top-Hats from a base program, which means offering various vehicles at a lower cost. In the short term, the office in Mexico is a better option due to experienced engineers currently working there.

Improving Industry Attractiveness

Mexico has a large cluster of automotive suppliers, some of them have manufacturing facilities as well as PD Offices. Other OEM's opened engineering centers in Mexico City due to the proximity of the suppliers. China is starting to attract automotive automakers to open domestic PD Offices due to the large market, better proximity to customers and having a better understand of their specific needs. Recently, India started new product development offices as consequence of Tata buying Jaguar and Land Rover to Ford Motor Company.

Normalizing Risk

By opening alternate PD offices, the company will be reducing risk in case of the closure of Headquarters. With alternate PD offices, the company further reduces risk in the case of future financial crisis that could lead to bankruptcy. An alternate office would allow continued seat development at a low cost.

Generating Knowledge

Offshoring the development of the seats will generate knowledge in these new locations and the company will be able to learn more about the local customers due to being close to them. As stated before, Mexico could easily develop the needed expertise, but China would be good long-term investment due to its growing market.

4b.3 Porter's and Virtual Diamond (Obukhova, 2012)

Porter's and Virtual Diamond is a tool that helps to identify the pros and cons of moving one process or part of a business to another region or country. This tool bases its analysis in four aspects:

Rivalry – Are there any competitors in the alternate region or country? It is beneficial for innovation to have competitors in the region.

Demand Conditions – Will moving to the alternate country increase the sales of the company?

Related and Supporting Industries – Is the infrastructure for your operation developed in this new country? e.g.: suppliers, IT support

Factor Conditions – Government policies, work force, economic factors are some of the aspects reviewed in this aspect.

The following figure includes Porter's and Virtual Diamond analysis of offshoring the components of the seat subsystem to China, Mexico, or India obtained from the DSM.

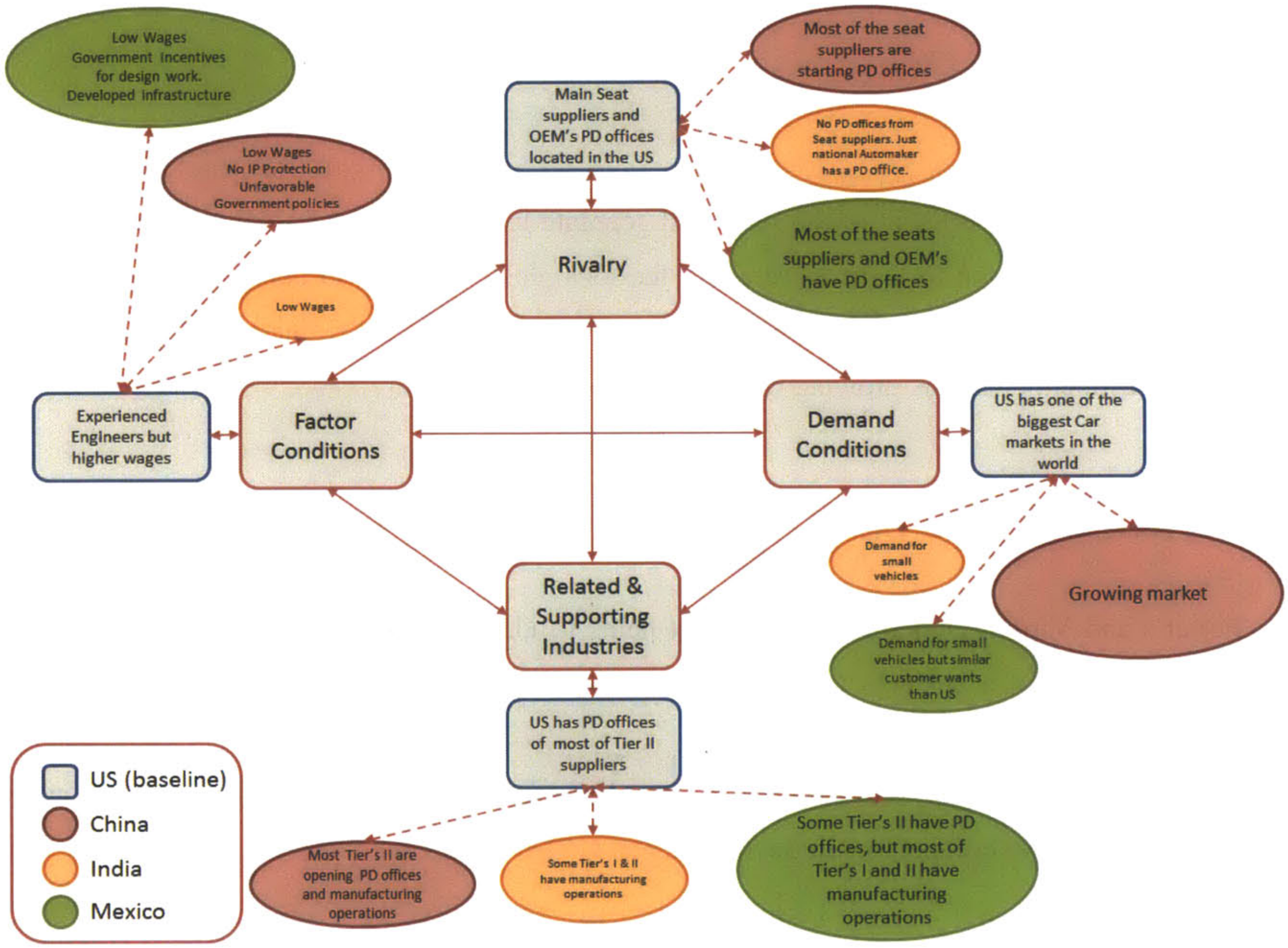


Figure 47 - Porter's and Virtual Diamond
(Modified from Badin, Beristain, & Zamora, 2012)

The results of the three frameworks presented (CAGE, ADDING, and Porter's and Virtual Diamond on this chapter will be interpreted in the next chapter.

5 Results

Chapter 4 presented the analysis performed with DSMs, which were used to identify which components of the subsystem could be sent offshore. Analysis was also done with three different frameworks to determine where offshore the components should be sent. The results of these analyses are explained in this chapter.

5a. Communication Between Offices Based on DSM Analysis

The first DSM shown in Figure 44 suggests that the components that could be offshored are the ones included in the "Seat Top Hat" cluster. This group includes the development of guide sleeves, head restraints, trim covers, foam, SAB and CCS. It makes sense that all of these components should be developed in the same PD Office because this will enhance close communication among the engineers responsible for these components along the development process. Switches and plastics are other components, in addition to the "Seat Top Hat" cluster, that could be offshored to an alternate PD Office according to the analysis.

This same matrix also showed that the Seat Complete and Seat Systems Functions should be relocated to the alternate office. This would help the team to have better communication, and as a consequence better results for the project. Professor Tom Allen explains, *"The likelihood that we will communicate with someone is strongly determined by the distance between us at any time"*. (Allen & Henn, 2007)

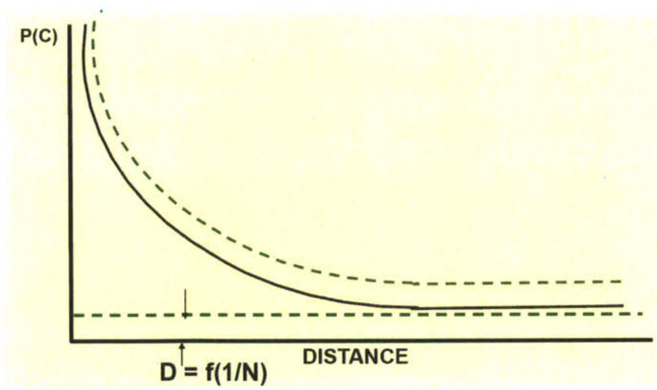


Figure 48 - Communication as a function of Distance (Allen, The Effect of Organization, 2012)

The previous graph illustrates Professor's Allen statement that the larger the distance between team members the lower the probability of communication. This concept supports the results of the DSM to move the Systems and Seat Complete functions to the offshore office. Because these two functions, in conjunction with the components being offshored, are the ones that will be working together throughout the development of the seat.

Professor Allen also presented during one of his lectures the following: Assuming there are an A and B offices in different geographical locations (within the same or in different country); it is always beneficial for communication to have a member of office A located in office B or vice versa. Professor Allen stated that this person from the other office will be a *"bridge for communication."* (Allen, The Effects of Transferring Staff Between Locations, 2012)

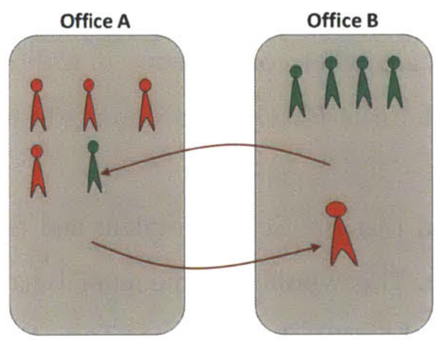


Figure 49 - Bridge of Communication
(Allen, The Effects of Transferring Staff Between Locations, 2012)

This effect of improving communication between two separate locations can be achieved in a variety of ways. The company can send engineers from the offshore office to the headquarters for a small period of time. This will increase communication, but the Low Cost Strategy will be lost due to the expense of the engineers travelling to the main office. This option is also not optimal because why offshore the components if the engineers are going to be in the main PD office?

This is when the results of the matrix shown in Figure 45 are helpful. This DSM shows interactions among Seat organization and other areas as well. As previously stated, this matrix was modified in order to visually identify which phases of the PDP the Seat Engineers will need to be at headquarters or the assembly plant. This information will aid in developing a travel plan for each of the engineers so that resources can be spent efficiently. In addition, this matrix illustrates not just the six phases of the PDP stated at the beginning of this thesis; it also gives the specific 31 steps of a PDP. This matrix is also a perfect tool to quickly identify the phases where there is more interaction within a specific area. Further explanation from the DSM analysis is below.

Phase 1

Seats Engineers will be in continuous contact with Studio Engineers, and most of the PMT's (Program Management Teams) working to define the initial concept of the seat. Because of this continual close work, it is recommended that at least one member of the team be located in the main office until the seat concept is define. This person could be the seat complete or systems engineer.

Phase 2

Since there is still frequent interaction with studio, the representative of the offshore office can go back to the alternate location for a short period of time, returning to the main office to finalize surfaces.

Phase 3

Most of the interaction during this phase is with members of the seat area, assuming the "Top-hat" cluster is located in the offshore location. The whole team can work at this offshore location while keeping in close communication with the team at the main office via email, conference calls and/or virtual conferences.

Phase 4

Assuming there is not a testing infrastructure in the offshore office, it is recommended that during the testing phase an engineer travels to the main office to review the testing samples as well as the test results. These tasks could also be performed by a test engineer located at the main location, who could be assisting with various programs from the offshore office.

Phase 5

During this phase it is imperative that at least the seat complete engineer supports the launch of the seat in order to solve the issues aroused during the prototype builds.

Another way to create a bridge of communication, which is actually implemented in the corporation where I am employed, is to send supervisors or/and managers from the Headquarters to the offshore office. This action presents several benefits, such as: increasing communication between offices, improving knowledge of the seat development, and transferring experience to members of the offshore office Top management will be more confident about off shoring product development to an alternate office since they know that the team will be managed by an experienced person from the main office. The relocation of supervisors and managers from Headquarters to the offshore location can be done for just a specific period of time while the offshore team gains the knowledge needed and then be managed by someone from their own office.

In regards to the Systems Engineer Function, I am suggesting two different scenarios:

- If the entire vehicle is developed in an offshore location; this would include the Chief Nameplate Engineer being in the same location. The Seat Systems Engineer should also be located in the offshore office since most of the team will also be located there.
- If only the seat is developed offshore, the Seat Systems Engineer should be located at the main PD office. This engineer will be the bridge of communication and the face of the team at Headquarters.

The two above options can be applied over the time as two sequential phases according to the experience the offshore office acquires. It is assumed that this offshore office will begin with developing just a few components until it then reaches a point of being able to develop the complete vehicle or Top Hats. This assumption is similar to what Dr. Eppinger and Professor Chitkara explain in their paper referred to section 2b of this thesis. (Eppinger & Chitkara, The New Practice of Global Product Development, 2006)

5b Selecting an Offshore Office

The CAGE framework helped in understanding the various distances between the main office (US) and the three optional low-cost country offices to which the components revealed from the DSM could be offshored.

Upon evaluation of the Cultural Distance, China is easily identified to be the farthest country due to the fact that they do not share language as well as a work culture with the US. Further examination reveals that there is not much of a difference between the cultural distance from the US to India and the US to Mexico. Both offshore options have a similar work culture as the US, so it would be comparable to work with either India or Mexico

The administrative distance to Mexico is the closest because the Mexican government sponsors companies supporting the development of research or engineering within the country. This benefit, in addition to the NAFTA, makes it easier to deal with Mexican engineers. In contrast, China government does not have policies in place to protect intellectual property, which is a risk for any company performing product development within its borders.

The most common distance evaluated in this type of analysis is the geographical one. In this case, it is obvious that Mexico is the best offshore option due to proximity and negligible difference in time. A flight from Mexico City to the US is easily managed if an engineer must travel from the main office to the alternate one or vice versa. Also, there is only a one-hour time difference between Mexico City and the US (EST). However, there are also benefits to a nine-hour time difference as is the case for India. This time difference could be used to start a 24/7 PD office. When one shift finishes working, the alternate location would continue the work so that progress never stops. In theory, this strategy sounds perfect, but unfortunately it is hard to perform or almost impossible. (Eppinger & Chitkara, 2006) In this case China is the farthest country to the US so it is not an optimal option.

Considering the economic aspect, China has an advantage due to the low wages in this country. However, considering geographical locations, travel expenses from the US to China or India will be higher compared with travel from the US to Mexico.

The ADDING framework helped in understanding what the company would gain by offshoring the seat subsystem components. By offshoring product development to China, the company would enter a potential new market in this country; however, the purpose of this thesis is to analyze offshoring the development of components of the seat subsystem for global products, not national ones. Developing national produts in China should be part of a separate analysis. None of the offshoring options will directly increase the volume or sales of the company.

All of the three offshoring options analyzed in this thesis will decrease product development costs due to low labor costs. China and India have lower wages than Mexico, however higher travel expenses to these two countries offsets these savings. Travel expenses to Mexico are the lowest, but these cost savings are not comparable to the savings related to low wages. Yet, all three countries could decrease Product Development costs, and lower costs relate to potential differentiation for the company. The rationale behind this is that the company will have more money to invest in new global products. Assuming that the offshore office will be developing Top Hats, the company will have the opportunity to offer a large variety of products from the same platform.

The Mexican office also is better in regards to the Improving Industry Attractivness aspect. Mexico has an important group of suppliers already established, and some of these suppliers have their own facilities with PD centers. China may look like a good long-term option and most automakers are opening PD offices in this country, however the experience of the engineers is low at this time.

From the Normalizing Risk and Generating Knowledge point of view, Mexico will have better results due to the closessness to the US. If for some reason the main PD office in the US needs to close, it will be a short trip for the American engineers to Mexico to maintain operations. Other than that there is not major benefit in these categories of offshoring product development to any of the countries analyzed.

Figure 47 includes the results from Porter's and Virtual Diamond comparison. From the diagram in Figure 47, I used the size of the circles to determine the benefits of offshoring seat development to each of the countries analyzed. For example, Mexico appears to be a better offshoring option from the Rivalry, Related & Supported Industries and Factor Conditions categories. On the other hand, China would be the best option in reagards to Demand Conditions due to its growing market. From just these four categories, India does not seem to be a viable option for offshoring seat product development. Yet, it is important to highlight that offshoring PD to any of these countries would benefit Headquarter with the perspective from these four points of view.

The following matrix in Figure 50 sumarizes the results from these three frameworks with a quantitative approach. The three offshoring options were evaluated according to each aspect of the frameworks. The evaluation was based on the previously stated analysis and represented with a value from 1 to 3. A value of 1 was the least favorable option and 3 was the best option.

Framework	Aspect Evaluated	Offshoring Option		
		China	India	Mexico
CAGE	Cultural Distance	1	2	3
	Administrative Distance	1	2	3
	Geographical Distance	1	2	3
	Economic Distance	3	2	2
ADDING	Volume	2	1	1
	Decrease Costs	3	2	2
	Differentiating	2	2	3
	Improving Industry Attractiveness	2	2	3
	Normalizing Risk	2	2	3
	Generating Knowledge	3	3	3
Porter's and Virtual Diamond	Rivalry	2	1	3
	Demand Conditions	3	1	2
	Factor Conditions	2	1	3
	Related & Supporting Industries	2	1	3
	TOTAL	**29**	**24**	**37**

Figure 50 - Choosing Offshore Location Frameworks Summary & Evaluation

This matrix shows that overall the best option to offshore the seat subsystem components is Mexico's PD office. This is assuming that the Headquarters are located in the US.

6 Recommendations

6a.0 Transformation of the Organization

Chapter 5 showed which components of the Seat Subsystems can be offshored and where would be the best option to do this based on the analysis of Chapter 4. During this chapter, I would like to propose how the organization needs to be changed or adapted in order to support the offshore strategy. I will use three methodologies; the first one is the Enterprise Architecture Sequence Model from Dr. Donna H. Rhodes and Prof. Deborah J. Nightingale (ESD.38 Enterprise Architecture), the second one is the 4P's of Strategy, and the last one is the Seven Strategy Questions, the last two are from Prof. Robert Simons (Simons, 1373 Designing Winning Organizations , 2012) (Simons, 4P's of Strategy, 2012)

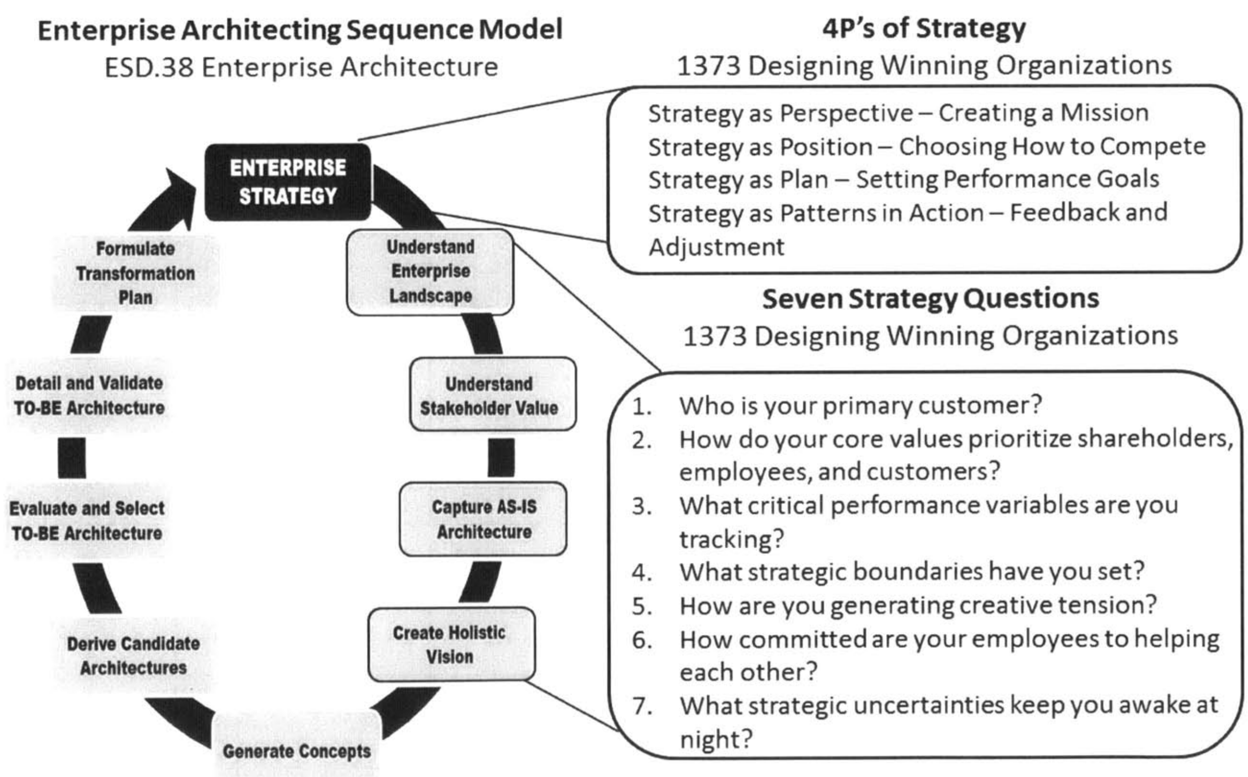


Figure 51 - Adapting the Organization Methodologies
(Nightingale & Rhodes, 2012)
(Simons, Performance Measurement & Control Systems for Implementing Strategy, 2000)
(Simons, 1373 Designing Winning Organizations , 2012)

As shown on Figure 51, these three methodologies are complement each other. The ten steps of the Architecting Sequence Model are going to be base used to define recommended reorganization of the Seat Subsystem. However, the Seven Questions and 4P's from Professor Simons will help giving a better understanding of the current organization, which are steps two to five from the Architecting Sequence Model and the strategy of the Seats Organization which is step one.

6a.1.1 Enterprise Strategy

The strategy of the Seat Organization was defined and explanied in section 3b.2 of this thesis, which was based on the 4P's of Strategy. Below is a summary of the strategy:

Strategy as Perspective – Creating a Mission
Harnessing diverse global talents to develop world class products that excite the customer, leveraging scale while meeting individual customer needs.

Strategy as Position – Choosing how to compete
To have global:

- Seats Structure Platform
- Comfort DNA
- Materials Specifications
- Design Rules

Strategy as Plan – Setting Performance Goals
The strategy is cascaded throughout the entire enterprise starting with the objectives score card of the company (CEO) until it reaches the individual objectives of each of the engineers within the Seat Organization.

Strategy as Patterns in Action – Feedback and Adjustment

The strategy as Plan ensures that the objectives of each of the engineers are aligned with the strategy of the company. Yet how does one ensure that the engineers are achieving these objectives? With Strategy as Patterns in Action the objectives of each of the members of the organization are reviewed twice a year with their direct supervisors. It is in the mid-year review where some of the objectives can change in order to reflect the real needs of the organization.

6a.1.2 Understand Enterprise Landscape

The Seat Organization Landscape was explained in section 3a.0, which includes the description of Seat Design and Development, Manufacturing Industries and the Seat Product Development Process. In Section 3b.3, the stakeholders and their needs were identified.

Stakeholder	Needs
Program	On time delivery of Seats Cost effective designs
Suppliers	Specifications Timing
Purchasing	Cost effective designs Specifications
Assembly Plant	Easy to assemble On time delivery of Seats
Studio	Engineering feasibility Product to support their surfaces
Marketing	Features Appearance
Final Customer	Comfort Appearance Features
Regulatory Agencies	Regulations Compliance
Employees	Challenges Training Working tools
Other Subsystems	No interferences

6a.1.3 Undestand Stakeholder Value

The previous step helped in understanding the surroundings of the organization as well as identified its stakeholders. The objective of this step is to identify the priority that each of the stakeholders have in the organization. This ranking was based on three criteria: the power that each stakeholder has, legitimacy, and urgency. This prioritization is called the Stakeholder Salience, and it is shown in Figure 47.

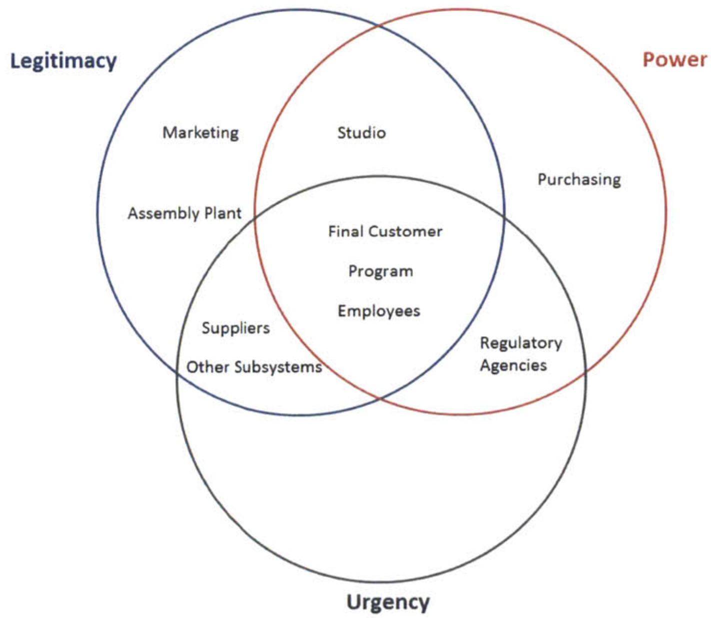


Figure 52 - Seat Organization Stakeholders Priority

The priority or importance of each of the stakeholders is compared to the value delivered to the stakeholder from the enterprise. These comparison are shown in the following Figure 48:

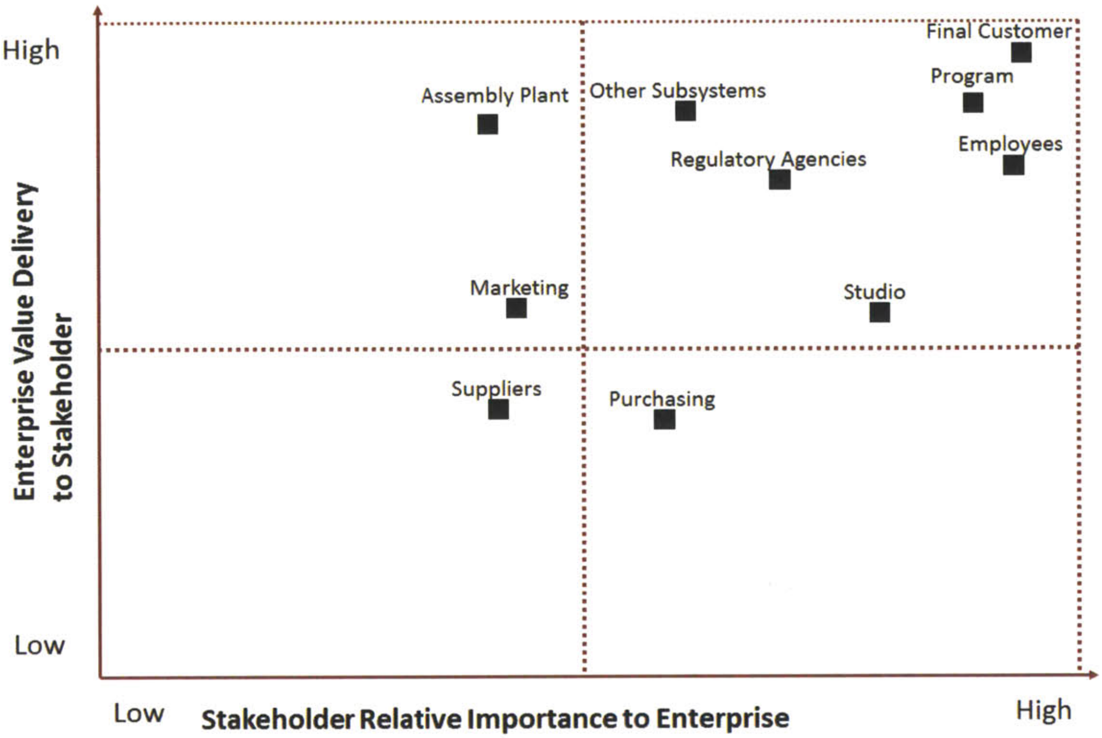


Figure 53 - Seats Organization Value Delivery to Stakeholder vs. Stakeholder Relative Importance to Seats Organization

Figures 52 & 53 show that the most important stakeholders for the organization are: Final Customer, Program and Employees. However, accroding to Professor Simons, *"The first imperative and the heart of every successful strategy implementation is allocating resources to customers."* (Simons, 1373 Designing Winning Organizations , 2012). This means that the organization must define its primary customer in order to allocate the necessary reosources to satisfy the needs of the customer. Otherwise, the enterprise will be splitting resources among different stakeholders, and the necessities of the primary customer might not be completely fullfille. Thus, this is the base of the first Seven Strategy Questions.

Who is your Primary Customer?

A good method to identify the primary customer is to look at the strategy as perspective of the organization.

Harnessing diverse global talents to develop world class products that excite the customer, leveraging scale whilst meeting individual customer needs

At a first glance it appears that the primary customer is the employees because it specifies that the organization needs to take advantage of the various talents in each of the offices around the world. However, the mission mentiones twice the final customer, which tells that the real primary customer is the final customer. This is because the Seat Organizationis focused in developing seats with a world class quality, appereance, and performance, which need to excite and meet the needs of the final customer. This explanation clarifies that the Final Customer is the primary customer and most of the resources must be allocated to satisfiy his/her needs. It is also from this mission where the answer for the second of the Seven Questions of Strategy can be answered.

How do your core values prioritize shareholders, employees and customers?

The mission shows that the customer is the must important stakeholder, even above the employees and shareholders. This is reflected in the core values of the organization. The Seat Organization has three core values: safety, reliability and innovation. The first one is related to the safety of the driver and passengers, reliability means that the seat needs to perform its function all the times, and if possible this needs to be done in a new way which is the third core value.

The organization makes it clear that safety is always above everything, which tells us that the customer is over the employees and shareholders when making decisions. This priority is reflected in the design rules and decisions made within the organization.

6a.1.4 Capture AS-IS Architecture

The current architecture of the Seat Organization was explained in section 3b.0 of this thesis. Below are figures that illustrates this architecture. These figures show how the architecture is a hybrid of Local Value Creation and Expert Knowledge Unit structures. Each Regional Seat Office has Expert Knowledge architecture because they are divided by experience for each component: such as Structures, Plastics, Foam or Trim Cover. The architecture among these local offices is a Local Value Creation.

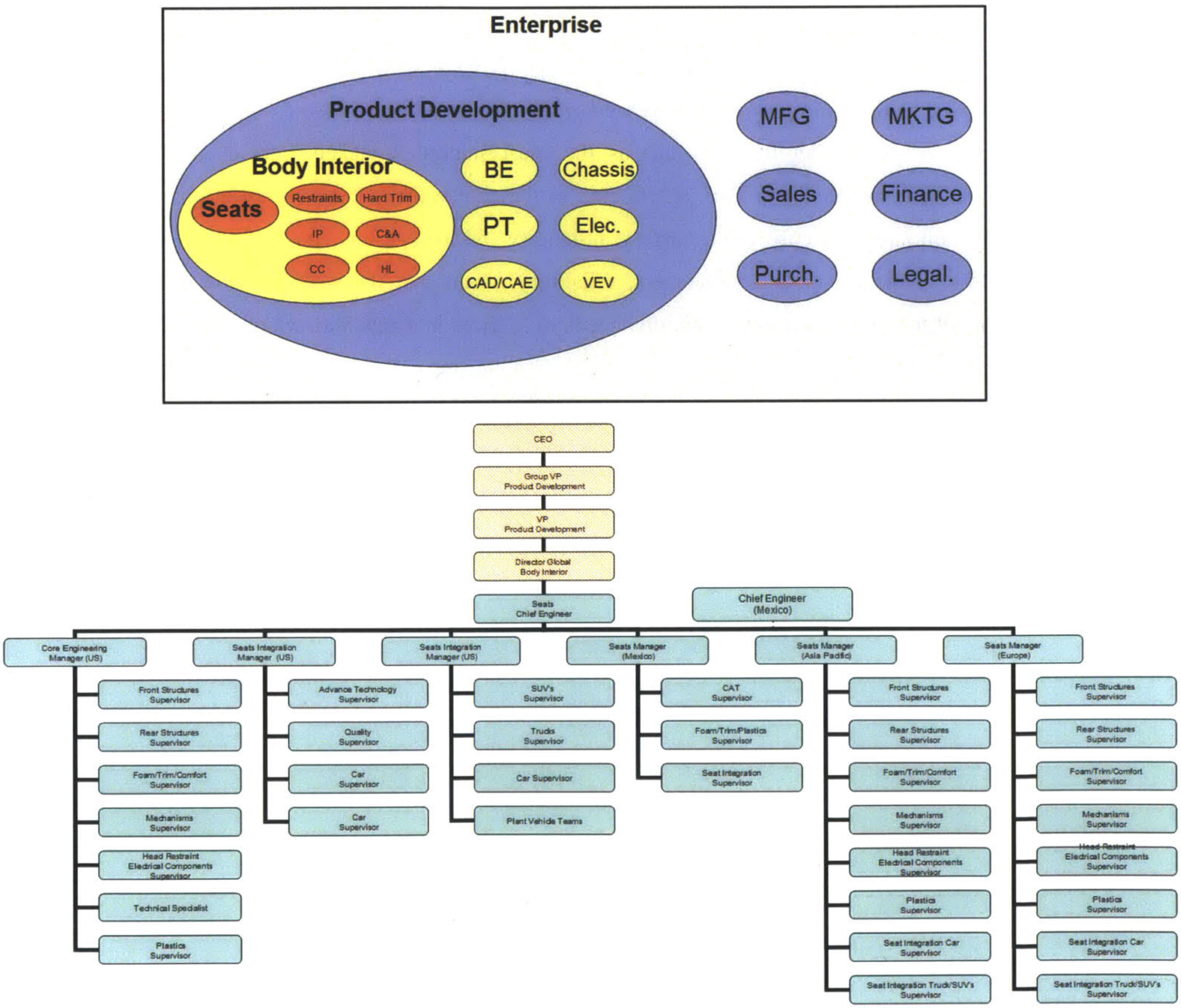


Figure 54 - AS-IS Architecture

In order to know how this architecture is helping the organization to achieve its objectives, I am going to answer questions three to six from Professor Simons' *Seven Strategy Questions:*

What critical performance variables are you tracking?(Simons, 1373 Designing Winning Organizations , 2012)

A Balance Socrecard is used to track the performance variables. These variables are divided within the scorecard in the following main areas: Quality, Costs, Product Deliverable and People. These four main areas summarize all the critical variables that need to be closely followed in order to determine the performance of the company.

The quality portion tracks the warranties, TGW's, R/1000 of the seats for the vehicles in production. These metrics are critical to the future success of the company because a large amount of claims will mean that customers will not consider in buying the same brand in the future. After the 2008 financial crisis, cost metrics are as important as all the other ones. The company needs to ensure that reosurces are spent efficiently. This portion of the scorecard mesures the cost of the seat per vehicle which needs to be in accordance to the annual target set at the beginning of the year. The Product Deliverable section helps management track if the seats designed are delivered on time to the programs. This timing is controled by the specific program according to the PDP of the company.

People, the last section of the scorecard is a critical variable with the current strategy. Since there are many new hires in the offshore offices, this metric helps the company to know the expertise of each of the engineers working within the Seat Organization. This metric, similar to the other ones, has an annual target that each of the offices around the world must achieve.

Professor Simmons asked us during his lecture, which were the Critical Performance Variables that if missed, would cause the strategy to fail? Answer

1. Safety
2. Reliability
3. Deliverables on time
4. Expertise
5. Wages at low cost countries

The first two variables are part of the core values of the company. If the company does not track these variables, there will be a risk of future recalls leading to a tremendous failure to the primary customer. If the primary customer stops buying vehicles, then the company's market share will decrease. If the third variable, on time delivery is missed, this could give competitor an advantage with earlier launch of their product, which could mean a potential decrease on the market share. Expertise, variable number four, must be tracked, because the quality of the final product depends on the expertise of the engineers, even the engineers in the growing offshore offices. The last variable, wages at low cost countries, is critical because the Low Cost Contry Strategy, is based in the assumtion that the wages on these low cost contries is cheaper than in the main offices.

What strategic boundaries have you set?

There are different strategic boundary systems within the Seat Organization: design rules, internal audits, PDP deliverables, TDR (technical design reviews) and one pagers.

The design rules give the engineers guidelines of what to avoid while designing their subsystems, i.e., not having sharp edges on the seat structures. These rules guide non-expert engineers during the development process. Internal audits and PDP deliverables are established in order to review the work of the engineer during the development process. These procedures and boundaries ensure that the engineer is not cutting corners and that safety and reliability are at an optimum. TDR is the process in which each engineer presents his design to management and the technical specialist so possible failure modes are not missed. The technical design review is conducted in order to ensure that all the designs comply with safety requirements. Finally, a one pager is a document in which design changes require an investment are approved. With this boundary, management reviews changes required by any other area (i.e., marketing). If the change goes against the core values of the company, management will reject the change in order to avoid wasting resources that are not aligned with the company's strategy.

These processes are related to the Dangerous Triad, also presented by Professor Simmons in which he defined three situations that if presnet, an employee will make poor decisions. (Simons, Dangerous Triad, 2012):

1. Rationalization – Not having established rules set can allow the employee to think a bad decision is a good one
2. Performance Pressure – Pressure from the organization or management to achieve high objectives
3. Opportunity – The situation, such as an emergency, makes it easy to reach a poor decision.

In the Seat Organization, management does not apply too much pressure on the engineers. This situation is because in a PD office management wants the engineers to follow established processes, innovating when necessary yet within guidelines and design rules. Due to internal audits and PDP deliverables, engineers understand what they need to do and when it needs to be done, so there are few opportunities to make poor decisions. In regards to rationalization, management always "walks the talk" so the engineers cannot rationalize doing something outside of the boundaries.

Professor Simons developed the Risk Exposure Calculator, which defines for a company the likelihood of employees making errors that would put the company's strategy at risk. According to the calculator, the Seat Organization is in the Safety Zone because the total score is below 20.

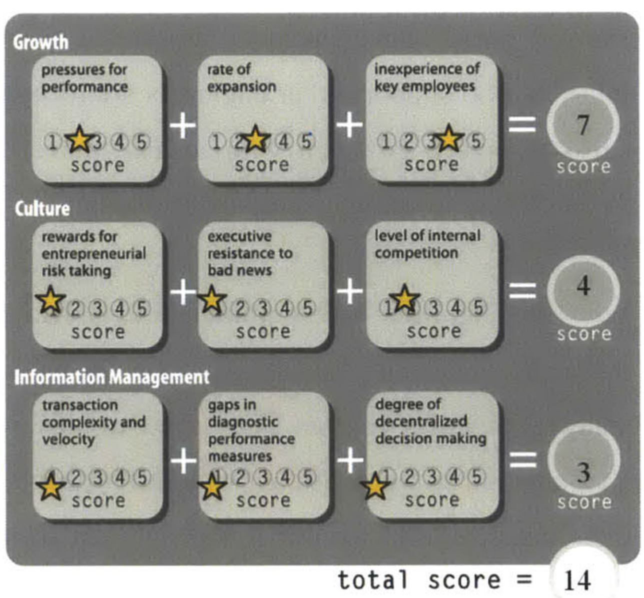


Figure 55 - Seats Organization Risk Calculator
(Simons, How Risky is Your Company?, 2009)

The Seat Organization needs to be in the safety zone because the work of both Product Development and the Seat Subsystem is with seats, a safety item within the vehicle. Management does not want engineers to be more entrepreneurial and add unnecessary risk to the process. Innovative ideas should be presented a step prior to Product Development, which is Research and Development.

How are you generating creative tension?

As shown in Figure 45, the Seat Complete and System Engineers interact with many other areas within the enterprise, obtaining specific information and results from other divisions. However, having the need to obtain this data does not mean that the Seat Complete and Systems Engineers have power over these other areas. In other words, the engineers are accountable for more than that which they have control. The organization generates creative tension with the engineers seeking ways to obtain the needed information.

How committed are your employees to helping each other?

Due to the recent creation of offshore offices, management has been clear that all employees should be helping each other when necessary because inexperienced engineers need to gain knowledge from experienced ones. Management established a program called "Peer to Peer Recognition" where engineers who support other engineers are recognized in front of the entire organization and they also receive a gift card with a small monetary amount. This weekly recognition motivates the engineers to continue helping each other.

Another example of how the engineers are committed to assisting each other within this organization occurred during the financial crisis. At that time, the workforce was reduced, as was the situation within many companies in the US. Due to this reduction, engineers were challenged to produce the same amount of work but with fewer people to do so. Thus, engineers started helping each other complete tasks even if it was not their own responsibility. Based on these two examples, I can say that most of the engineers within the Seat Organization are committed to help whenever they can.

6a.1.5 Create Holistic Vision (TO-BE Architecture)

A new holistic vision was created to represent the needs of the organization.

Strategy as Perspective – Creating a Mission

To deliver on time seats to the program *by* innovating and developing best in class seats *with* system and failure mode avoidance approaches *while* taking the final customer needs, safety, costs, appearance, functionality, reliability and feasible to manufacture/assemble into account.

This new mission was applied to the stakeholders and their needs, presented in the following matrix.

Mission	Stakeholder	Needs
To deliver on time seats to the program	Program	On time delivery of seats Cost effective designs
To deliver on time and feasible to manufacture/assemble	Suppliers	Specifications Timing
To deliver on time and feasible to manufacture/assemble	Assembly Plant	Easy to assemble On time delivery of seats
by innovating and developing best in class seats	Studio	Engineering feasibility Product to support their surfaces
by innovating and developing best in class seats	Marketing	Features Appearance
by innovating and developing best in class seats *with* system and failure mode avoidance approaches *while* taking the final customer needs, safety, costs, appearance, functionality and reliability into account.	Final Customer	Comfort Appearance Features
Costs	Purchasing	Cost effective designs Specifications
Safety	Regulatory Agencies	Regulations compliance
by innovating and developing best in class seats with system and failure mode avoidance approaches	Employees	Challenges Training Working tools
appearance, functionality	Other subsystems	No interferences

6a.1.6 Generate Concepts

With the holistic vision created in the previous step, new concepts were generated based on the assumption that the DSM analysis presented in chapter four would be applied to each of the offshore offices. Under this assumption, the concepts will need to assist the company in following its strategy as well as satisfy the needs of the primary customer and the stakeholders.

The following Architecture Concepts were generated:

- Global Programs Architecture
- Global Expert Knowledge Hubs
- Regional Offshoring

6a.1.7 Derive Candidate Architectures

<u>Global Programs Architecture</u>

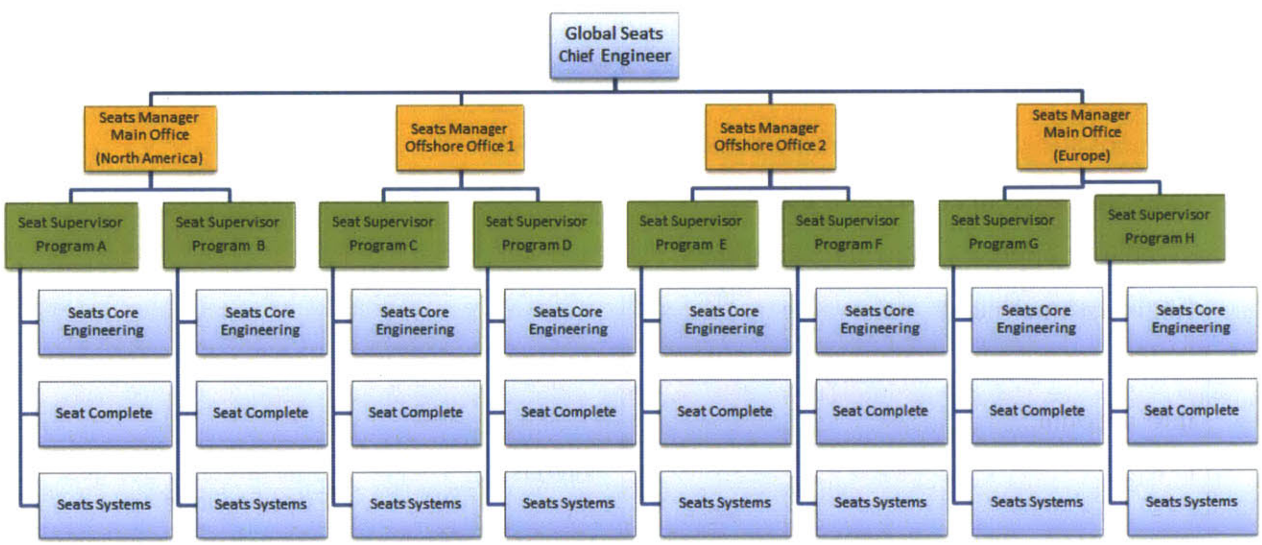


Figure 56 - Global Programs Architecture

The idea behind this architecture is to design and develop the seats globally for various programs. With this organization each of the offices around the world will have responsibility for specific programs. These offices will need to adapt the seats from their own programs to comply with regulations from each of the regions around the world. Under this structure each office will be independent of each other when designing the tophat of the seat, but each office can still use a global structure for the seats.

Global Expert Knowledge Hubs

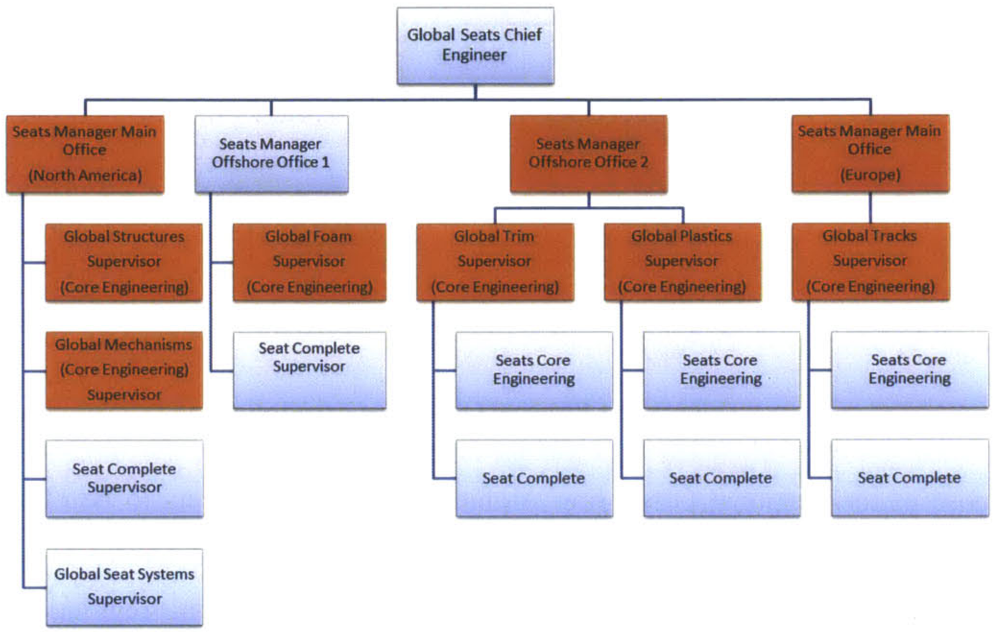


Figure 57 - Global Expert Knowledge Architecture

The Global Expert Knowledge Architecture's main objective is to develop expertise for specific components of the seat in each region. The component expertise for each office will be determined by performing a DSM analysis, similar to the example shown for the Mexican Office in chapter four. With this organization each region will be developing components for all markets around the globe.

Regional Offshoring

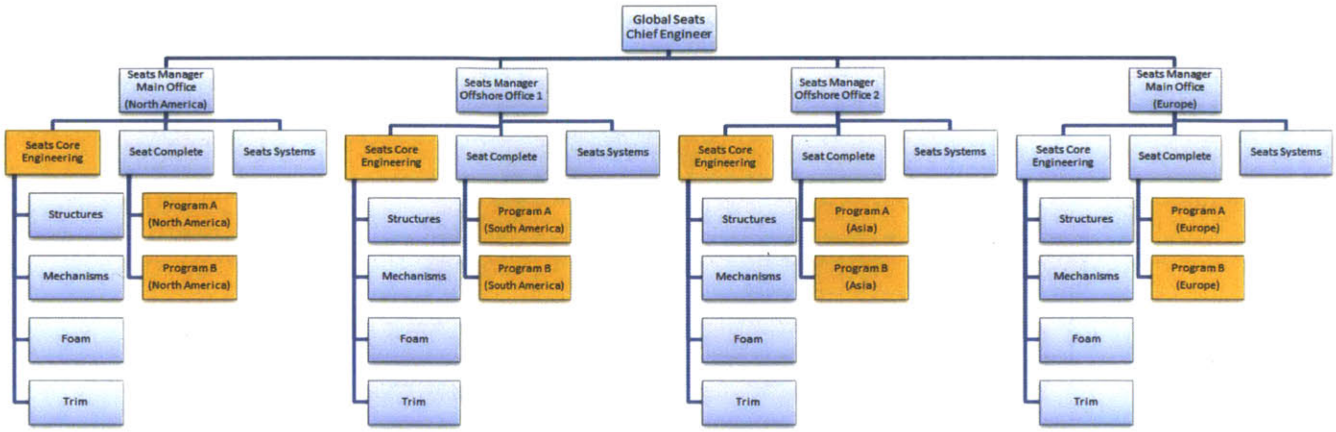


Figure 58 - Regional Offshoring Architecture

The purpose of the Regional Offshoring Architecture is for engineers to be closer to primary customers and understand their needs as the final user. This architecture is achieved by developing seats in the Main Offices and adapting them to each region's regulations. Each office will need ot have their own Core Engineering, Seat Complete and Systems area to be able to develop the seats for their customers.

6a.1.8 Evaluate and Select TO-BE Architecture

Once the concepts were generated, they needed to be applied to an offshore strategy and compared to identify the pros and cons of each The results of a SWOT analysis is presented below.

Architecture	Strengths	Weaknesses
Global Programs Architecture	• Decrease in Seat Development costs • High expertise in specific program needs	• Low understanding of regional primary customer needs • Low communication among offices
Global Expert Knowledge Hubs	• Better usage of resources • High expertise in specific components • Usage of expertise level in each region	• Low understanding of regional primary customer needs • Low communication among offices needed • Slow response on customer needs
Regional Offshoring	• High understanding of regional primary customer needs • Quicker response in customer needs	• Low communication among offices • Waste of resources
Architecture	**Opportunities**	**Threats**
Global Programs Architecture	• Potential increase in innovation for specific vehicle segments • Low complexity during integration of seat complete phase	• Low employee satisfaction due to necessary travel • No connection among offices • Waste of time while solving design issues • Potential positions duplicated • High travel expenses
Global Expert Knowledge Hubs	• Lower travel expenses • Potential increase in innovation for specific components • No duplicated positions	• Complex integration of complete seat
Regional Offshoring	• Low complexity during integration of seat complete phase • Lower travel expenses	• Potential positions duplicated • Waste of time while solving design issues • Duplicated position

The SWOT analysis shows that all of the architectures can give advantages to the organization while working with offshore offices. Because of this, I would like to propose a hybrid architecture which can provide the benefits fromall three architectures listed above. The objective of this hybrid architecture will be to align the Seats Organization to the needs of the primary customer while taking care of the needs of remaining stakeholders.

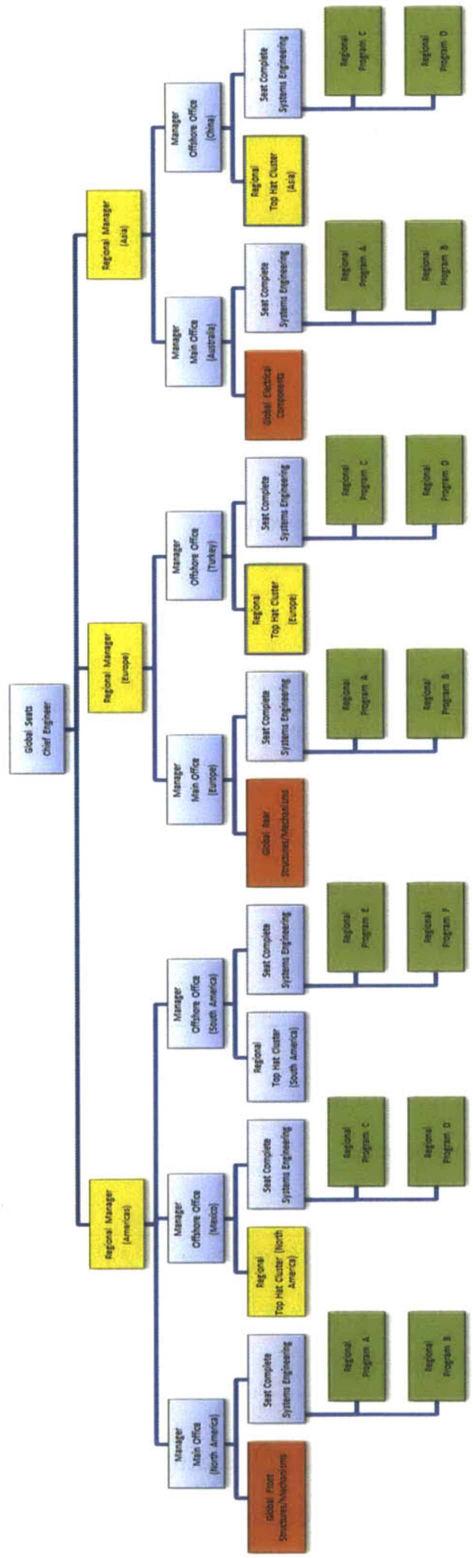


Figure 59 - Hybrid Global Knowledge & Regional Top Hat Offshore Architecture

6a.1.9 Detail and Validate TO-BE Architecture

Hybrid Global Knowledge & Regional Top Hat Offshore Architecture

The hybrid architecture includes the cost benefits of designing global components as well as the benefit of the regional product being close to the primary customer. With this architecture, the main offices will be designing components that can be shared among several programs, or in other words the platform of the seat (Structures, Mechanisms and Electrical Components). This architecture also implies a better utilization of company's resources because these components will be designed and developed just once for all of the company's numerous products.

In addition, having the offshore offices design the top hat cluster shown in Figure 44 will allow the company to satisfy the specific needs of regional customers. These offshore offices will be adapting seats to match the wants of regional customers. This closseness to the customer, will increase regional and local customer satisfaction. In addition to managing programs on a regional basis, the company will continue developing expertise in the offshore offices. In the specific case of China, this last point is critical. Due to the size of China's local market and potential growth, it may be possible that this offshore office start developing products for its local customers.

As can be seen on Figure 59 this hybrid architecture has an additional level in the organization. The Regional Managers' objectives will be to function as "bridges of communication" among local offices. Also, another beneffit of the Regional Managaer is that they can set objectives, such as cost and quality, that will be shared among local offices. These shared objectives will encourage communication and promote willigness among the engineers and managers of the local offices to assist each other.

These benefits can be represented with what Profesor Obukhova stated during his lecture about the I&R (Integration and Responsiveness) framework. The Seat Organization will have high global integration as well as high local responsiveness.

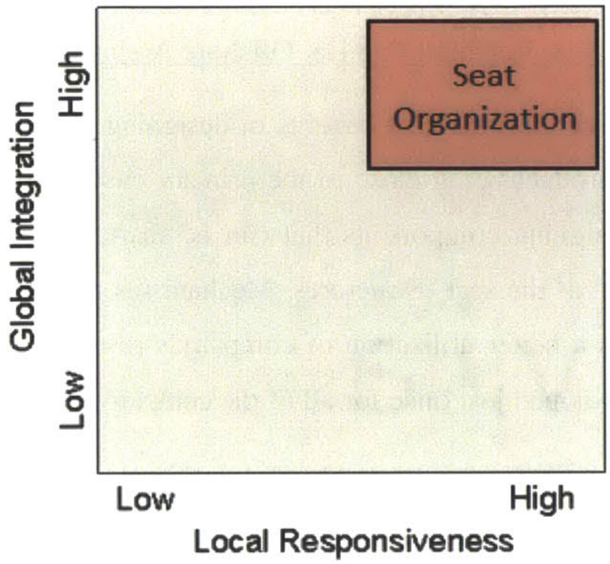


Figure 60 - Hybrid Architecture I&R

To validate this proposed architecture, an effectiveness, effort, and risk evaluation was performed. The effectiveness analysis will evaluate the architecture versus the needs of the stakeholder, and how this architecture satisfies those needs. The effort portion of this evaluation will help in understanding how difficult it will be for the organization to apply the proposed architecture. The third portion of this evaluation will show the risk the company may take while implementing this architecture.

Effectivness (Modified from Beristain, Badin, & Zamora, 2012)

Specific weights were given for each of the most important stakeholders from Figure 52. As seen in the following matrix, the primary customer (Final Customer) has the highest weight value. Then, for each of the remaining stakeholders a weight of importance was given based on their needs.

Stakeholder (Based on Figure 47)	Needs	%	Global Programs Architecture	Global Expert Knowledge Hubs	Regional Offshoring	Hybrid Global Knowledge & Regional Top Hat Offshore Architecture
Final Customer (50%)	Comfort	20%	2	2	5	5
	Safety	40%	5	5	5	5
	Features	10%	2	1	5	5
	Reliability	20%	5	5	5	5
	Appearance	10%	2	2	5	5
		Subtotal	1.90	1.85	2.50	2.50
Program (25%)	On time delivery of seats	30%	5	4	4	5
	Reliability	40%	5	5	5	5
	Cost effective designs	30%	1	5	4	4
		Subtotal	0.95	1.18	1.10	1.18
Employees (25%)	Challenges	30%	5	5	3	4
	Professional development	40%	5	4	5	5
	Recognition	30%	5	5	4	5
		Subtotal	1.25	1.15	1.03	1.18
		Final Score	4.10	4.18	4.63	**4.85**

Figure 61 - Effectiveness Evaluation

Effort (Modified from Beristain, Badin, & Zamora, 2012)

For this evaluation, seven different categories were choosen to evaluate the effort needed to apply each of the architectures. A weight was assigned to each of these categories.

Category	%	Global Programs Architecture	Global Expert Knowledge Hubs	Regional Offshoring	Hybrid Global Knowledge & Regional Top Hat Offshore Architecture
Leadership support	15%	4	3	3	4
Employee acceptance	15%	3	2	3	4
Staff capability	10%	3	4	3	3
Stakeholders support	15%	4	2	2	4
Architecture/infrastructure complexity	5%	4	4	3	2
People knowledge development	20%	4	3	3	3
Cost	20%	1	3	3	3
	Final Score	3.15	2.85	2.85	**3.4**

Risk (Modified from Beristain, Badin, & Zamora, 2012)

The risk evaluation was based on what are the chances of failure of this strategy, and the impact of this failure.

	Global Programs Architecture	Global Expert Knowledge Hubs	Regional Offshoring	Hybrid Global Knowledge & Regional Top Hat Offshore Architecture
Impact	Medium	Medium	Medium	Medium
Likelihood	Medium	Low	Low	Low

The following graph summarizes the three previous evaluations. The X axis represents the effectiveness , the Y axis the effort value and the size of the bubble illustrates the risk variable where the bigger the bubble, the lower the risk. The graph shows how the Hybrid Global Knowledge & Regional Top Hat Architecture is the best option for the organization.

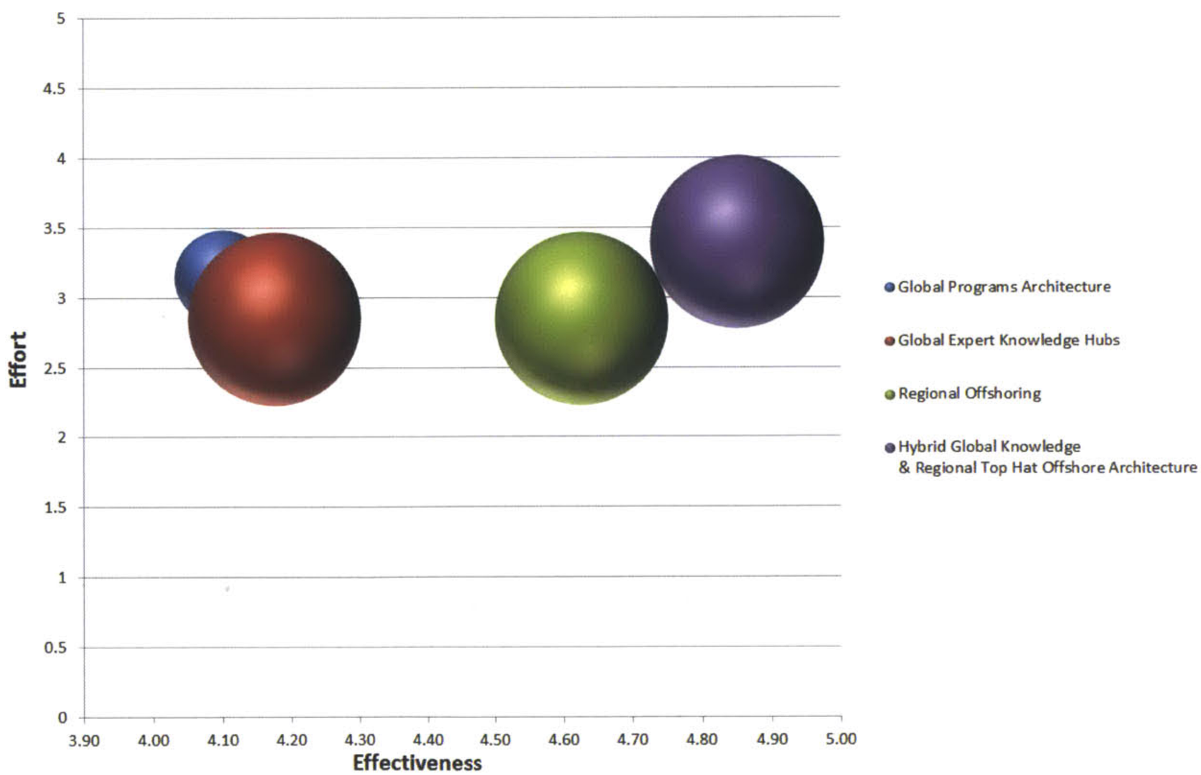


Figure 62 - Effort, Effectiveness & Risk Summary (Beristain, Badin, & Zamora, 2012)

6a.1.10 Formulate Transformation Plan

A transformation plan for this hybrid architecture is simple because some aspects included in this architecture are currently happening in the organization, or just need to be adapted. The following steps were identified in order to implement the proposed architecture.

1. Create Regional Manager positions
2. Evaluate the expertise of each of office around the world to determine which main office will develop which component of the platform.
3. Assign global components to main offices.
4. Assign programs to each of the offices based on expertise and proximity to the customer.

Once this new architecture is established, it is importat to keep in mind the last of the Seven Strategy Questions from Professor Simons:

What strategic uncertainties keep you awake at night? (Simons, 1373 Designing Winning Organizations , 2012)

Answering this question includes the metrics the company should be following in order to determine when a change in strategy, process or organization is needed. These uncertainities are:

- Fuel prices – To determine which size of vehicle the final customer will be looking for.
- New technologies – In case raw material prices increase, it will be safer to have another technology ready to be implemented.
- Innovations – It is always better to be a pioneer rather than a follower, i.e.: a new way to operate the seats.
- Financial metrics – To avoid repeating what happened during the Financial Crisis of 2008.
- Expertise of the offshore offices – To determine when they are ready to develop new components
- Customer wants and needs – To know what the seats should include: appearance, features, and comfort.
- Low cost countries wages – To adjust the strategy once the wages are similar to the main offices.

7 Final Chapter

7a Summary and Conclusions

At the beginning of this thesis it was shown how due to the 2008 financial crisis various automakers needed to change their strategy. As part of this new strategy, these companies changed their way of looking at low cost countries. These low cost countries, such as Mexico, China, India, and Turkey, were not just manufacturing countries; they were a feasible option for reducing product development costs due to low wages. This new strategy raised the first research question.

Q1: What part of the product architecture can be designed efficiently offshore?

In Chapter 2, I presented what Dr. Tripathy presented in his PhD thesis "*Work Distribution in Global Product Development Organizations*". In Dr. Tripathy's work, he shows that there are three ways to divide a product in order to offshore some of its components.

- One component with interrelations with another component within the architecture of a product. This will require a high level of coordination between locations.
- Offshore both components with relationships.
- Offshore an independent component.

In Chapter 3 of this thesis, it was shown how the decision to offshore is currently made by one American automotive company. After an interview with a Body Interior Manager and a Seat Chief Engineer, it was clear that the decision is based on the expertise of the offshore office and the complexity of the subsystem. Figure 36 summarizes this decision in a model.

With the same objective in mind, deciding which part of a system can be offshored, the analysis performed in Chapter 4 demonstrated that using a Design Structure Matrix could determine which part of a product architecture can be designed offshore. The Design Structure Matrix visually identified which components of the product have greater relationships among them. Once these relationships are identified it can be determined which part of the product can be developed offshore.

Three different approaches were taken to answer the first research question of determining what parts of the product architecture could be efficiently designed offshore: Dr. Tripathy's three options of how to choose what to offshore, the current decision model used in the American automotive company, and the usage of DSM analysis.

Further, Chapter 4 explained how to apply the DSMs to a specific product. This application was made to the seat subsystem and divided its architecture into clusters based on the relationships among its components. This matrix application and analysis helped answer the second research question:

Q2: Which components of the Seat Subsystem architecture can be designed in an office offshore?

A product DSM was used based on a real world case study of an American automotive company's offshore Product Development office in Mexico City. This analysis was performed with the assumption that the main office is in the United States. To this DSM, three variables were added in order to determine which clusters could be developed offshore. These variables and their levels were:

- Level of Expertise Required – Low (L), Medium (M) and High (H)
- Supplier Available in Alternative Location – Yes (Y) and No (N)
- Engineer Expertise in Alternative Location - Low (L), Medium (M) and High (H)

With these assumptions and variables, the seat DSM was reorganized until the following clusters were created:

1. Guide sleeves and head restraint
2. Trim cover, foam and SAB
3. Recliners, tracks, structures and risers
4. Plastics and switches
5. Systems Engineering and Seat Complete

From these clusters, and with the usage of the three additional variables, it was determined that the offshoring strategy for the Mexican office can be applied in two phases.

Phase 1

- Offshore components included in cluster one and two, with the exception of the SAB due to the lack of expertise in the development of this component.
- Offshore the development of seat plastics.
- Offshore Seat Complete function.

Phase 2

In addition to the components offshored during Phase 1:

- Offshore SAB and CCS, which in conjunction with clusters one and two makes what is called the Top-Hat cluster.
- Offshore switches due to the close relationship with seat plastics.
- Offshore Seat Systems Engineering function.

Previous research questions provide answers as to what components can be offshored, but do not address how to choose where to offshore these components and functions. In Chapter 4, three frameworks were used to determine which country is the best option to offshore these components:

- CAGE
- ADDING
- Porter's and Virtual Diamond

The results of these frameworks were evaluated and summarized in Chapter 5. These results determined that Mexico is the best option to offshore the clusters found in the DSM analysis, with the assumption that the main office is localized in the United States. It is also in Chapter 5 were Professor Allen's curve was shown. This curve revealed that the larger the distance, the lower the probability of communication between people or locations. From the framework analyses and based on Professor Allen's theory, it can be said that geographical distance between the main and offshore PD Offices is a fundamental variable for a successful offshore strategy.

With this basis, if a product has a modular architecture, it may be easier to split the development process among different locations. However, with efficient communications processes among the offshore locations, the offshore product development cannot be exclusively accomplished with a modular architecture

After determining where to offshore and the components which could feasibly be developed in this location, a Process/Organization DSM was created for the same case study in order to answer the next research question:

Q3: What part of the design is better to be resourced offshore: Core Engineering or Integration?

The results of the product and process/organization DSM's confirmed that the offshore process could include both core engineering and integration. The product DSM determined which components of core engineering could be offshored. The organization/process DSM results suggested that it was actually better to offshore not just core engineering, but also the integration of the complete seat. This conclusion was based on the high level of interrelationships with other functions in the Seat division within the corporation. Thus, if both Core Engineering and Integration were offshored, communication among engineers would be better and consequently the timing and iterations of the design would improve.

These DSMs helped identify which components and functions of the Seat Subsystem could be offshored, but now the architecture of the Seat Subsystem organization should be modified in order to support this revised offshore strategy. This was the basis of the last research question:

Q4: How does the enterprise organization need to be adapted to support and enhance offshore development?

To answer this question, three methodologies were used in Chapter 6. These methodologies were summarized in Figure 51:

- Enterprise Architecting Sequence Model
- 4P's of Strategy
- Seven Strategy Questions

As part of these methodologies, three different architectures were developed and evaluated against the most important stakeholders and the primary customer. These analyses showed that the Hybrid Global Knowledge & Regional Top-Hat Offshore Architecture was the one that best fit the needs of the corporation. This Hybrid architecture kept the benefits of the other three architectures evaluated in Chapter 6. Some of these benefits include reduced costs by using a global approach for the development of the seat platform (structures, mechanisms, and electrical components). In addition, due to a better understanding of local and regional customers, adaptations could be made by the regional offshore offices while developing top-hat clusters.
This last advantage is also found in the list of benefits from Dr. Eppinger and A. Chitkara in Chapter 2:

- *"The center will provide a basis for understanding local markets and designing products based on that understanding"* (Eppinger & Chitkara, 2006)

The next step with the results presented in this thesis would be to apply a real world situation using Dr. Tripathy's algorithm in order to determine and compare costs that the company would incur with the coordination of developing the seat in the main and offshore offices. These results would quantify the cost reductions originated from this offshore strategy.

7b Replication Opportunities

The studies and analyses performed during this thesis can be applied to any other system where it is necessary to determine which part of the system could be developed offshore. The case reviewed in this thesis was based on the Seat Subsystem of a vehicle; accordingly, it would be natural to apply the same analysis to the Restraints Subsystem due to the close relationship with the seat. Furthermore, this study can be applied to several subsystems within a vehicle such as power train, exterior, chassis and other interior subsystems.

The following is a list of steps to be followed in order to breakdown the development of a product or system, and determine where to offshore each of these components:

1. Choose a system to be analyzed
2. Understand the environment of the system
    a. Industry
    b. Processes
    c. Organization
    d. Product Architecture
    e. Stakeholders
3. Perform a DSM analysis (product, process and/or organization)
    a. Collect data
    b. Build DSM
    c. With the support of an expert on the process/product/organization, reorganize the DSM until clusters are found.
    d. Add the following variables to the DSM
        i. Level of Expertise Required – Low (L), Medium (M) and High (H)
        ii. Supplier Available in Alternative Location – Yes (Y) and No (N)
        iii. Engineer Expertise in Alternative Location - Low (L), Medium (M) and High (H)
    e. Find clusters that can be immediately offshored
    f. Determine which expertise needs improvement in order to offshore complete clusters

4. Apply the following frameworks to determine where to offshore the clusters found in step three.
    a. CAGE
    b. ADDING
    c. Porter's and Virtual Diamond
5. Determine which of the following two options fit your organization to ensure communication among locations.
    a. Send engineers from offshore office to main office
    b. Send supervisors/managers from main office to offshore office
6. Apply the following methodologies to determine how to transform the organization to support the new strategy (see Figure 51).
    a. 10-step Enterprise Architecting Sequence Model
    b. 4P's of Strategy
    c. Seven Strategy Questions

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