Creating a Systems-Oriented Framework to Mitigate the Risk of Failure in an Inexperienced Product Development Organization

by

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ABSTRACT

The recent challenges imposed by the highly competitive global automotive industry have led Ford Motor Company to search for improved product quality, performance and lower costs by leveraging the capabilities offered in developing countries such as Mexico. As demand for automotive engineering services in this country increase rapidly, the interest behind this work is to create a systems-oriented framework applied to the planning, execution and improving phases of the relatively inexperienced Product Development Organization in Mexico, to help achieve what they have defined as success.

To develop this framework, first, a systems decomposition approach was applied to a real organizational failure case to evidence the importance of defining the basic inputs of a product development system and its connections during the planning phase, and the optimal type of organization that should execute to achieve its strategic objectives. Second, for the execution phase, two cases were evaluated under a system dynamics approach to illustrate the effect of an inexperienced workforce on the overall productivity of the organization, and a mitigation strategy based on a mentoring and training policy when the only constant is change. Third, for the improving phase, a system dynamics approach was also used to illustrate the importance of embracing the learning capabilities of the organization to improve it execution.

The key outcome is a systems-oriented framework to guide an inexperienced manager to achieve success considering the following: Planning the inputs of an organization and maintaining a lightweigh structure approach will enhance high levels of execution responsiveness and quality at reduced costs. Mentoring and training policies while maintaining flexibility, agility and adaptability are key enablers to achieve a low cost execution responsiveness and quality in an inexperienced organization, but such policies reduce its productivity during the initial stages of the policy implementation. Finally, successful organizations are those that work harder to solve urgent issues now, and work smarter to increases its capabilities in the long run improving execution cost, quality and responsiveness.

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LIST OF ACRONYMS

Acronym	Description
A3	One-page report that presents all the information needed to make a decision, communicate status, share lessons learned or accomplish a specific goal.
BIC	best in class
PDOM	Product Development Organization in Mexico
FT&I	Facilities, Tools and Infrastructure
CCSE	Climate Control Systems Engineering
STA	Supplier technical assistance
CAE	Computer Aided Engineering
IT	Information Technology
ED&T	Engineering Development and Testing
PD	Product Development
AC	Air Conditioner
QCWF	Quality, Cost, Weight and Functional Targets
D&R	Design and release engineer
CAD	Computer Aided Engineering
PAT	Product Attribute Team engineer
GPDS	Global Product Development System
EMM	Engineering Matters Meeting
PST	Program Steering Team
To4	Team of four (engineering, finance, purchasing and cost estimation)
PMT	Project Management Team (Body Interior, Body Exterior, Chassis, Powertrain, and Electrical)
SDS	System Design Specification
ARL	Attribute Requirement List
SCCAF	Special Characteristics Communication and Agreement Form
DPA	Digital pre Assembly
VE	Vehicle Engineering
VEV	Vehicle Evaluation and Verification
DI	Digital innovation
SDM	Systems Design and Management program
Ilities	Emerging attributes of the organization such as flexibility, agility and adaptability.

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Chapter 0: Introduction

0.1) Background: Automotive Enterprise Landscape

The auto industry in the 19th century became one of the engines of the industrial revolution with Ford Motor Company as one of the leaders. Yesterday's market leaders, specially the so called "big 3" (Ford, Chrysler, General Motors), are struggling to survive in a market that has shifted from simply purchasing products (cars), to a demand generator for quality, high performance and low cost products and services. In today's competitive automotive market, only the companies capable of providing a new value proposition for their final customers can survive.

Two decades ago the automotive industry in North America started to suffer a transformation. Foreign automakers´ product execution dramatically improved and American companies' product performance and quality were severely challenged. As a result of increasing competitiveness, customer preferences shifted towards buying foreign automaker brands, which translated into a decrease in sales and market share for the Big Three American Automakers. Towards the end of the 20th century, American automakers realized that they were not delivering the products that their customers wanted and needed. This and the large gap in the quality of their vehicles in comparison with the quality of vehicles from foreign automakers were significant contributors to their loss of competitiveness.

These challenges forced Ford Motor Company to implement a new strategy focused on leveraging the capabilities of its global operations. In search for improving product quality, performance and lower costs, this automaker launched an aggressive growth strategy focused on improving the balance sheet of the company by leveraging the capabilities offered in developing countries such as Mexico, Brazil, India and China. As a result, high performance/low cost product development offices were established in these countries to support the global efforts of the organization.

0.2) Motivation and Objective

The Product Development Organization in Mexico (PDOM) has been widely benefited with this growth approach derived from the fresh organization´s strategy. Since 2011 this organization has been growing at an accelerated pace in budget, headcount and design responsibilities. Along with increased interactions, extra complexity is currently being built within this organization and a special attention is required to leverage its core capabilities in order to mitigate the risk of "organizational failure".

The long term sustainability of this organization depends on multiple key metrics such as: product quality, cost efficiency, effective project management, employee satisfaction, and performance. The interest behind this thesis is to guarantee, as much as possible, the long run success of this organization considered a system; therefore the goal of this work is to create a framework that can help maximize the probability of success, as complexity and risk to failure increase. Based on this goal, the research question behind this thesis is:

"What are some of the technical and managerial inputs, enablers and capabilities of the High-speed growing Product Development System in Mexico that could maximize its likelihood of success when present in its planning, execution and improving phases?"

The following hypotheses have been developed to support and guide the discussion:

i. Planning - Architecting the connections between and within the basic inputs of a Product Development organization will enhance high levels of execution responsiveness and quality at reduced costs.

i. Execution - In an inexperienced organization, mentoring and training employees and investing on "ilities" are key enablers to achieve a low cost execution responsiveness and quality, when the only true constant is change. (see list of acronyms for definition of "ilities")

ii. Improving – Increasing learning capabilities is key to achieve BIC responsiveness and quality while maintaining low costs.

0.3) Motivation Scenario

The intention of the following theoretical scenario is to provide a picture of what has been happening and will continue to happen in the Product Development Organization in Mexico for the next three to five years. Imagine *Chucho Perez*, he is a young engineer in his early 30's. Chucho has been working for the Product Development Organization in Mexico for about seven years and today, he is a valuable asset due to his high level and reliable performance at a relatively low cost (high value). During this period, he has had the opportunity to actively participate as a product development engineer in the design, validation, release and launch of two major new model programs and several on-going local product modifications. He has spent a total of two years working for the parent organization in the United States under an international assignment ramping up his technical and managerial skills through an intense training based on learning-by-doing.

Since Chucho has developed "enough" technical skills and has demonstrated potential leadership values, he has been recently promoted within the Mexican organization and now he occupies a junior leadership engineering position with eight Mexican engineers reporting directly to him. Due to the increasing demand for engineering services as a result of the global environment in which the company executes, the Product Development Organization in Mexico, being a key player, is facing the challenge to maintain a sustainable growth enabling the organization to achieve *success* as defined in the subsequent pages. The real challenge Chucho and many other relatively inexperienced leaders of the organization face is how to perform to accomplish success in a high-speed changing environment. This thesis is developed with the emphasis to provide a simple framework for leaders like Chucho who might need a simple guide to maintain the pace towards that attainment.

0.4) Definition of Success of the Product Development Organization

The development of these thesis starts with the idea of success that the PDOM has defined to guarantee its sustainability towards 2015. The PDOM´s idea of success is based on its corporate vision which is defined as follows: (extracted from the PDOM A3. See list of acronyms for definition of A3)

Develop Product Engineering capabilities in Mexico to support Global needs, reaching Best in Class performance in terms of Responsiveness, Quality of execution and Cost.

Based on this definition, the first step to understand this definition of success was to create a pictorial description of it illustrated in figure 1.

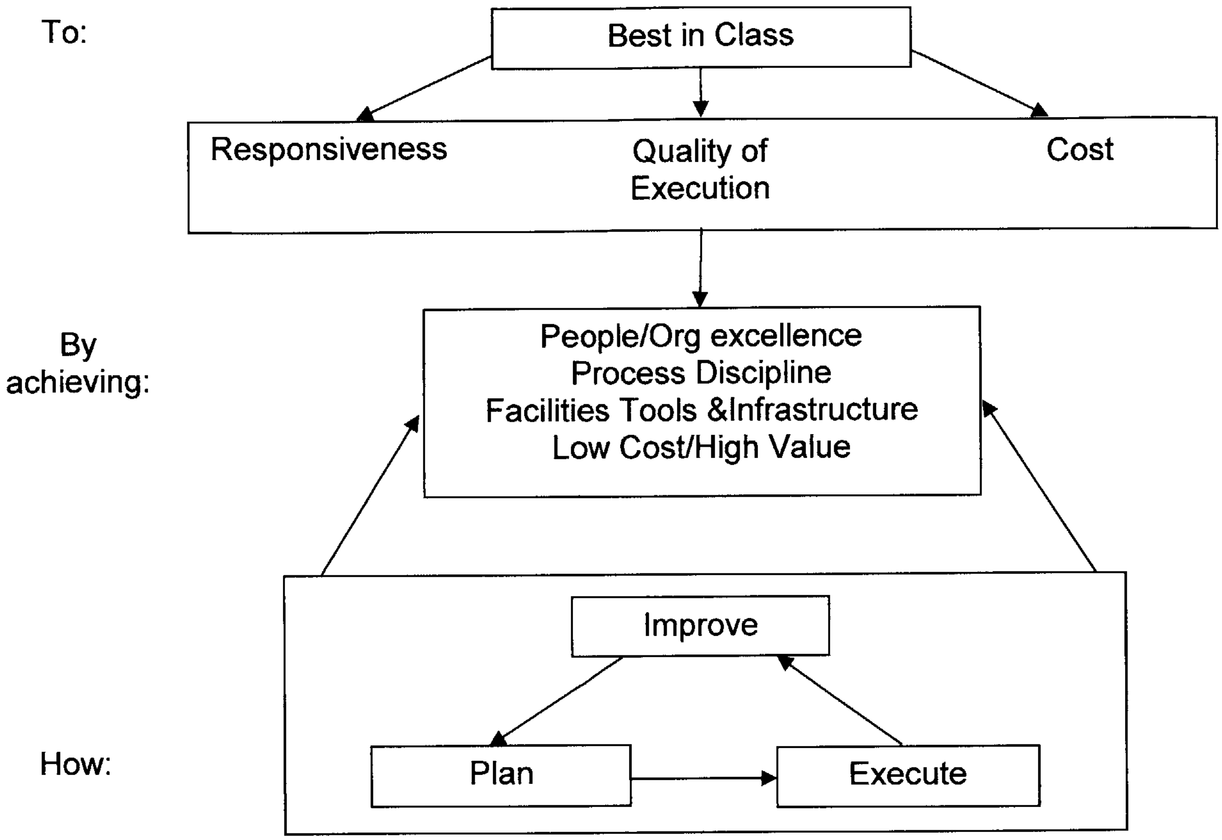

Figure 1: Pictorial Definition of *success* of the PDOM

As figure 1 illustrates, I have decomposed this definition of success in 3 levels:

- *System Level or Organizational Objective (To):*

To develop Product Engineering Capabilities in Mexico to support global needs reaching best in class performance in terms of responsiveness, quality of execution and cost.

- *Strategic objectives and Action Plans (By Achieving):*

People Excellence:

The first strategic goal focuses on creating a culture in the organization that differentiates the Mexican engineers from those in other high value regions, focusing on building a team that is outstanding due to the attitude, the quality of execution, the job culture and the intelligence among them. To measure the current and the future state of this goal four metrics are utilized:

- Competency Level: Track the knowledge and experience of their engineers
- Key Talent Retention: Make sure that the turnover is low, especially for Key talent
- Employee Satisfaction Index: Best in class employee satisfaction

- Headcount: Maintain headcount accurately

Process Discipline:

The second goal focuses on creating an efficient, nimble, flexible and clean organization. To accomplish this goal, four metrics are utilized:

- Scorecard Related Metrics: Provides health status of the projects.
- Efficiency Metrics: Provides health status of the organization.
- Integrator Deliverables: Ensure processes related to the Global Product Development System are being executed.
- Part Churning: Monitors the amount of changes to each vehicle component.

Facilities, Tools and Infrastructure:

The third strategic goal focuses on reducing the operating costs in the company by using Digital Innovation, Computer Aided Engineering and IT, as well as an optimized office layout to promote productivity, communication and teamwork. Two main metrics are being used:

- Facilities for New Hires: Tracks the availability of essential facilities for new members
- Facilities for Top Hats: Tracks the availability of essential facilities to develop a top-hat program.

Low Cost / High Value Automotive Operations Alternative:

The fourth strategic goal focuses on acquiring ED&T in-sourcing responsibilities and maximizes the use of available incentives (Federal and State incentives). Three metrics are used in order to track the progress of this goal:

- Track the amount of cost savings
- Specific program savings: Tracks cost saving per program

- *Framework Structure (How):*

The bulk of this thesis is developed around the 3rd level of the decomposition of the PDOM definition of success which I define as the "How" level. As defined in the motivation, the intention of this work is to create a framework that can provide a basic guide for engineers like Chucho to strive for success in this young organization. Figure 2 provides a simple illustration of how I visualize this framework. It is simple and is intended to address the impact of the technical and managerial inputs, enablers and capabilities of the High-speed growing PDOM present in its planning, execution and improving phases; where inputs are shown to the left, transformation happening in the center enhanced by controls and enablers, and outputs generated to the right. The transformation square (center) is represented by the strategic objectives and action plans defined by the PDOM previously.

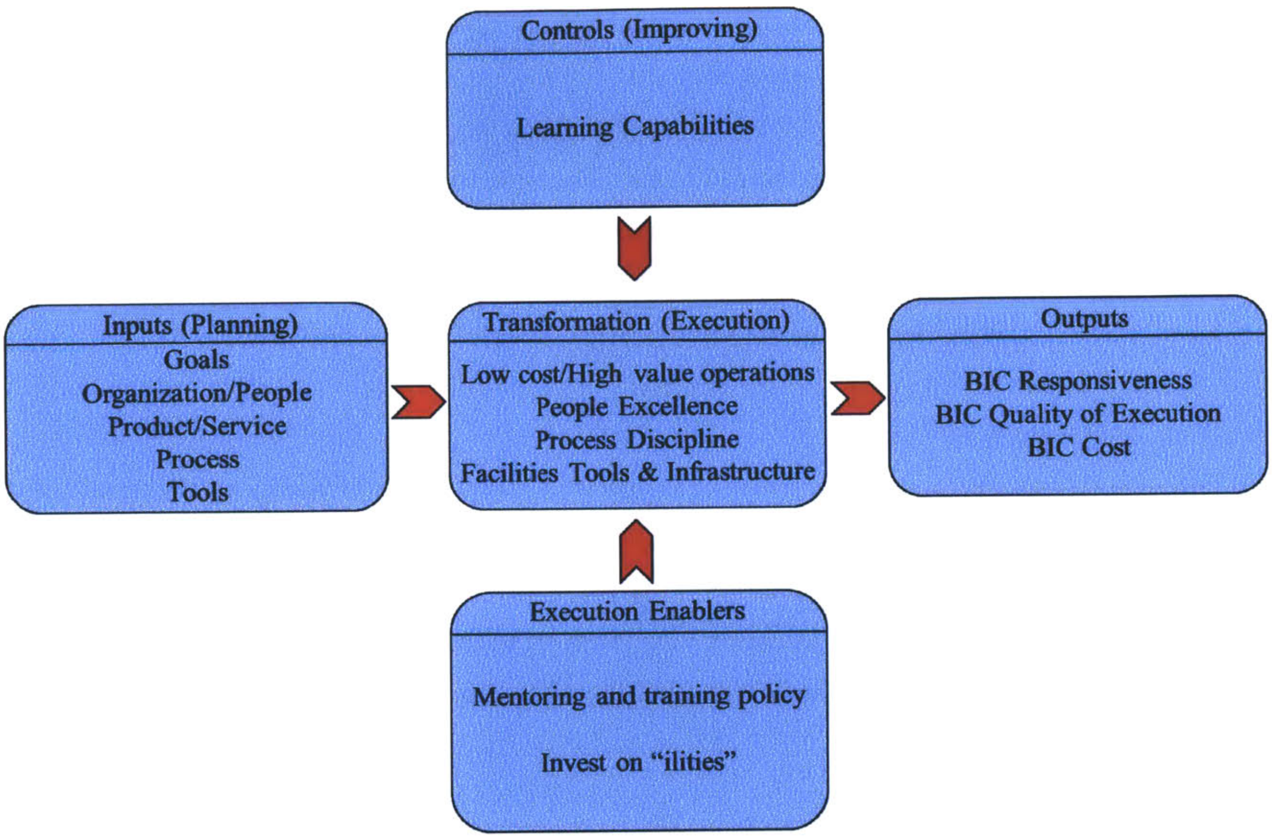

Figure 2: Context Diagram for Definition of Success

0.5) Research Method

To explore the research topic that motivated this thesis, the first action I performed was to draft a set of questions that could guide the development and generation of information. These questions were generates as a result of my own curiosity, experience and passion about the research topic and enriched from general thoughts extracted from the PDOM SDM meetings. These questions are focused on guiding the discussions of each of the main structure chapters as proposed in the framework of Figure 2 (planning, execution and improving) towards answering their respective hypotheses. The complete set of questions can be found in Appendix A, and the overall explanation of what the PDOM SDM meeting is and the ideas extracted from it can be found in Appendix C.

To obtain the answers for the *planning* phase questions explored in Chapter one, an interview-based approach was applied to a real life failure example in order to obtain insight from six key stakeholders of the CCSE organization in Mexico. With the agreement from each of the interviewees, these short interviews were conducted as informal chats and the objective was to generate, from the planning perspective of the organization, an overall idea of what led to the qualitative failure of the CCSE organization in Mexico during its initial stages. The general insight obtained from this interview can be reviewed in Appendix B. With this insight, a systems decomposition approach was applied to the same failure case to evidence the importance of defining the basic inputs of a product development system and its links during the planning phase.

In order to obtain answers for the *execution* phase questions explored in Chapter two, a couple of theoretical cases extracted from real assumptions of the PDOM were evaluated under a system dynamics approach to illustrate the effect of a relatively inexperienced workforce on the overall productivity of the organization when the only constant is change. This approach was also implemented to illustrate the benefits of a strategy based on a mentoring and training policy that could potentially mitigate the effect of the inexperienced organization on its productivity. The system dynamics method applied in this chapter is based on the theory developed by Oliva and Sterman (2010).

Finally, to obtain answers for the *improving* phase questions in Chapter three, a system dynamics approach developed by Repenning and Sterman (2001) was also implemented to illustrate the importance of embracing learning capabilities to improve the organizations performance. In this chapter, this approach was used as the method to illustrate the dynamics of work harder and work smarter loops in the overall responsiveness, execution quality and cost of the organization. An illustrative real case was exposed as evidence to demonstrate the effect of these loops. In the second part of this chapter, a capability-based analysis developed by Spear (2009) was used as the method to illustrate the importance of increasing capabilities through the dynamics of the learning cycle in order to enhance work smarter loops.

0.6) Thesis Overview

While you read this thesis you will find a vast pool of acronyms. Please use the list of acronyms in page 11 to understand them. This thesis is divided in three principal chapters to follow the development of the framework structure. Chapter one develops on the importance of dedicating time to plan the inputs (goals, people, products, services, processes and tools) of an organization and its links as key to achieve success. A real life example illustrates how "qualitative failure" prevailed during the early conception stages of the young PDOM CCSE organization due to the lack of planning of the basic inputs of the system and failure to identify its connections. Equally, this chapter provides an example of how the basic inputs of the organization could be defined to minimize the risk of failure. Finally this chapter provides a discussion around which type of team structure should prevail in the PDOM in order to maintain flexibility, adaptability and agility.

The second part of the framework focuses on the enablers that allow success during the execution phase of the organization. In order to present illustrative results, Chapter two develops two theoretical cases that illustrate the effect of an inexperienced organization over the overall average productivity of the organization and how this rookie effect can be mitigated with a mentoring and training policy considering the side effects of it. Chapter two also frames the importance of maintaining flexibility, agility and adaptability to overcome the effect of change during the execution phase of the organization.

Chapter three provides an illustrative case of how learning capabilities can help the organization to improve its overall execution and why sometimes organizations fail to do that by falling into the vicious cycle of suppressing learning. As in the previous chapter, two theoretical cases are evaluated under a system dynamics approach to illustrate the importance of documenting and spreading leaning through the virtuous cycle of learning to achieve success. The second part of this chapter provides an overview of how to beat the vicious cycle of suppressing learning by focusing on policies that yield results in the short and long terms. To illustrate the implementation of such policies, a real life example is presented as evidence to support the arguments.

Finally, Chapter four provides a summary of the main ideas extracted from each of the chapters and a series of suggestions directed to Chucho in regards to how to plan, how to execute and how to improve the organization.

Chapter 1: Planning

Hypothesis – Architecting the connections between and within the basic inputs of a Product Development organization will enhance high levels of execution responsiveness and quality at reduced costs.

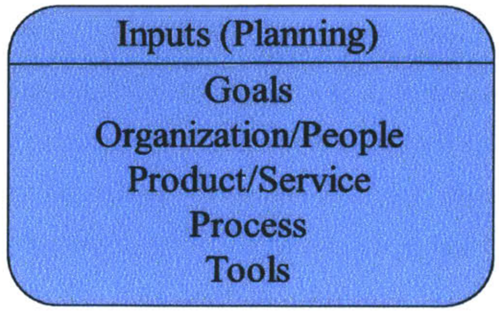

Figure 3: Inputs of a Product Development System

The first step of the linking framework illustrated in Figure 2 is related to the planning phase of a system. The intention of this chapter is to demonstrate the importance of correctly identifying the inputs of the Product Development System and the importance of designing the links within and between them to focus on achieving success as defined by the organization; and how this design contributes to the transformation of the desired strategic objectives of the PDOM. In order to guide the discussion, the following questions have been formulated to support the generation of information.

- What are the basic inputs of the Product Development System?
- How these inputs should be designed (planed) to maximize chances of success?
- What characteristics should the employees of the organization have to execute the action plans?
- Based on the incoming responsibilities acquired by the PDOM, what type of organization should execute the plans?

1.1) Architecting and Planning Product Development Systems Inputs

The initial step to designing a system is to understand where the system is currently standing, where the system wants to be in the future, and what is needed to get where the system wants to be. My experience working at a complex product development organization indicates that the first step to build a culture looking forward to achieving success is to understand and define the essential inputs of the System during the planning phase.

What are the basic inputs of the product development system? The Product Development System is defined by Aguirre (2008) as "all the elements, links and structure necessary to develop a new product". In his thesis, he cites the work previously developed by Browning, Fricke, and Negele in 2006 to define the basic elements of structure of a product development system as: "Organizational Goals, Products, Services, Processes, People and Tools (Aguirre, 2008, pp. 39)."

In the context of the framework explored in this thesis, I define these elements of structure as the key Inputs for the long run success of a High-Speed growing organization. The method used in in this chapter is based on a systems decompositions approach applied to illustrate the importance of identifying the hierarchical design levels of these inputs in early stages of the organization creation process in order to achieve the strategic objectives. Figure 4 provides an illustration of how these basic inputs of a Product Development system are linked/connected and interact together in the context of this thesis. This figure can be described as follows: The goals of the organization are achieved when the right people design, validate, release and launch high quality, low cost products and services through robust and uniform processes with the support of tools and infrastructure.

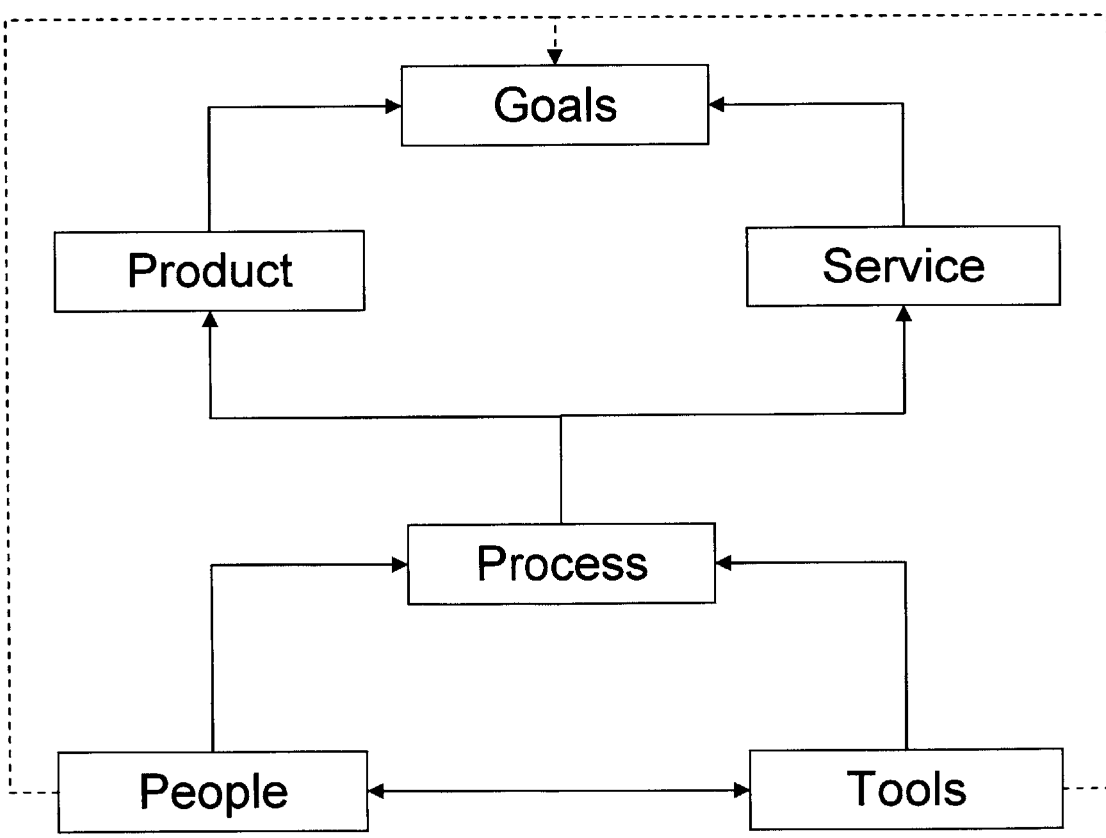

Figure 4: Essential Elements of Product Development System

1.1.1) Decomposition of Inputs (People, Product/Service and Process)

During the system´s planning phase, one of the most common approaches to fully understand its elements of form and function is by decomposing systems into sub-systems and components. The next relevant question to support the development of the hypothesis is how should the inputs in Figure 4 be designed in order to meet the strategic objectives and action plans of the organization? Steven J. Spear (2005) elaborated a useful normative or framework intended to identify four distinct levels of decomposition and the appropriate design questions associated with each decomposition level. This framework can be applied in the analysis of both tangible and intangible systems (inputs), and the basic elements as well as the questions inherent to each of those levels are defined in table 1:

Table 1: Hierarchical Decomposition Levels (Modified from Spear, 2005)

Hierarchical Decomposition Levels	Critical Questions
System Objectives	What goals and objectives should the elements (inputs) meet? What product, services or information does the organization produce and deliver, for whom, when?
Architecture/ Responsibility	What individual functions are assigned to what elements, components, or pieces in the system? Who is responsible for what work-Activities, to create what intermediate product, service, or information for whom, in what order?
Interface / Connections Exchanges / handoff	How are the elements, components, or pieces connected between and within? How does someone indicate that they need an item (product, service, or information), and how does those who supply and item learn that something is needed?
Components/ Methods	What are the designs of the individual elements, components, or pieces of the system, given the functions and interfaces assigned to them? What are the work-element content, sequence, timing, location, and output for people to do the work for which they are responsible?

The best way to illustrate the application of this framework is by developing an example. Let us assume that this framework can be utilized to decompose components, sub-systems, and systems; and that the performance of a component would affect the overall performance of the whole system. Given the latter, I analyzed the Climate Control Systems Engineering (CCSE) Organization in Mexico as the example to apply the decomposition framework in order to obtain insight to whether architecting the connections between and within the basic inputs of a Product Development organization will enhance or not high levels of execution responsiveness and quality at reduced costs. This example was developed with the collaboration of key stakeholders of the CCSE organization in Mexico and the focus was to provide both an example of the advantages that this normative or framework provides and also to set the initial grounds of what the CCSE organization in Mexico should look like to get aligned with the definition of success previously defined.

1.1.2) Example of Inputs Decomposition (CCSE organization in Mexico)

In order to understand this example I should state that each of the inputs in Figure 4 were considered input components of the CCSE organization in Mexico and are suitable to being decomposed, therefore the information contained in table 2 below was generated by answering each of the questions of the hierarchical decomposition framework applied to the CCSE organization in Mexico.

System Level design of the CCSE organization Inputs:

Working from the top of the Hierarchical Decomposition Level framework, the first step to understand the organization is to define the "To-Be" System level objectives of each of its key inputs. Based on the interviews with key stakeholders of the organization, we defined system level objectives for each of the inputs of the "To-Be" organization. (See System level in table 2)

Architecture Level of the CCSE organization Inputs:

The second level in the hierarchical decomposition framework is the "To-Be" Architecture of the system. As Edward Crawley defines, architecture is "The embodiment of concept and the allocation of physical/informational function to elements of form, and definition of relationships among the elements and with the surrounding context (Crawley, 2011)." The architecture is determined by the elements of form and function that coexist and interact within the system; the design of each element of form plus the design of the interactions between them will command the emerging behaviors of the whole system. The elements of form can be both tangible as for example people performing within the organization and physical components; and intangible as for example activities or tasks. (See Architecture level in table 2)

Interfaces / Connection Level of the CCSE organization Inputs:

With the high level definition of the "To-Be" architecture, the third step of the hierarchical level decomposition is to identify Interfaces and Connections within the architecture. This links embody both the physical and information connections between the elements of form in the system. I anticipate the outcome of this step to be one of the most crucial in the planning of the Low Cost / High Value CCSE Organization since good interfaces facilitate the generation of a *lightweight* structure enabling effective communication towards problem solving. Section 1.4 provides a real life case were poor interfaces and connection lead to an organizational failure. The outcome yielded from this example idealizes a CCSE organization oriented to maintaining a system integration mindset in order to keep track of the interactions happening within each of the employees and how they should follow integrated processes to understanding the interfaces/connections happening in the design of products and services. (See Interfaces and Connections level in table 2)

Component Level of the CCSE organization:

In the fourth and final step, the lowest level of the hierarchical decomposition framework is to define the components design. The components are defined as the individual elements of form that integrate the architecture of the system. These elements of form can be defined as sub-systems of the parent system and can also be decomposed for further analysis. As mentioned previously, the elements of form can be both tangible as for example people performing within the organization and physical components; and intangible as for example activities or tasks. (See Component level in table 2)

Table 2: Summary of Hierarchical Decomposition Level of the Low Cost / high Value CCSE Organization

	Inputs of the CCSE organization in Mexico			
	People (Organization)	**Service**	**Product**	**Process**
System (Objectives)	1) To support global PD operations by becoming a low cost/high value (on time, effective and low cost) CCSE organization. 2) To become the global CCSE organization's excellence design center for AC lines. 3) To support top-hat initiatives in Mexico by	Low cost/high value (on time, effective and low cost) engineering and managing services.	Low cost/high value (on time, effective and low cost) Vehicle (Top-Hat) Climate Control Systems and AC lines that meet or exceed Quality, Cost, Weight, and Function targets (QCWF).	Robust and clear processes to provide a consistent method to generate the desired services and products.

	developing Climate Control Product Engineering and managerial capabilities.			
Architecture (Responsibility)	1) AC lines core engineers and D&R with CAD capabilities oriented to designing, validating, releasing and launching AC lines. 2) System integration, PAT, and applications engineers oriented to connecting / integrating CCSE sub-systems throughout the development of a program. 3) CAE engineers to support sub-system development and validation activities	Design, validation, release, and launch (activities) of CCSE Component, sub-systems, and systems, performed by engineers.	Tangible CCSE Systems composed of modified/carry over refrigerant and air handling sub-system architectures, comprised of modified/carry over parts and interfaces.	Follow Functional and Program related process architecture based on the GPDS architecture to design, validate, release and launch.
Interface / Connections (Exchange / Handoffs)	Systems integration engineers connecting / leading application engineers and AC lines D&R teams and supported by PAT and CAE engineers.	Systems Integration-oriented design and execution to connect component, sub-system and system development activities.	Critical modified/carry over physical interfaces / connections within CCSE components / sub-systems and with other sub-systems such as Body Interior, Body Exterior, Powertrain and Electrical.	Engineering (EMM) and Program (PST) processes to maintain a systems integration-oriented focus.
Components (Methods)	High Skilled/low cost Mexican engineers	On time, effective and efficient individual engineering and managerial deliverables.	CCSE components designed to meet component sub/system and system level requirements and attributes.	Program = GPDS deliverables, To4 and PMT processes Engineering = SDS, ARL, Design Rules, Robustness, SCCAF Mechanical Package = DPA, Virtual series

As part of the planning phase, this decomposition framework provided a valuable tool to define the potential basic architecture, interfaces, connections, and components (Form and Function) of the "To-Be" CCSE organization, oriented to achieving its ultimate system goals. Along with the information generated here, this exercise provided a useful tool to create a pictorial illustration of the "To-Be" CCSE organization's architecture that could potentially preform accordingly to meet the requirements of the ideal organization defined above (Figure 5: CCSE desired organization architecture decomposition). This potential organization architecture was designed to enhance communication between and within the stakeholders; although the potential benefit will only be measured once this structure is implemented.

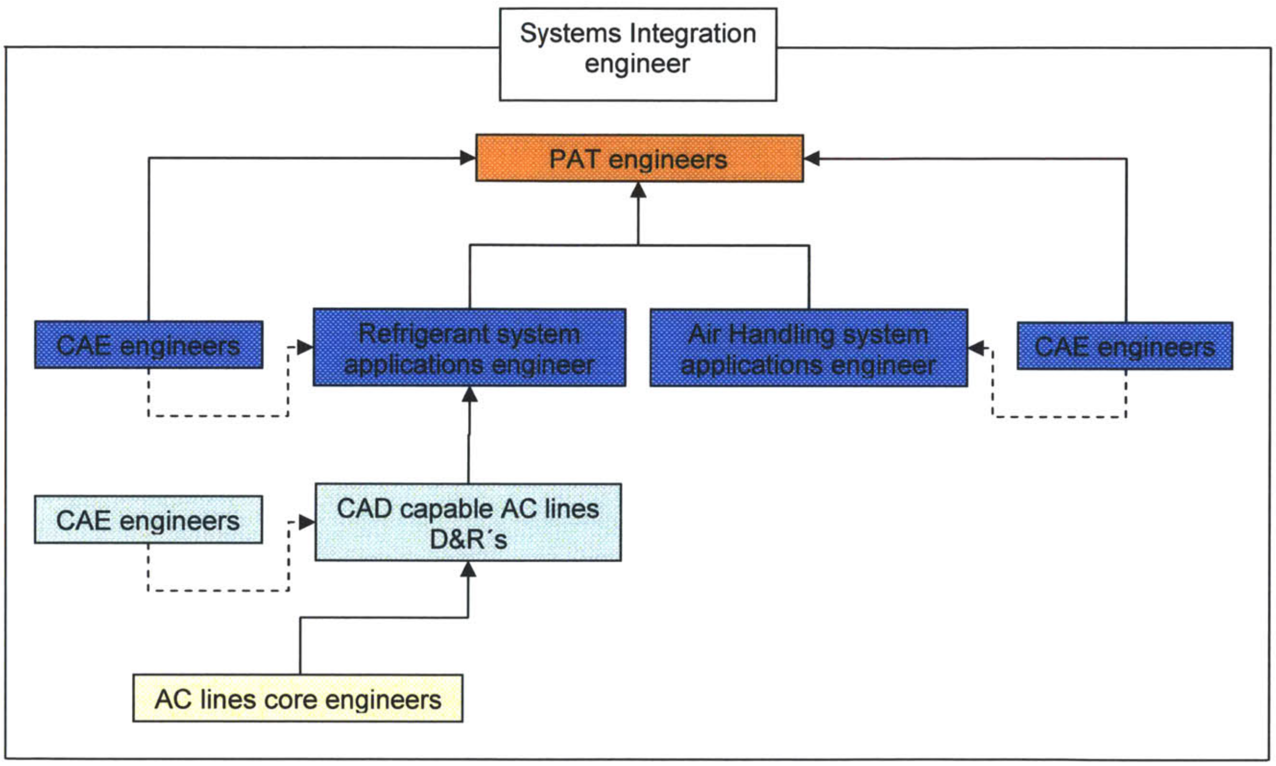

Figure 5: CCSE "To-Be" organization architecture decomposition

Finally the Hierarchical decomposition level framework developed in this chapter provides a simple method to map and illustrate systems decomposition. This decomposition of systems is helpful to understand the complexity within the basic inputs or elements of a system and ultimately mitigate it. Although it is true that this exercise provides an illustrative example of how inputs could be architected, this by itself does not allow to generate a firm conclusion in regards to whether it is true or not that planning the links between and within the inputs will help the PDOM to become the best engineering organization in terms of responsiveness, quality of execution and cost. In order to obtain clearer information to support the hypothesis, this framework was also applied to illustrate, from a planning perspective, why systems could fail if the inputs' hierarchical decomposition level is not understood. The following case shows how lack of inputs connections identification and complexity led to an organizational failure due to the emergence of *siloization.*

1.2) Understand Failure in the Inputs Planning Phase

1.2.1) Planning inputs: Real Life Failure Example

The example used to develop the failure story is based again on the CCSE organization in Mexico which first couple of years of life where turbulent and problematic. The results, although not catastrophic, forced the organization to revise its original goals. The following analysis provides a snapshot of the hierarchical decomposition level of key inputs such as goals, products and services and an explanation of why this organization failed in its early years of life. The information was again obtained through personal experience and interviews with key stakeholders of this organization which were affected by the initial turmoil. Their testimonies helped to understand the dynamics and complexity involved in this failure (See Appendix B: Why CCSE failed during its early stages?).

Note: In this example I highlighted in red, the elements that we concluded contributed to the failure of the organization.

What was wrong, from the People (organization) perspective, with the alignment of goals, architecture, interfaces and components?

Table 3: Failure case (People)

Hierarchical Decomposition Level	Critical Question	Response
People/Organization objectives	What goals and objectives should the organization meet?	1) To become a low cost/high value appendix of the North American CCSE organization to support new and current programs 2) To develop CCSE applications and core engineering capabilities in Mexico
Architecture	What individual functions are assigned to what elements,	Refrigerant and air handling sub-system core engineers and applications D&R oriented to design, validate, release and launch CCSE

	components, or pieces in the organization?	components.
Interface/Connection	How are the elements, components, or pieces connected within?	Unidentified interface/connection between applications D&R engineers and core engineers. Independent silos with no interactions between them
Components	What are the designs of the individual elements, components, or pieces of the system, given the functions and interfaces assigned to them?	High Skilled/low cost Mexican engineers

What was wrong, from the Product/Service perspective, with the alignment of goals, architecture, interfaces and components?

Note: In this example we defined "product" as an engineering service provided by the CCSE organization.

Table 4: Failure case (Product/Service)

Hierarchical Decomposition Level	Critical Question	Response
Product/Service Objectives	What goals and objectives should the product/service provided meet?	To produce low cost/high value engineering services to support the North American Climate Control organization
Architecture	What individual functions are assigned to what elements, components, or pieces of the product/service?	Design, validation, release, and launch engineering activities performed by D&R´s and core engineers
Interface/Connection	How are the elements, components, or pieces connected within?	Unidentified links/connections between component, sub-system and system development activities performed by the D&R´s and core engineers
Components	What are the designs of the individual elements, components, or pieces of the system, given the functions and interfaces assigned to them?	On time, effective and efficient individual engineering and managerial deliverables.

What was wrong, from the Process perspective, with the alignment of goals, architecture, interfaces and components?

Note: This table is limited to provide an example of process decomposition of the core engineers of the CCSE organization.

Table 5: Failure case (Process)

Hierarchical Decomposition Level	Critical Question	Response
Process Objectives	What product, services or information does the organization produce and deliver, for whom, when?	To improve component suppliers quality and efficiency
Pathways/Responsibilities	Who is responsible for what work-Activities, to create what intermediate product, service, or information for whom, in what order?	Core engineers in Mexico should provide engineering support and review quality claims with component suppliers located in Mexico
Connection/Exchanges	How does someone indicate that they need an item (product, service, or information), and how does those who supply and item learn that something is needed?	Core engineers should track field quality reports and review them with component suppliers with an open issues list. Core engineers should share insight to improve manufacturing quality.
Component work-activity/Methods	What is the work-element content, sequence, timing, location, and output for people to do the work for which they are responsible?	Field quality data should be available to core engineers to conduct active support to suppliers.

1.2.2) Final Notes and Conclusions of Real Life Failure Example

To start the discussion it is important to mention that the CCSE organization in Mexico fought to survive during its first year of existence. Qualitatively speaking, it failed to deliver the desired levels of execution responsiveness and quality expected by the PDOM. This failure was translated in undesired levels of attrition, poor execution responsiveness, low quality and as a result, high operating costs. From the **people (organization)** perspective we can conclude that the CCSE organization failed to perform at the desired levels of responsiveness and quality for three reasons:

1. Poor definition of system goals. These goals were simply not realistic not achievable with the current technical capabilities of the CCSE organization in Mexico, the available infrastructure and the company's financial situation since by definition, core engineers required high levels of technical skills and full time contact with specialized tools not available in Mexico.
2. As a consequence of the previous point, the architecture of the CCSE organization in Mexico was poorly designed.
3. With a poor architecture design, the interactions and connections between key engineers failed since those were not properly identified either. As a result, core engineers had little or no incentives to interact with applications engineers for the following reasons:
    - Core engineers activities were independent of any program timing
    - Core engineers in Mexico did not belong to a specific integration team
    - Core engineers in Mexico had poor communication with core engineers in USA
    - Core engineers activities in Mexico were not linked to the activities developed by the applications engineers in Mexico
    - Coaching and mentoring was sporadic and inconsistent
    - Two independent silos emerged with independent goals and objectives

Consistently, an analysis of the **engineering services** that were generated in this organization suggests as well that the activities performed by one key engineer had little or no relation with the activities performed by other. Interfaces and connections between people, processes and products/services failed and communication was not enabled, as a result, the engineering services in this organization were not compact. Two independent engineering services emerged as a result of poor interconnections; one oriented to core engineering activities and the other focused on engineering application. In this case the CCSE organization in Mexico performed close to what a Low-performing organizations looks like where those tend to be purely *functional oriented* and do not manage the relationships among all the elements adequately (see section 1.3.1 for a definition of functional oriented team).

From a **processes** perspective, it is important to introduce the definition of an STA engineer. The roll of these engineers is to provide the necessary technical support to the suppliers in order to guarantee the accomplishment of quality targets required by the Global Product Development Organization. This in paper sounds similar to what the core engineers in the CCSE organization in Mexico were assigned to do. This absence of clear roles and responsibilities led the organization to perform redundant processes that did not add value to the outcome of the organization.

Based on this information we can summarize the failure as a result of:

- Poor definition of system goals.
- Poorly designed architecture of the organization
- Poor identification of the interfaces/connections of inputs
- Poor definition of processes

Finally, this example was useful to illustrate how a poor definition and design of inputs like people (organization), product/services, and processes led the CCSE organization in Mexico to underperform (slow responsiveness and quality) and eventually to increase its operating costs. Furthermore, this analysis helped to demonstrate that when links and connections were not identified properly, the risk of failure was evident. Section 1.3.1 of this chapter provides a deeper analysis to support this conclusion.

1.3) People as Input and Enabler

One of the key inputs of the organization that can guarantee success is the people that integrate it. The subsequent sections of chapter one argue about the importance of hiring the best people and providing them with the best tools to achieve BIC in execution responsiveness, quality and cost. The statement below is probably one of the truest statements I have ever read.

"In my forty-eight years in the auto industry, I probably made six hundred speeches about management. Since my retirement, I've made many more. And I've always said the same thing: Here's what management is about: Pick good people and set the right priorities (Lee Iacoca)."

"Hiring is a unique moment and opportunity for an organization; it allows infusion of new thoughts, perspectives and energy allowing the organization to stay fresh. It is also the point in time at which much of the intrinsic direction and culture of the organization will be defined. So important is hiring the right people, that pressure to grow an organization must never prevail over the search for the right talent and individuals (Aguirre, 2008)." The general consensus agrees that one of the key inputs to organizational success is the talent available to execute as desired. Without this talent the chances of success in the long run significantly diminish. Equally important is to provide this new talent with the necessary tools to execute successfully.

This section is focused on providing a guideline at the planning phase that will help the organization to select the best people during the recruiting process as part of the essential definition of this input; individuals that are paid more but are worth more. In order to answer the question about what characteristics should the employees of the organization have, these guidelines were developed by compiling information from key stakeholders of the PDOM and recommendations obtained from literature. The following elaborates on the critical characteristics that should be observed and considered when hiring new talent, forming teams and retaining talent:

Attributes of individuals and teams extracted from Thomson and Tracy (1993) and notes obtained from SDM meetings:

- Owns the outcome: People that show interest in thinking, analyzing, and delivering better results than ever before, in other words, obsessed with perfection.
- Demonstrates full engagement and commitment: People capable of working together and committed to the outcome of their work.
- Builds confidence in others: People committed to their own development and its peers. Always looking to *go further* and turned on by the opportunity to prove something or have greater impact.
- Capable of understanding the tasks to be performed: Clever and intelligent people relentlessly searching for wisdom. Passionate people fostering technical excellence.
- Loud voice to be heard: People and teams capable of clearly communicating things that went well and/or wrong.

More information and deeper analysis has been developed in the work of Adrian Aguirre (2008) and Takahiro Endo (2008). In their work both argue that the hiring process has to be designed taking into account the individual characteristics mentioned above. The successful planning of the hiring process will afterwards become a key enabler during the execution phase to achieve the action plans towards achieving success.

1.3.1) Planning the Team Structure:

Indeed people attributes are relevant to the success of an organization, but planning accordingly to hire the best people is not enough to execute properly. An adequate team structure and architecture is required to leverage the people´s capabilities. Within the next few years, the PDOM will observe an increasing demand for engineering services and will have to learn to operate appropriately to satisfy it. Along with this, the organization will have to learn to respond to change during execution; therefore it will have to find a way to maintain flexibility, agility and adaptability. Wheelwright and Clark (1992) and Spear (2005) define four types of product development teams:

Autonomous: Composed of people from different disciplines working as a single group usually clustered together at an off-site location and away from normal resources and incentives provided by the parent organization. This allows cross-functional problem solving, enables continuous communication and integration, and allows discussion around problem solving and concept generation. This team structure is desired when **system** goals and objectives have not been designed.

Example: Directors and Functional Chiefs in charge of:

- Strategy definition
- Establish design goals and objectives

Heavyweight: A rigid structured team led by senior managers with authority to allocate resources and delegate responsibilities at their teams' convenience. Since these teams share characteristics from the autonomous and functional teams, they show a high degree of communication and integration while focusing on a component level technical development. This team structure is desired to design functions within the product and responsibilities within the team **(Architecture).**

Example: Teams led by Functional and Program Chiefs and managers capable of controlling its own resources:

- Assign function to elements responsibilities
- Assign elements to people responsibilities

Lightweight: A more flexible structure that combines the advantages of heavyweight and functional teams, where tight communications and integration are emphasized though a less senior manager compare to the heavyweight team. The main responsibility of the leading managers in a lightweight team is to facilitate communication and discussions across boundaries in order to motivate problem solving. This team is desired when **interfaces and connections** have to be designed.

Example: Teams composed of people from different backgrounds to facilitate communications, and which team members are empowered to make decisions at the low hierarchical levels:

- Design product interfaces and act as connections between functional teams.

Functional: Formed with people from different disciplines who contribute at a component or sub-system level and which, as opposed to the autonomous teams, remain within their parent organization physically and in terms of accountability. This structure allows the team members to gain deep insight about their technical knowledge and apply it to new product design. This team structure is desired to provide deep technical expertise to designing **components**.

Example: Core engineering teams led by technical leaders:

- Deep technical expertise

Each of the team types has its own strengths and weaknesses and the advantage of one team type over other depends on which level of the system design wants to be accomplished. What is the team type that should dominate the relatively young PDOM? In order to answer this question we should clarify that the responsibility of the PDOM within the next years will be to design, validate, release and launch top-hat products. Antonio del Puerto (2010) defines Top-hat products as: "all new, single model, single series vehicle development programs that are built upon a validated legacy platform and thus a previous top hat. Customized vehicles made with components that are intended to provide differentiation from other products built from the same platform (del Puerto, 2010)."

The key concept extracted from this definition is: "to create a new product based on an existing architecture". By definition this requires a high degree of component integration, interface design and systems oriented execution based on communications, therefore the focus of the PDOM will have to address the complexity of creating interfaces and connections effectively within inputs like people, products/services, and processes and tools. The Product Development Organization in Mexico is facing a huge opportunity to construct the foundations to perform as a High-Velocity (high-performing) organization. Steven J. Spear (2009) argues that low-performing organizations tend to be functional oriented and do not manage the relationships among all its elements adequately. These organizations usually fall under the "silo" effect, where their different departments execute independently without a real integration, relying on the performance of their functional teams only, leading them to fail. Communication gets complicated and usually firefighting arises due to lack of integration in their execution phases.

Furthermore, del Puerto concludes extensively on the importance of addressing continuous and clear communication in the development of top-hats. The following arguments are conclusions extracted from his work (del Puerto, 2010):

- "Constant communication between the Design Engineers co-located in the engineering site and the Design Engineers collocated in the Studio is crucial. Touch screens and conferencing tools must be used in both sides to improve informal communication prior to Engineering cut-off.
- It is imperative that the Design Engineer takes the role of system integrator from the surface perspective, this is, they must be aware of all the potential surface changes derived from the

informal communication processes, understand the implication to surfaces of other components, and lead the resolution that best accomplishes vehicle performance of attributes, cost and quality.

- There must be daily information exchange between the Engineering organization and the Design Studio to communicate any issues that would impact styling.
- Periodical face-to-face meetings are also important to improve the willingness to accept ambiguous information and to reduce the effects of the "not-invented here" syndrome by enhancing the team identity (del Puerto, 2010)."

The common concepts embedded in these conclusions are: **links, exchanges, communication and integration** which imply the utilization of interfaces and connections therefore, these conclusions suggest that a lightweight team structure can address the need for these links between inputs. Given the relatively young structure and inexperience of this organization, the efforts should be focused on properly managing the connections and interfaces of people, services, products and processes; so as defined previously, it will become vital for this organization to learn to operate under a Lightweight structure in order to maintain flexibility through tight communications. Section 1.2 of this chapter provided a supportive example of how the silo effect led the CCSE organization in Mexico to fail during its early years of life. This means the CCSE organization failed to incorporate a lightweight approach since interfaces and connections were absent.

1.4) Hypothesis conclusion

Chapter one was mainly developed to answer the following hypothesis: **Architecting the connections between and within the basic inputs of a Product Development organization will enhance high levels of execution responsiveness and quality at reduced costs.** The failure example analyzed in section 1.2 has proven to be useful enough to asseverate that the hypothesis stated above is true in complex systems; but although planning the inputs of an organization and its links might enhance high levels of execution responsiveness and quality at reduced costs, the planning phase of an organization is founded on the definition of multiple assumptions such as: demand for products and services, capability to respond to that demand and desired performance of the organization among others. By definition, assumptions are things that are accepted as true or as certain to happen, without proof (google definition), therefore assumptions are susceptible to change.

A key element to maximize chances of success is not only to identify as much assumptions as possible but to transform those not proven assumptions into proven knowledge; but although planning is important, organizations should recognize that not all outcomes are predictable. The data that would let organizations be more certain about their future simple might not exist yet (Gunther and MacMillan, 2009). The real challenge here is to determine the amount of time that should be allocated in order to transform the maximum possible amount of assumptions from not proven to proven; but at the same time making sure that the time allocated for planning is used efficiently.

Second, the hierarchical decomposition framework provides a supportive argument in favor of the hypothesis confirmation. It demonstrated how critical it is to plan/architect correctly the inputs of a complex system during the planning phase, specially the links between and within them. When inputs are not correctly identified as seeing in section 1.2, failure is likely to occur. Several relevant questions were used to focus the discussion around confirming it and the answers that support this statement are:

What are the basic inputs of an organization?

Aguirre (2008) and Browning, Fricke, and Negele (2006) identify Goals, Service, Product, Process, People and Tools, as the basic elements of product development systems.

How these inputs should be designed?

The decomposition framework used in this chapter is a useful tool (nevertheless not the only one) to design each input at the following levels: System, Architecture, Interfaces and Components.

What characteristics should the employees of the organization show to execute the action plans?

- Owns the outcome
- Demonstrates full engagement and commitment
- Builds confidence in others
- Capable of understanding the tasks to be performed
- Loud voice to be heard

What type of organization should execute the action plans in order to maintain attributes such as flexibility?

Again, the failure case presented in section 1.2 suggests that a predominant but not exclusive *lightweight* approach is desired to enable continuous communication within the PDOM and the parent PD organization in order to avoid the silo effect. Figure 5 provides an example of links in the CCSE organization. A key element to maximize success is to keep consistency between the level of design and the type of organization implemented to design it. The product development organization in Mexico will be focused mainly on integrating existing and new vehicle components and sub-systems with relatively minor modifications to create top-hat automobiles, and accurate communications skills will be required to beat complexity (see definition of top-hat in section 1.3.1). As a result, integration activities will become key elements for success. The framework presented in this first chapter suggests that integration and connections should be developed by a Lightweight organization to facilitate communication and discussions across boundaries in order to motivate problem solving at the lowest levels.

Also from this case we can see that interfaces and connections within a system are critical to avoid individual silos and enhance flexibility. This case demonstrated how failing to identify correctly the interfaces and connections in the planning phase of products/services and organizations slowed down the organization's execution speed and quality preventing it to become the best in class organization in that respect. From this case it is valid to argue that the ability to achieve success as defined in this high velocity Product Development organization will be measured by the capability it has to identify links and connections within and between the different sub-organizations that compose it.

When we think about a car we think of an integrated machine greater than the sum of its parts. A critical attribute of an automobile is the degree of integration between its sub-systems and the effectiveness to connect the whole with the users. For example, the climate control system is tightly linked to the Powertrain system. Both systems exchange material, information and energy. In order to blow cool, de-humidified air inside the cabin, it is necessary to pump a refrigerant substance through the automobiles refrigerant sub-system. The pumping action is performed by transferring a rotation energy coming from the engine, into the AC compressor; therefore if the engine does not work, the air conditionings will not either.

This simple example illustrates how critical it becomes to understand the interfaces and connections between sub-systems. Failure to identify them during the design planning phase will lead to inaccurate design assumptions. Equally, failure to connect the various functional activities will result in poor communications as seen in the failure case. In other words, the conclusion of this chapter suggests that the PDOM should learn to operate primarily as a lightweight organization.

Chapter 2: Execution

Hypothesis - In an inexperienced organization, mentoring and training employees and investing on "ilities" are key enablers to achieve a low cost execution responsiveness and quality, when the only true constant is change. (Refer to the list of acronyms for a definition of "ilities")

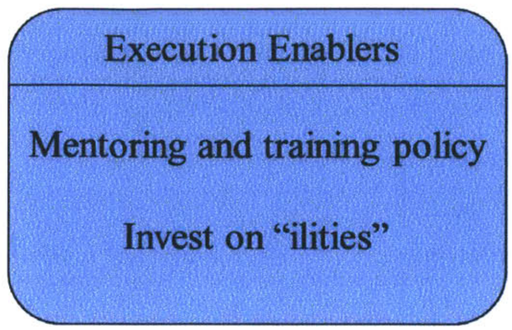

Figure 6: Execution Enablers

The PDOM will phase within the next 5 years an increasing demand for product development (engineering) services. The biggest challenge will be to respond to this demand with what has been defined as an inexperienced organization. In the previous chapter we discussed the importance of hiring the best people and the suggested structure of the organization, now the question is how the organization should execute in order to achieve success as defined in the beginning of this thesis. In order to guide the discussion, the following relevant questions are stated:

- What are the common reasons why young organizations fail to respond to increasing demand for services?
- What is the effect of the inexperience organization during the execution phase on achieving success?
- What is the effect of the "pressure to do more with less" during the execution phase on achieving success?
- How are the "rookie factor" and the "pressure to do more with less" overcome?
- What are some of the "ilities" necessary to sustain the organization in a constantly changing environment?

Previous studies focused on establishing the basic grounding of the PDOM suggest that a Mentoring and training policy is one of the key enablers to reach success (see Aguirre, 2008). But this policy has to be supported by a continuous investment on emerging attributes defined as "ilities" such as flexibility, agility and adaptability to enhance the capabilities of the organization towards achieving the ultimate goals especially when the only constant is change. The focus of this chapter is to present two organizational enablers that could contribute to execute the action plans defined by the PDOM as: Low Cost / High Value operations, People Excellence, Process Discipline, and Facilities, Tool & infrastructure, taking into account the relative inexperience of its members.

In Chapter one (Planning) we explored the advantages of understanding the design levels of some of the key inputs of the organization (goals, services, products, processes) towards achieving long run success. Also, the key characteristics that should be considered when hiring a new employee and the importance of providing the necessary tools and facilities as inputs and enablers towards success were presented. This chapter is focused on addressing the effects of: 1) **Mentoring and training** and 2) **Investing on "ilities"** as key enablers to achieve success.

To start this discussion, the first question is why choosing these two enablers? To answer it we should keep in mind that the main product of the PD organization in Mexico is an engineering service. Oliva and Sterman in their paper Death Spirals and Virtuous Cycles (2010) conclude that during the execution phase, "service organizations are commonly trapped in vicious cycles that prevent them to respond to service demand mainly for two reasons (Oliva and Sterman, 2010):"

- The rookie factor effect: Inexperienced organizations facing growing service demands struggle to acquire capacity fast enough deriving into lack of productivity.
- The continuous pressure to "do more with less" pushes organizations to operate with little margin to accommodate demand variability and creates a burn-out effect

The following sections develop on these two reasons.

2.1) The Effect of an Inexperienced Organization on the Productivity

2.1.1) Rookie Factor Effect

A system dynamics model is used as the method to illustrate how and why organizations struggle to acquire capacity fast enough during the execution phase to respond to services demand and the impact of inexperienced employees on its average productivity as concluded by Oliva and Sterman. In order to support and present tangible results, two case scenarios developed with real and theoretical data, are applied to the discussion of this section.

i. Case scenario

In order to model the rookie effect in the performance of the organization, a theoretical scenario was developed based on some of the current assumptions of the PDOM established in the A3 (see list of acronyms for definition of A3). Let us assume that the PDOM would have to increase its headcount from approximately 550 employees to 1000 employees from 2011 Calendar Year (CY) to 2015 CY as a response to one of the principal needs of the global product development organization; to development low cost/high value engineering services (design, validation, release and launch). The initial metrics of the organization suggests that 30% of these employees in Mexico are considered *inexperienced.* I define them as new co-workers that have had little or no exposure to the PD organization's systems, products, services, processes and tools. The target towards 2015 CY is to reduce the amount of inexperienced employees from 30% by the end of 2011 CY to 10% by the end of 2015 CY at a rate of 5% per year in order to improve the average productivity of the organization. In other words, increase the amount of experienced employees from 70% to 90% in the same period. I define experienced employees as co-workers capable of applying, leveraging or mastering systems, products, services, processes and tools. Given this scenario, it is important to assume the following modeling conditions obtained from real assumptions:

- Period = beginning of 2011 CY to end of 2015 CY
- Workforce at the beginning of year 2011 = 550 employees
- Constant Rookie productivity fraction (Build) = 20%
    - Literature suggests that in complex services organizations such as financial and product development, the rookie productivity fraction is 20% of a *fully* experienced employee. (Sterman, 2000)
- Experienced Employee constant average productivity fraction (Apply, leverage, Master) = 80%
- Inexperienced Quit fraction = 30% per year
- Experienced Quit fraction = 10% per year
- Average assimilation Time = 104 weeks (2 years). Based on CCSE technical maturity model
- Year over year Headcount growth rate is given by the desired Headcount level at the end of each year and is indicated in table 6:

Table 6: PDOM expected Growth Rate

	End of 2011	End of 2012	End of 2013	End of 2014	End of 2015
Headcount	651	780	934	934	1000
Growth Rate	18%	19%	19%	0%	7%

To keep the model simple it is assumed that every new employee has been hired taking in consideration the attributes laid down in chapter one, and each of them are considered inexperienced regardless the amount of time spent and experience gained working with a competitor or analogue industry. It is important to point out that in this model employees gain experience automatically and without cost and the attrition rate is fixed and not influenced by factors such as employee satisfaction. Also, it is assumed that experienced employees perform in such a way that they achieve the desired execution responsiveness, quality and cost to become BIC.

ii. Dynamic Model Description

The simple model illustrated in Figure 7 is useful to understand the dynamics of the learning curve in an organization and how this acquires capacity to respond to service demand by increasing the effectiveness and productivity of its workforce. The base architecture of the model is formed by 2 employee stocks: inexperienced (Rookie) employees and Experienced employees. The Inexperienced employee stock increases as new hires are incorporated into the organization as dictated by the growth rate in table 6, and decreases as inexperienced employees which have yet not become experienced employees, quit the job per the inexperienced quit fraction. On the other hand, the experienced employees stock is fed by inexperienced employees that have acquired knowledge (automatically and at no cost) through exposure to systems, products, services, process and tools ; and have migrated from an inexperienced status to an experienced status. In this case the assimilation time is constant at 104 week. A decrease in the Experienced employees stock is caused by the attrition rate of experienced employees given by the inexperienced quit fraction due to multiple reasons not relevant for this analysis, therefore as mentioned before this attrition rate is constant.

This model includes three important variables that define the capacity of the organization to execute as a response to an increase in services demand. The first one is The **Rookie Fraction** which indicates the portion of inexperienced employees out of the total amount of employees in the organization. The second variable is the **Average Productivity** defined by the expected productivity of inexperienced employees plus the expected productivity of experienced employees. The third variable is the **Effective Workforce** defined as the amount of effective experienced employees plus the amount of effective inexperienced employees.

Figure 7: Rookie factor learning curve model, provides a pictorial description of the model. This model has been modified from the original created by Oliva and Sterman. For further description of the model refer to the work of Oliva and Sterman (2010).

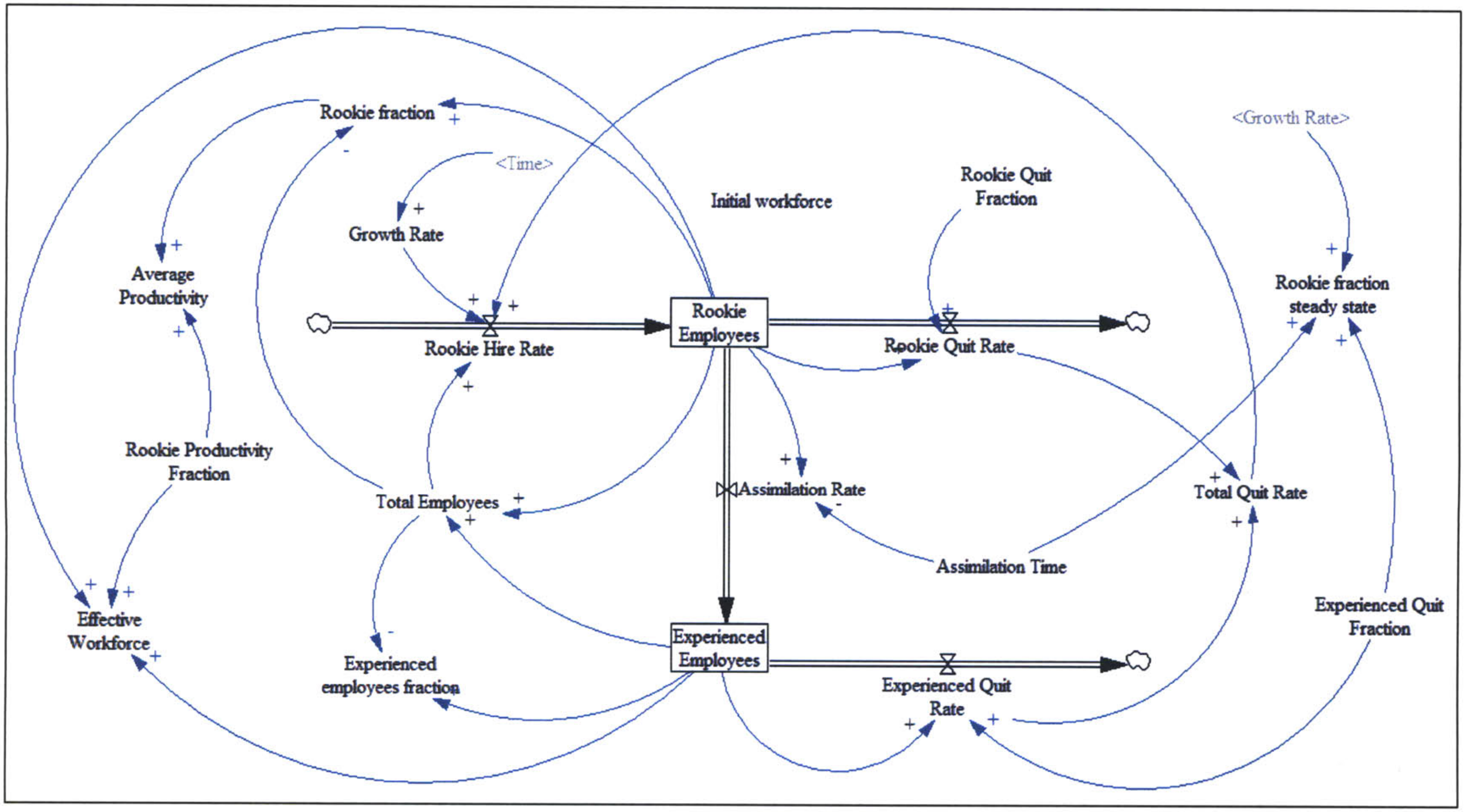

Figure 7: Rookie factor learning curve model (adapted from Oliva and Sterman, 2010)

iii. Results

The simulation of this model using the assumptions defined above generates the results detailed in the subsequent pages. Please note that some of the figures below are expressed in "Dmnl" units defined as:

Dmnl = dimensionless units where 1 equals 100% and 0 equals 0%.

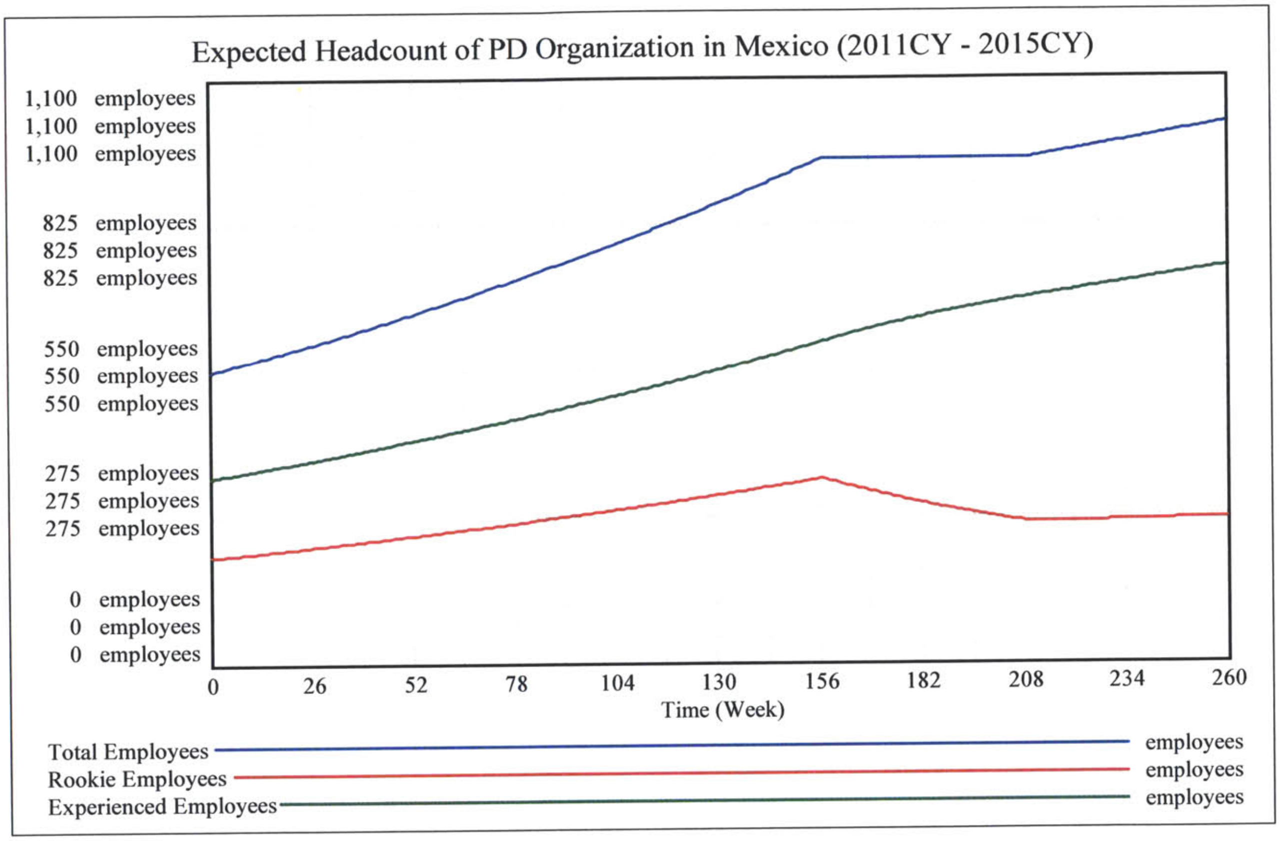

Figure 8: Expected Headcount of PD Organization in Mexico (2011CY – 2015CY)

The graph above is a close-enough illustration of what the PDOM would expect in terms of headcount growth from the beginning of 2011CY to the end of 2015CY, where the organization would grow from approximately 550 employees to about 1013 according to the assumptions described before. The total headcount is defined as the sum of inexperienced employees plus experienced employees. Throughout the 5 years, the approximate ratio of experienced employees to inexperienced employees is maintained at approximately 2 to 1. Note that the number of inexperienced employees grows from year one to year three in almost constant rate. As expected, when hires are frozen (per the assumptions "zero" headcount growth planned in 2014CY), the amount of inexperienced employees decreases from approximately 345 to 262 inexperienced. If this is true, year 2014CY would signify an acceleration of the level of expertise in the organization mainly due to a freeze in the hiring process.

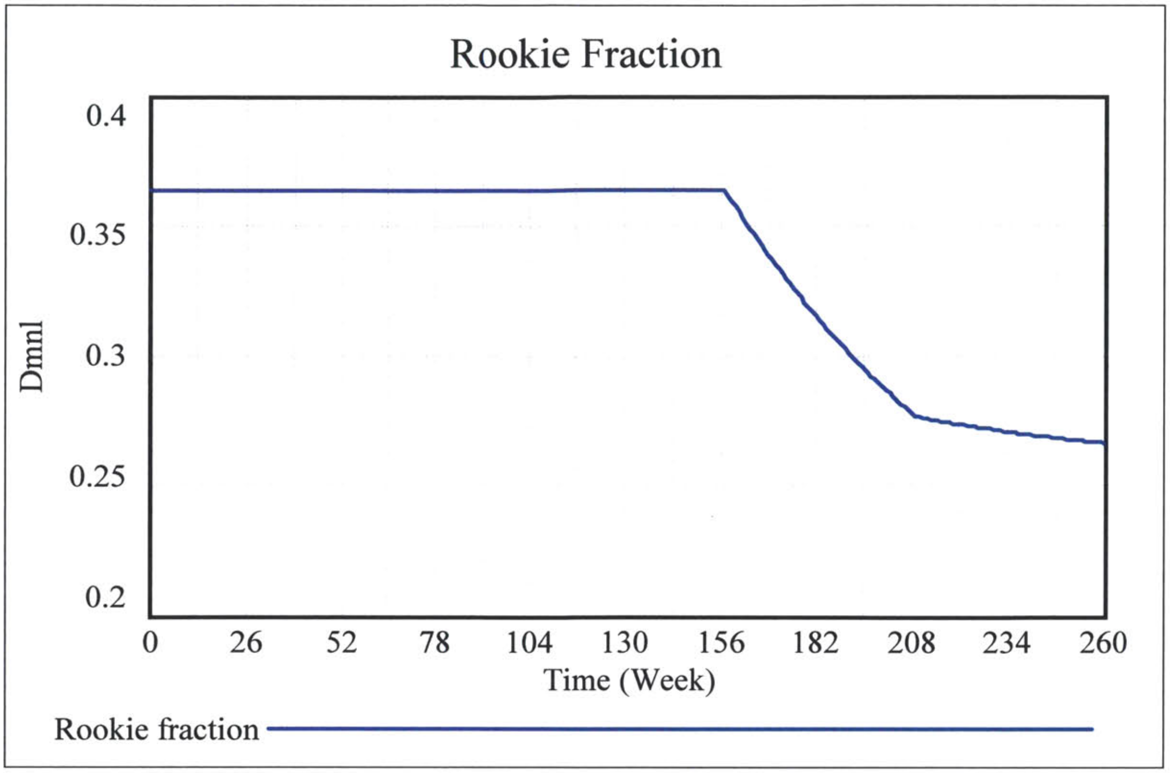

Figure 9: Expected Rookie fraction of the PD Organization in Mexico (2011CY – 2015CY)

As mentioned before, one of the most important indicator of the organizations capability to respond to growing services' demand is the **Rookie Fraction variable** which specifies the portion of inexperienced employees out of the total amount of employees in a given week. Figure 9 interestingly shows that the rookie fraction is kept constant at around 36% for 156 weeks or 3 years, from the beginning of 2011 CY and until the end of 2013 CY. This plateau effect of the rookie fraction between 2001 CY and 2013 CY is given by the fact that the rookie fraction is a function of the inexperienced employees and the total employees. Since both variables growth in equal proportions, then the fraction is unaffected. What this tells us is that the conversion rate from inexperienced to experienced employees defined as the "assimilation rate" is not boosted or accelerated along the learning process. This is true since in the model, the assimilation time is kept constant at 104 weeks keeping the assimilation rate constant as well.

In response to a headcount growth rate reduction in years 2014 CY and 2015 CY, the amount of inexperienced employees starts decreasing at a constant rate after the week 157 and until the week 208. This model suggests that by the end of the 5 year period, the percentage of inexperienced employees in the organization would only have decreased to approximately 26%, significantly short of the target (10%). It is important to mention that if the organizations growth rate was kept constant, then the rookie fraction would also be constant for the full duration of the study.

As expected, these results demonstrate that a linear growth of knowledge and skill or what we assumed as Automatic learning (see model assumptions) is not enough to achieve the percentage targets for experienced and inexperienced employees by the end of the 5 years (90% experienced and 10% inexperienced). This suggests that in order to achieve those targets, a policy focused on achieving exponential growth of knowledge and skills (learning) will have to be implemented to boost or accelerate capacity during the execution phase.

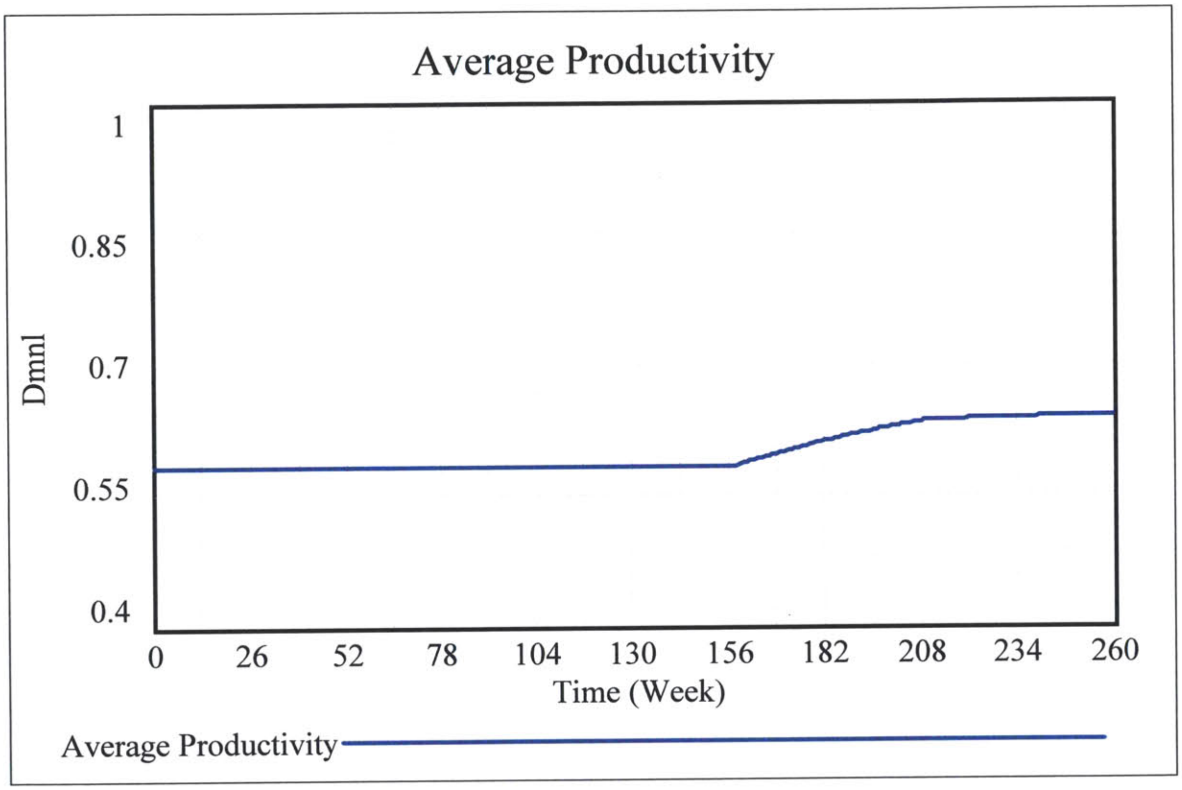

Figure 10: Expected Average Productivity of the PD Organization in Mexico (2011CY – 2015CY)

Another key indicator of the organization's capacity to execute according to service demand growth is the **Average Productivity** defined by the expected productivity of inexperienced employees plus the expected productivity of experienced employees at a given week. Consist with the rookie factor results the average productivity of the organization is kept constant at approximately 58% (of the potential productivity) from 2011CY to 2013CY while the organizations growth rate is kept unchanged. After the week 156, the average productivity increases at a constant rate for one year until it decreases the rate at which the organization becomes more productive to end at an average productivity of 64% approximately. Note that the jump in productivity is due to the decrease in the rookie fraction (Figure 9) as a result of the de-acceleration of the organization's growth and not due to the implementation of a learning booster policy. These results also confirm that such a policy is required to achieve the targets for experienced and inexperienced employees (90% experienced and 10% inexperienced).

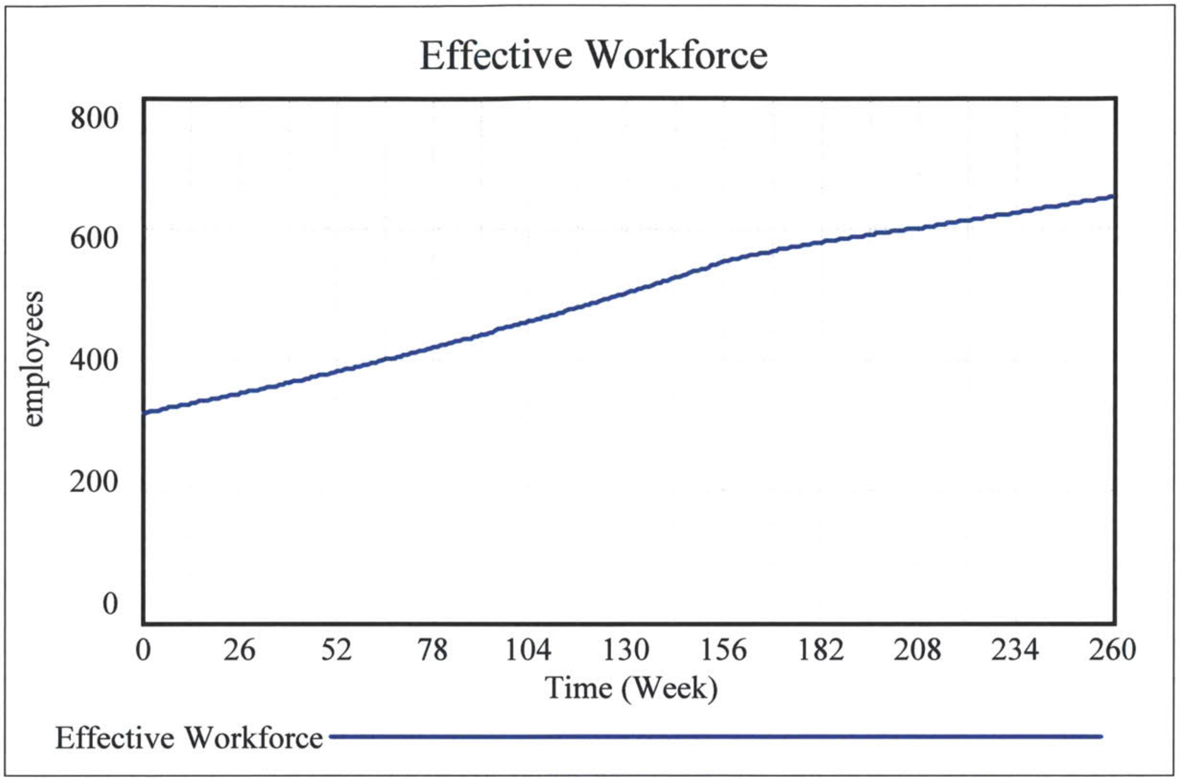

Figure 11: Expected Effective Workforce of the PD Organization in Mexico (2011CY – 2015CY)

In a high-speed growing product development organization, one would expect to see an exponential growth of the **Effective Workforce.** This workforce is defined as the amount of effective experienced employees plus the amount of effective inexperienced employees. As defined in the assumptions, an experienced employee is only 80% effective and an inexperienced is only 20% effective, therefore the effective workforce of an organization will be composed primarily of experienced employees. The curve in Figure 11 shows the growth of the effective workforce in the organization from 2011 CY to 2015 CY and the tendency is far from being exponential as would have expected. As opposed, the effective workforce is showing a growth trend close to linear which suggests that the *status quo* in the learning process is not being challenged.

iv. Model Conclusions

There is not too much to add, but we can say that by definition, we want a low cost/high value organization that produces more with less or as I technically define, an organization with the highest possible average productivity levels. The results of this model suggest that a policy should be implemented in the organization to enable capacity acquisition through learning. Low cost/high value can be achieved by implementing a learning booster policy driven by mentoring and "learning by doing" training but, it has its consequences addressed in the next section.

2.1.2) Mentoring and in-job-training to Acquire Capacity (booster policy)

According to Oliva and Sterman (2010), there are multiple ways to increase the productive capacity of an organization. The first obvious strategy is to expedite the hiring process of employees with high initial capabilities like effectiveness and efficiency amongst others. The PDOM has understood the importance of getting the best people available and Chapter one provides a quick guide (suggestions) of the overall attributes and skills that the new employees should have.

The second strategy is to "increase the responsiveness of service capacity by accelerating the learning process (Oliva and Sterman, 2010)." Given the latter, they conclude in their studies that there are two parameters that determine the speed and strength of the learning curve in an organization:

- "Rookie productivity fraction: The productivity of inexperienced employees relative to fully trained employees.
- Assimilation time: How long it takes inexperienced employees to become fully experienced".

The relevant question in this case is how can the two parameters above be achieved? Tyre and von Hippel (1993) have studied the dynamics of the adaptive learning process and learning by doing in complex organizations. According to them, "adaptive leaning is *situated* in that it depends on experts' ability to utilize resources and to gather information that is embedded in particular physical settings. Thus, to understand and resolve problems, experts need to make use of the practices, occurrences, beliefs, and artifacts available in specific, concrete settings (Tyre, and von Hippel, 1993)." On that same token, they define Learning by doing as a simple "form of problem-solving that involves application of a production process (or product, service or technique) in its intended use environment. Learning by doing involves users or others who are actively problem-solving to change the environment in order to create unanticipated problems for products or processes or services that operate within it (Tyre, and von Hippel, 1993)." A common example of adaptive learning by doing is the use of rapid prototyping in the auto industry. These techniques enable the organization to create robust products/services by creating unanticipated problems through changing the environment in which they perform. This is what the essence of learning by doing is and by implementing it, significant costs are avoided and assumptions are rapidly transformed into knowledge increasing the capabilities of the organization.

The basic discussion extracted from the arguments above is that the adaptive learning process of the PDOM should not fight against the benefits of Learning by doing or in-job training schemes to leverage the continuous learning process of the organization. Learning by doing has demonstrated to have significant effects on reducing cost of production as well as contributed to increasing the capabilities of an organization. A great example of a mentoring policy intended to become an in-job-training or learning by doing policy adopted by the PDOM is the "team leader program" implemented in 2011 CY. This program was a simple mentoring scheme where a fully experienced and capable employee was assigned to train 2 to 4 relatively inexperienced employees. Team leaders not only kept their own engineering responsibilities but acquired the roll of mentor, which in most cases increased their work significantly.

So why did this program fail? The following section develops an argument in favor of a *booster policy* called **mentoring and in-job-training** (learning by doing) as key to increase the speed and strength of the learning curve in the organization and also illustrate one of the effects of the mentoring process on the overall productivity of the organization in early years of implementation. The implementation of this policy in the Product Development organization is seeking to increase the productivity of inexperienced and reduce the time it takes them to become experienced as suggested by Oliva and Sterman.

v. Case Scenario

The Model conditions and parameters are the same as in the previous example case except that now the *booster policy* called Mentoring and in-job-training (Learning-by-Doing) has been implemented. The effect of the booster policy has been added in the model structure illustrated in Figure 14: Rookie factor learning curve model with Booster Policy. This model assumes that the policy impacts directly the rookie productivity fraction and the assimilation time and negatively affects the productivity of the experienced employees since they need to dedicate some of their time to train the inexperienced employees. In order to maintain the model simple, we assume that the effectiveness of the training policy in the organization is reflected in a linear improvement where the overall rookie productivity fraction and the time it takes to assimilate experience in the organizations behave as follows:

a. Linear improvement of the Rookie Productivity fraction from 20% to 50% approximately.

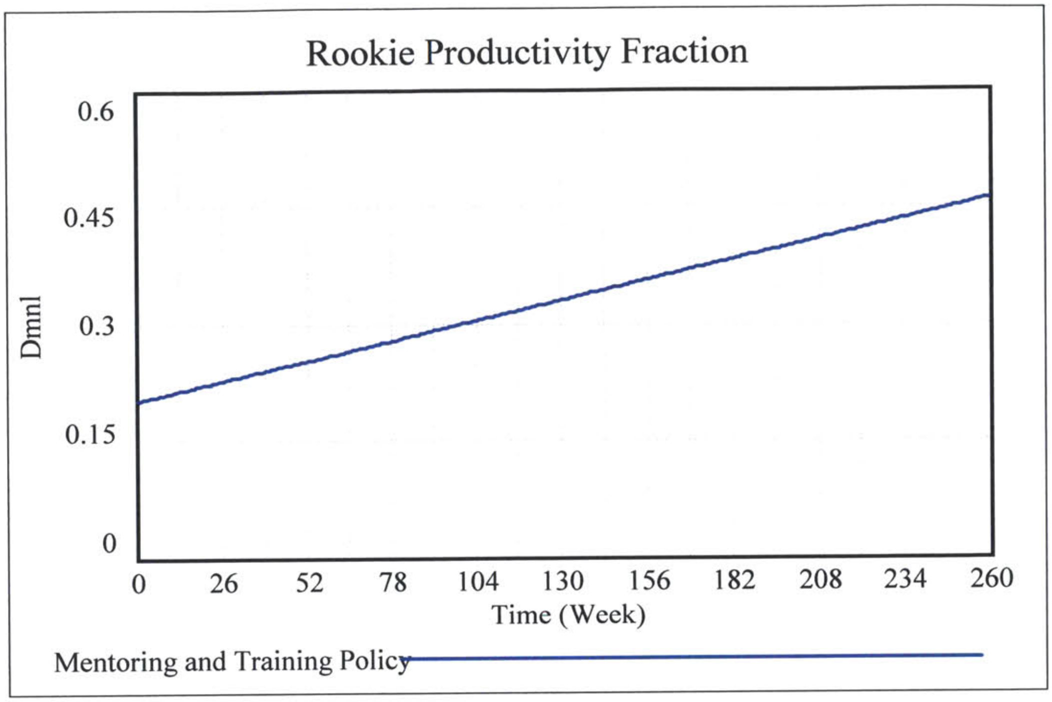

Figure 12: Rookie Productivity Fraction (Mentoring and Training Policy)

b. Linear improvement of the Assimilation time from 104 to 78 weeks approximately.

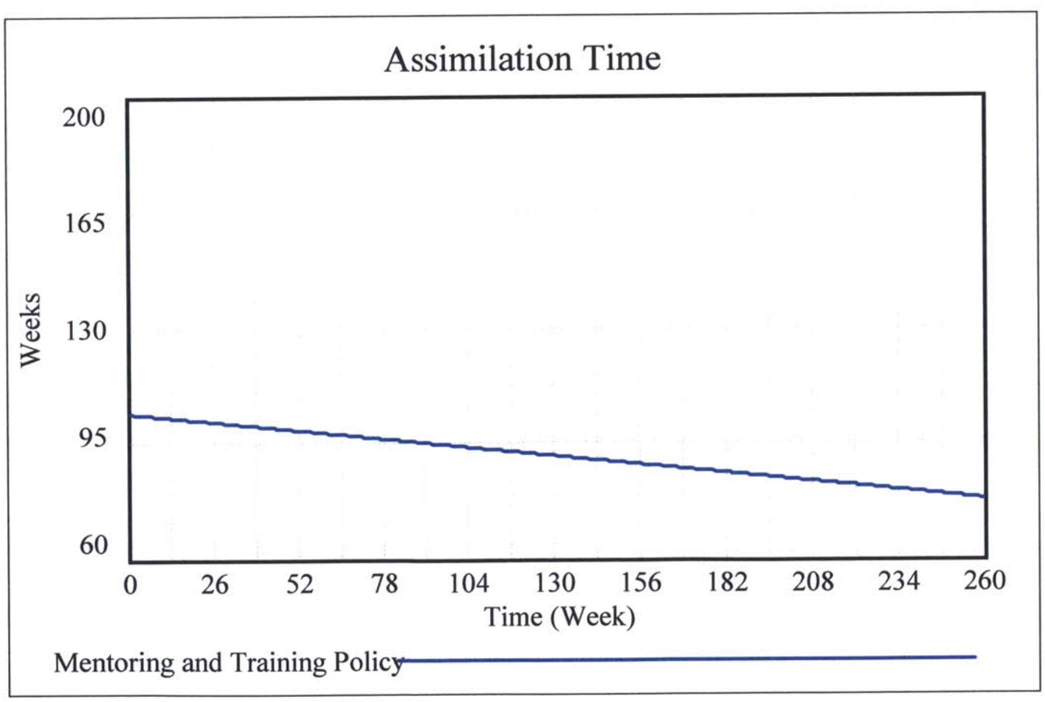

Figure 13: Assimilation time (Mentoring and Training Policy)

c. Linear improvement of the Fraction of experienced employee's time required for mentoring from 0.2 to 0.1 approximately over the 0.8 of original productivity.

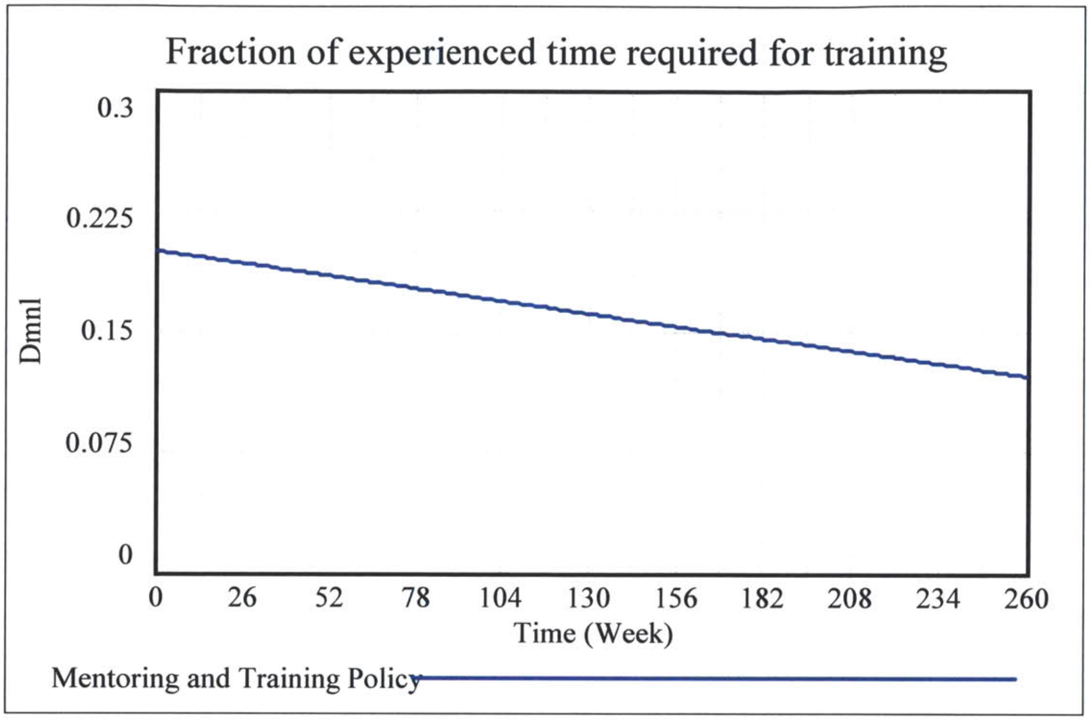

Figure 13A: Fraction of experienced time required for training (Mentoring and Training Policy)

Figure 14: Rookie factor learning curve model provides a pictorial description of the model. This model has been modified from the original created by Oliva and Sterman. For further description of the model refer to the work of Oliva and Sterman (2010).

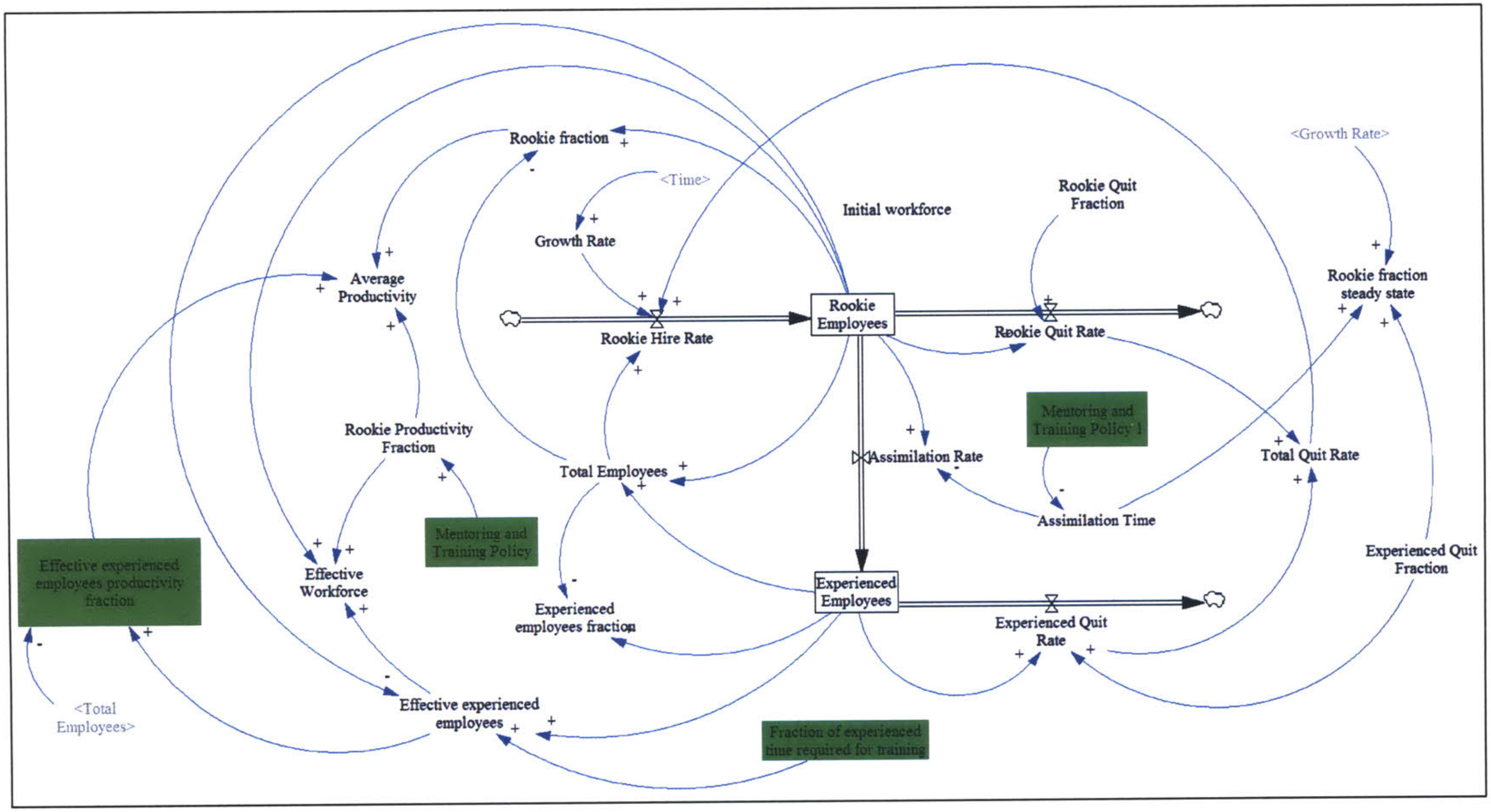

Figure 14: Rookie factor learning curve model with Mentoring and Training Policy

vi. Results

The simulation of this model using the assumptions defined above and the Mentoring and Training policy generates the results detailed in the subsequent pages. Please note that some of the figures below are expressed in "Dmnl" units defined as:

Dmnl = dimensionless units where 1 equals 100% and 0 equals 0%

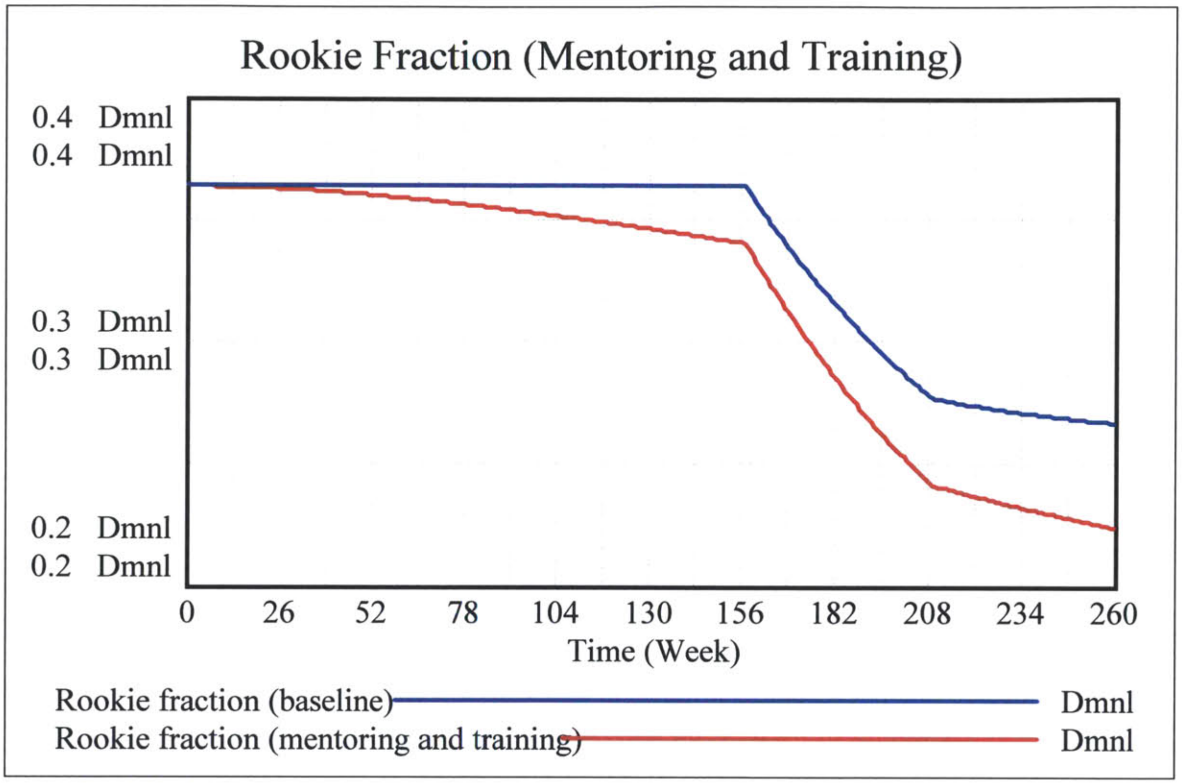

Figure 15: Expected Rookie fraction of the PD Organization in Mexico with Mentoring and Training Policy (2011CY – 2015CY)

Figure 15 provides a comparison between the behavior of the rookie fraction with and without the booster policy. As expected, with the policy in place, the Rookie Fraction decreased at a faster rate compared to the non-policy model as a result of boosted assimilation time and rookie productivity fraction. The rookie fraction starts at around 36% and decreases down to 34% at week 156 weeks or 3 years. In the previous example, the rookie fraction was kept constant during the same period. By the end of the 5th years, the rookie fraction went down to 22% compared to 26% previously obtained with no policy. Although these results are still shy from the target of 10% rookie fraction by year 2015, they indicate an improvement in the learning curve of the organization therefore the conclusion is that this is the right way to proceed in order to boost the capacity of the organization to address demand growth for services. Is this fast enough? Figure 16 might indicate that it is not.

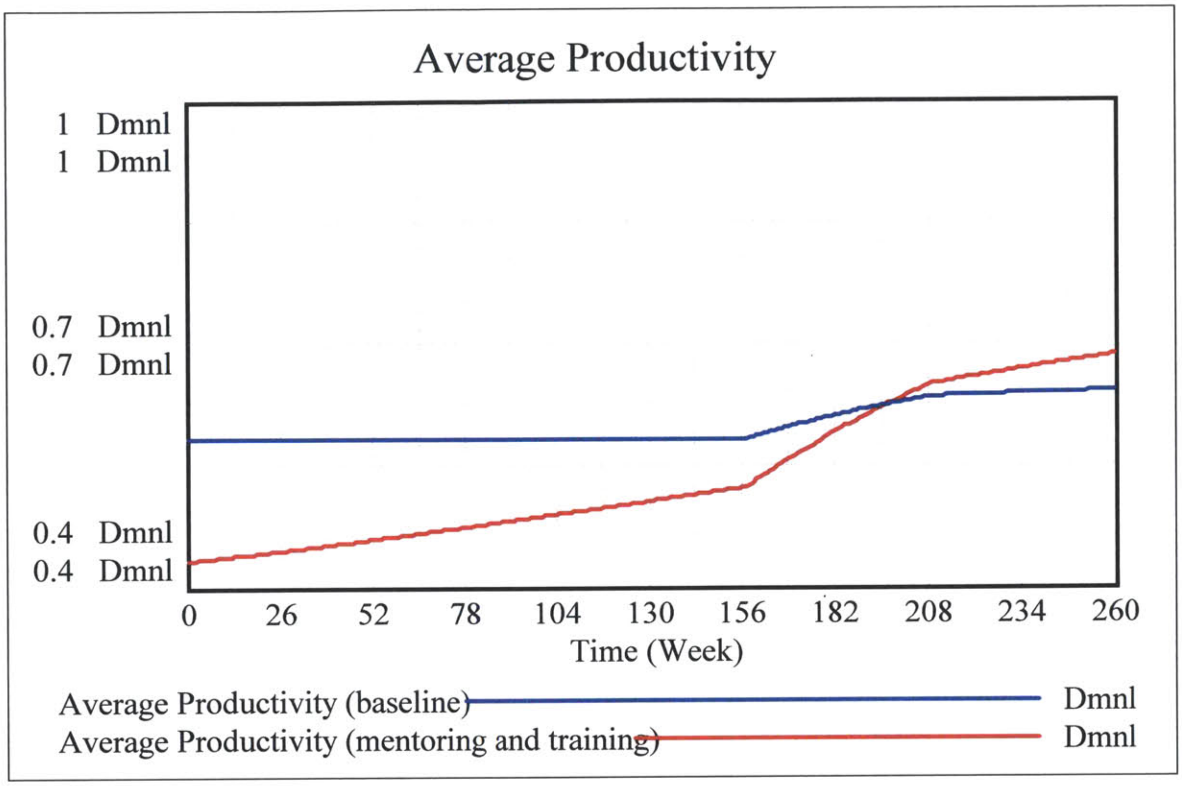

Figure 16: Average Productivity of the PD Organization in Mexico with Mentoring and Training Policy (2011CY – 2015CY)

As figure 16 illustrates, at the beginning of 2011 CY the **Average Productivity** with the mentoring and training policy in place is about 15 points lower than the average productivity without this policy and it remains lower for about 197 weeks (3.8 years). This is explained by the fact that mentoring and training requires experienced employees to dedicate some of their productive time to train inexperienced employees therefore reducing the "experienced employees' productivity fraction" which in the baseline example was assumed at 80%.

However, we can see that the speed at which the average productivity increases is faster with the policy in place compared to the non-policy model. By the end of the 5th years, the average productivity of the organization is 5% higher with this policy compared to the non-policy example. Unfortunately, in this particular theoretical case, this capacity acquiring rate might not be fast enough to address the increasing demand for engineering services during the first 4 year. Assuming that the PDOM is not affected by extraordinary events like massive head cuts, natural disasters, and is not affected by increasing attrition rates, focusing on increasing the rookie productivity fraction and reducing the assimilation time will indeed boost the average productivity of the organization in the long run but the organizations should expect a reduction in the performance during the first stages of the policy implementation.

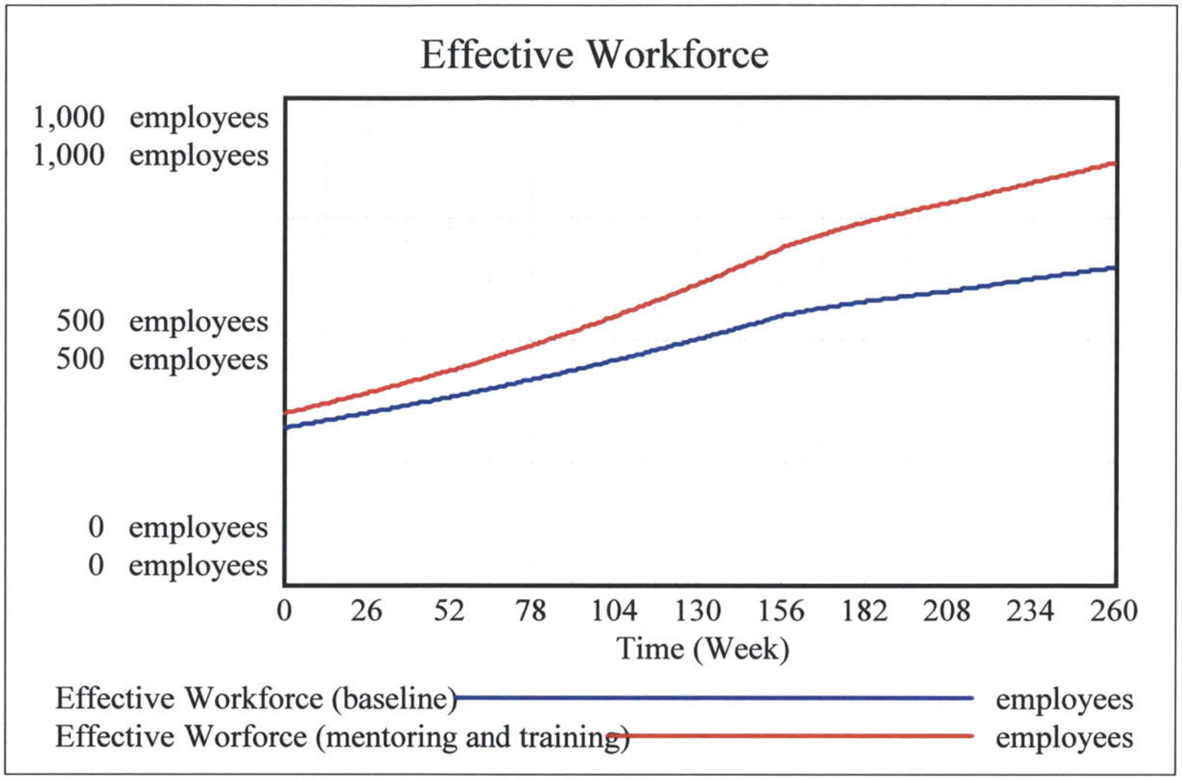

Figure 17: Expected Effective Workforce of the PD Organization in Mexico with Mentoring and Training Policy (2011CY – 2015CY)

Although the average productivity of the organization is lower than the baseline example during the first 3.8 years approximately (197 weeks), as expected, with the mentoring and training policy in place, the **effective workforce** grows at a faster rate, therefore by the end of the 5th year the effective workforce grows to about 863 out of 1013 employees (Figure 17). This means a 21% increase compared to the baseline example at the end of the period. During the first 3 years the growth of the effective workforce follows an exponential pattern as expected in a high-speed learning organization, but this growth de-accelerates due to the hiring freeze projected in year 2013 CY. If the hiring rate was maintained constant up to the end of 2015CY, this exponential growth would have been maintained.

vii. Model Conclusions

As mentioned at the beginning of this chapter, organizations facing growing service demands struggle to acquire capacity fast enough to satisfy that demand. This lack of capacity is translated into non desired levels of average productivity. Assuming that the PDOM is not affected by extraordinary events like massive head cuts, natural disasters, and increased attrition rates, a simple policy composed of mentoring and on-the-job training can provide the necessary *boost* to increase productivity by improving two things: **The rookie productivity fraction and the assimilation time.** By definition, the improvement of the average productivity will increase the effectiveness of the organization yielding a faster execution response. Also a higher average productivity will result in improved efficiency therefore lower cost and higher quality. But this policy might not yield results fast enough to respond to demand since, as seen in figure 16, the productivity of the organization tends to decrease during the initial stages of the implementation of the policy. This argument reinforces the fact that in order to acquire capacity fast enough it is therefore critical to hire the best people possible to improve even further the rookie productivity fraction and reduce the assimilation time.

The results of the boosted model speak by themselves. The following table provides a comparison of the key variables between the two models:

Table 7: Model comparison results

	Inexperienced Employees Fraction		Average Productivity		Effective Workforce (employees)	
	Beginning	End	Beginning	End	Beginning	End
Baseline model (no policy)	0.36	0.27	58%	64%	318	648
Mentoring and Training policy model	0.36	0.22	43%	69%	318	863

Finally these results support the argument that in order to respond to a rapid increase in services demand a booster policy such as the mentoring and training policy can be implemented to help meet that demand by accelerating the learning process; but since inexperienced typically learn with the help and mentoring of experienced employees and on-the-job training, this is not free from negative effects (Oliva and Sterman, 2010). "Mentoring lowers average productivity and reduces the time experienced personnel can allocate to their own work as they supervise inexperienced, demonstrate proper procedure and answer their questions. In the case where mentoring is implementing, the effective workforce is thus determined by the effective number of experienced employees, which is the number of experienced workers net of the time they devote to mentoring. The effect of mentoring on average productivity is proportional to the number of inexperienced that need to be trained. Thus, it can have a dramatic impact in situations where the rookie fraction is high, when the organization is growing rapidly (Oliva and Sterman, 2010)."

This effect illustrates one of the multiple reasons why an organization cannot support the implementation of mentoring and training schemes such as the "team leader program" implemented by the PDOM. A reduction in productivity may not be acceptable for the organization therefore making such programs ineffective during the first months or years. The key to making these programs effective is by reducing the effect of mentoring on the "fraction of experienced employees time required for training". To improve the effectiveness of this program, what could have been done differently in terms of time spent mentoring inexperienced employees?

- Implement real in-job-training policies rather than shadowing policy:

Considering again the importance of planning when architecting a system; it is therefore important to plan what the roles and responsibilities of an inexperienced employee would be since day one of his assignment. The concept of shadowing implies a full time experienced employee being followed all the time by an inexperienced employee. At the time the shadowing starts, the only responsibility of the inexperienced employee is basically to imitate what the experienced employee is doing but without having a real assignment or responsibility, in other words, the inexperienced employee is limited to learning from others with very little real implementation of what has been learned. The immediate effect is the reduction of the average productivity of the experienced employee down to 55% approximately at the beginning of the policy and slowly ramping up to 75% according to this model (vs. an assumed 80% in the previous model). If otherwise, the inexperienced had an incremental responsibility in a program, the inexperienced could start learning by himself through in-job-training rather than shadowing; and he could only use the experienced employee´s help when needed. This could definitely impact in a positive way the "fraction of experienced employees time required for training"

2.2) Investing in "ilities"

Efficiency and Effectiveness enhanced by mentoring and training is not enough to avoid shortfalls during the execution phases. Organizations are required to identify, understand and embrace *Change* to become sustainable. More important, as suggested by Aguirre (2008) and Miles (2010), organizations are in need to maintain flexibility, agility and adaptability to respond to variability (change) during execution, as a key element to increase efficiency and effectiveness (low cost / High value).

As mentioned in the beginning of chapter two, everyday organizations around the world fail to address demand since they face the challenge to produce more with less. Organizations that fail to respond efficiently and effectively to increasing levels of demand as a result of constant change usually suffer from burn-out as a consequence of fatigue (see chapter three for more information). "These are the realities of the PD Organization in Mexico, an environment of change and great uncertainty. The ability of this organization to adapt to changing circumstances, yet be efficient at the tasks it must do a thousand times, is a balance that is challenging to achieve. Flexibility of the product development system's capabilities is therefore crucial to surviving in today's product development environment (Aguirre 2008)." With this increasingly challenging environment in which the But this policy might not yield results fast enough to respond to demand since, as seen in figure 16, the productivity of an organization tends to decrease during the initial stages of the implementation of the policy.

2.2.1) Defining Flexibility, Agility and Adaptability

The following argument extracted from DeNeufville and Scholtes provides a simple but useful illustration of how variability is inherent in any process:

> "Unfortunately, it is impossible to predict exactly what the future will bring over the long term, and over the life of systems. Experience demonstrates, again and again, that specific forecasts turn out to be far removed from what actually happens. Exceptionally, we might be able to look back after 10 or 20 years and see that our long-term forecast was accurate, but few of us are ever so lucky (DeNeufville and Scholtes, 2010)."

By definition, there is inherent variability in all processes. All execution related activities assume a degree of uncertainty that is not supported by reality. Volatility is part of the ecosystem in which the organization operates (Trevor Miles, Embrace the Uncertainty). With these arguments in mind, successful organizations have developed emerging attributes that characterize its execution such as Flexibility, agility and adaptability.

One of the most important attributes of the Product Development organization is Flexibility which refers to the ability to make changes in the product being developed or in the process by which it is developed, even relatively late in the development, without being too disruptive (Smith, 2008). Aguirre (2008) in his thesis maintains that "Flexibility in product development allows a firm to tackle a diversity of engineering problems and drives engineers to engage in problem solving." He argues that "the flexible organization will move seamlessly from one problem to another and use the available resources in creative ways to solve problems. The ability to do this can help reduce the cost of engineering and stabilize work load."

Second, Agility refers to the ability that organizations develop to respond quickly to sudden changes in supply or demand in order to handle unexpected disruptions smoothly and cost efficiently (Miles, 2010). It is the ability of a system to be both flexible and undergo change rapidly. (ESD terms and definitions, 2001)

Third, Adaptability or adaptive capacity is the ability of the organizations to evolve over time as uncertainty reshapes variables such as economic progress, political shifts, demographic trends and technological advances (Miles, 2010). It is the ability of a system to change internally to fit changes in its environment. A flexible system is usually modified from outside the system while an adaptable system may undergo self-modification (ESD terms and definitions, 2001). Organizations have adaptive capacity when learning takes place at a rate faster than the rate of change in the conditions that require dismantling old routines and creating new ones (Staber and Sydow, 2002).

2.2.2) Embrace Change to Develop Emerging "ilities"

How to maintain flexibility, agility and adaptability to be able to solve issues today effectively and efficiently, in a constantly changing environment? These attributes can be achieved by paying special attention to the desired type of organization that would execute the daily tasks. As concluded in chapter one, in a young organization focused principally to manage interfaces and connections, a *lightweight* approach is desired to avoid the silo effect by enabling continuous communication between the team therefore increased flexibility. Besides this, experts conclude that in order to maintain desired levels of flexibility, agility and adaptability, the PDOM should keep a mindset and cultural behavior opened to embrace change and the following can serve as a guide (Smith, 2008):

Product/Service - oriented:

- Monitor customers continually: Do not assume that requirements are frozen. Customer trends, wants and needs are dynamic and change constantly.
- Address change in the design: Implement modular and platform-based designs to isolate change and maintain flexibility. De-couple designs to increase the ability to incorporate changes without major effects to the overall system. Handle interfaces between components, sub-systems and parts with special care.
- Try things out: Take full advantage of rapid prototyping tools such as CAE, breadboards and SLA mock ups. Example: In order to transform assumptions into knowledge, the CCSE organization (and others) is required to provide performance data of every vehicle program at the first prototype milestone. This initial performance is obtained with SLA and rapid prototyping parts.
- Explore the Design Space: Define the initial feasible space and proceed to impose constraints related to manufacturability, cost, weight or physics.
- Make decisions at the last responsible moment: It is usually hard for managers to understand this concept since they pay employees to take decisions and reduce uncertainty with facts and data, not to delay them. Usually we tend to make decisions soon in order to delete pending items from

our list but in doing this we reduce the opportunity to transform assumptions into knowledge with time. Example: Rapid prototyping is a useful tool to transform assumptions into knowledge in a relatively short amount of time. In a recent vehicle program, rapid prototyping and CAE allowed us to perform as many design iterations as possible to obtain the optimal results of the demister performance of the vehicle a few days before the design freeze milestone.

- Constantly consider risk and embrace uncertainty. The "flaw of averages" refers to the concept that it is not correct to calculate the average value of a project based on its performance under average conditions. "A focus on an "average" or most probable situation inevitably implies the neglect of the extreme conditions, the real risks and opportunities associated with a project, therefore, a design based on average possibilities inherently neglects to build in any insurance against the possible losses in value, and fails to enable the possibility of taking advantage of good situations (DeNeufville and Scholtes, 2010)."
- Do not fear to fail: A senior manager in the Product Development organization I work for continuously encourages teams to not to be afraid to fail, instead he encourages teams to fail but always learn from it. Obviously this is one of the most difficult things to achieve since many managers judge their employees performance based on the degree of success and target accomplishments.

2.3) Hypothesis Conclusion

Based on the information generated in this chapter it is valid to state that, when extraordinary events like natural disasters, major cuts in the workforce and other circumstances **do not** affect the normal course of the organization, **mentoring and training employees and investing on "ilities" are key enablers to achieve a low cost execution responsiveness and quality with an inexperienced organization, but it is important to say that this will most likely not be achieved in the short run**. As concluded before, by definition, the improvement of the average productivity of a workforce will increase its effectiveness as a result of a faster execution response and will also result in improved efficiency therefore less cost and higher quality; but in order to see an improvement in the average productivity and therefore effectiveness and efficiency, "time as a variable" should be added to the equation and unfortunately this delay might create negative effects on the productivity of the organization in the short term. The answers generated below provide a deeper insight to justify these arguments.

What are the most common reasons why young organizations fail to respond to increasing demand?

As suggested by subject matter experts, the Rookie factor effect and the increasing pressure to do more with less are common factors that prevent inexperience organization to respond appropriately to constantly growing demand for services.

What is the effect of the inexperience organization during the execution phase on achieving success?

The effect of an inexperienced organization (Rookie factor) negatively impacts the ability of the organization to promptly respond to increasing demand for engineering services. This lack of capacity derives in a low average productivity of the workforce.

What is the effect of the "pressure to do more with less" during the execution phase on achieving success?

The pressure to do more with less can reduce effectiveness and efficiency during the execution phase since it creates the burn-out effect in the organization. As the pressure builds on the organization, the employee satisfaction can diminish.

How are the "rookie factor" and the "pressure to do more with less" overcome?

Several enablers have been exposed in this chapter as countermeasures to mitigate the effects of the rookie factor effect on the productivity of the organization and the continuous pressure to do more with less focused towards supporting the action plans defined by the organization. The table below presents a summarized of the enablers presented in this chapter.

Table 8: Execution enablers affecting strategic objectives

Goal	Enablers
BIC Execution responsiveness, quality and cost	Hire the best people possible to reduce the time it takes to see positive results of a mentoring and training policy. Implement a booster policy to mentor and train new hires while performing the job (in-job training). This will improve productivity and reduce uncertainty when facing challenges in the long run.

	Enhance employee satisfaction by reducing stress and burnout.
	Invest on developing “ilities” in the organization to do more with less increasing efficiency and effectiveness and embrace change (flexibility, agility and adaptive capacity). As a consequence of improved efficiency and effectiveness, responsiveness, quality and costs are enhanced.

In order to increase capacity and address demand growth for services, it is not enough to hire the best people and provide them with the necessary tools and infrastructure. Organizations should pay special attention to boost the average productivity by implementing mentoring policies that enhance the rookie productivity fraction and their assimilation time; however mentoring can have a dramatic impact in situations where the rookie fraction is high and when the organization is growing rapidly since it lowers average productivity and reduces the time experienced personnel can allocate to their own work as they supervise inexperienced, demonstrate proper procedure and answer their questions (Oliva and Sterman, 2010). Furthermore mentoring is not free and it is not always possible or always effective for the following reasons:

- Mentoring lowers average productivity and reduces the time experienced personnel can allocate to their own work as they supervise inexperienced, demonstrate proper procedure and answer their questions.
- People can be mentored and trained, they could be provided with the best tools and methods to work and can be exposed to the best training available. If the people are not adequate, process discipline will never be fomented because they will show apathy against "on the job training" and "learning by doing".

Learning by doing and in-job-training enables the organization to create robust products/services by creating unanticipated problems through changing the environment in which they perform. By doing so, significant costs are avoided and assumptions are rapidly transformed into knowledge increasing the capabilities of the organization. For obvious reasons, learning by doing then contributes to reducing execution/operation costs. A key enabler for learning by doing and in-job-training policies is reducing the effect of mentoring over the time required by experts to mentor inexperienced. This can be done by replacing the shadowing programs with in-job-training programs.

What are some of the "ilities" necessary to sustain the organization in a constantly changing environment?

As defined in this chapter:

- Flexibility: the ability to make changes in the product being developed or in the process by which it is developed, even relatively late in the development, without being too disruptive
- Agility: the ability of a system to be both flexible and undergo change rapidly.
- Adaptability: the ability of a system to change internally to fit changes in its environment.

How to maintain flexibility, agility and adaptability?

1. Given the nature of the young PD organization in Mexico, as concluded in chapter one, a *lightweight* approach is desired to avoid the silo effect by enabling continuous communication between the team therefore increased flexibility.
2. Mindset and cultural behavior opened to embrace *change*
    - Monitor customers continually
    - Address change in the design
    - Try things out
    - Explore the Design Space
    - Build strong teams
    - Make decisions at the last responsible moment
    - Constantly consider risk and embrace uncertainty
    - Do not fear to fail

Finally, the development of this chapter suggests that organizations usually are risk averse and do not know how to execute under a constant changing environment. Usually High-speed growing organizations facing increasing services demand confront a series of fundamental contradictions that disturb the pace and rhythm of learning and executing. Some of the contradictions that this chapter encountered are:

- Do more with less
- Solve issues now but delay decisions as much as possible to reduce uncertainty
- Delay decisions today to gather facts and reduce the assumption to knowledge ratio

- Pressure to do work today at a faster rate will increase the time spent working but decrease the actual performance of the organization in the long run.
- Fix problems before they happened and never get credit for it
- Achieve perfection by embracing failure

Although the information and results gathered here were not focused to provide explanations and solution to how this contradictions should be managed, it is important to keep in mind that managers (experienced and inexperienced) will most likely find them during the execution phases of the organization.

Chapter 3: Improving

Hypothesis – Increasing learning capabilities is key to achieve BIC responsiveness and quality while maintaining low costs.

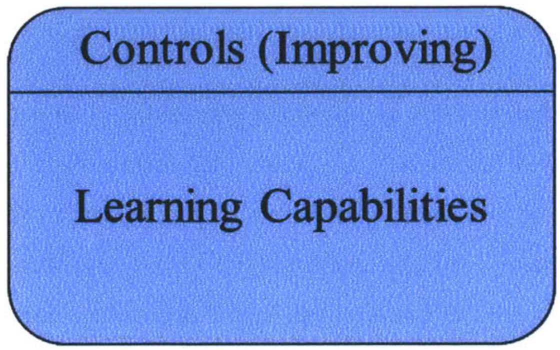

Figure 18: Execution Enablers

Successful organizations are those that learn from experience. The planning and execution phases should be driven by the application of lessons learned obtained from previous experiences. New failure modes identified in recent projects are expected to be included in the design of an organization during the planning, execution and improving phases. Given the latter, the following relevant questions are raised to guide the discussion in this chapter.

- Why organizations fail to learn (improve)?
- What is the best way to overcome the vicious cycle of suppressing learning?
- What are the organization´s learning capabilities that improve the execution responsiveness and quality?
- What are the learning capabilities that other high velocity organizations develop to achieve success?

This chapter is focused on developing arguments around the importance of facilitating the learning process in an organization in order to improve their overall operation and execution. The intention is to provide an illustrative case to prove that closing the learning cycle is necessary to improve execution performance and also to demonstrate how complicated it can be to enhance a learning mindset in an organization due to vicious cycles present in the daily operation and execution of the organization. A system dynamic model is again applied as the method to generate information to answer these supporting questions stated above.

3.1) The Vicious Cycle of Suppressing Learning

First, in order to illustrate the dynamics of learning in an organization, two opposing but complementing theoretical cases are developed in this chapter as a method to provide illustrative results supporting the argument of facilitating learning in an organization and to demonstrate how and why organizations fail to enhance it.

Let us assume that the PDOM has recently acquired the responsibility to design, validate, release, and launch a new Top-Hat product within the next two years (see definition of Top-hat products in section 1.3.1 of Chapter one) . As part of the overall goals of the organization, the team is required to execute with the highest levels of responsiveness and quality at the lowest cost, therefore this demand for engineering services sets the bar for the first variable called **desired performance.**

Immediately after the organization acquires the responsibility to design the Top-Hat, emerging **capabilities** arise. These capabilities are defined as "the measure of the ability of an entity to achieve its objectives, especially in relation to its overall mission" (business dictionary). These capabilities are inherent to the organization's inputs defined in chapter one (goals, products, services, processes, people and tools) and are defined as a stock, which means that the level of a given capability can be increased or decreased with time by **investing** or **eroding** them.

With the **desired Performance** set and the demand for engineering service established, the next immediate step the organization takes is to start executing (working) in order to close the **gap** between the **actual performance** and the **desired performance.** High velocity organizations such as the PDOM are expected to learn fast and at exponential rates therefore, as the rhythm of the project picks up, the organization is exposed to increasing levels of **pressure to do work** in a more efficient way each time; this means less room for variability and mistakes. **Time spent working** on the project increases as a result of higher pressures over the teams and the immediate results (short term) usually suggest an improvement of the performance of the organization (responsiveness and quality). However this pressure builds up in the organization creating a **burn-out effect** in the long run.

With apparently increased levels of performance as a result of continuous pressure to do the work, the gap between the current performance and the desired performance is lessened. When the gap between actual and desired performance is reduces, an inverse effect happens; the pressure to do work is reduces, the amount of time spent working decreases and the performance of the organization diminishes. This complete balancing cycle is defined by Repenning and Sterman (2001) as the **Work harder loop** illustrated in the model in Figure 19: The Work Harder Loop.

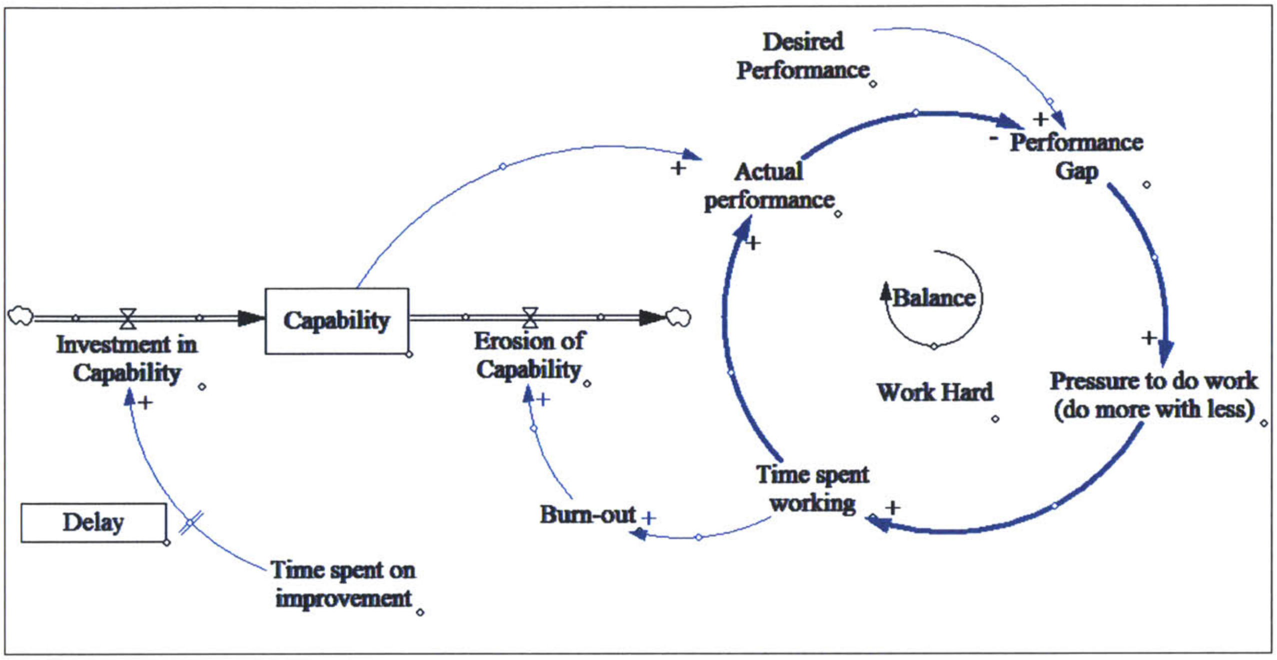

Figure 19: The Work Harder Loop (Adapted from Repenning and Sterman, 2001)

3.1.1) Real Life Example: Demister Duct Design

In a recent automotive project, the team that I worked for suffered the effects of the work harder loop described in the previous paragraphs and illustrated in Figure 19, creating unnecessary extra work, therefore lethargic execution and cost. We were 6 weeks away from the deadline to delivering the final design of the demister ducts. These ducts are present in practically every car and are used to direct hot air to the side windows in order to defrost them. Increased pressure to deliver the design without further delays to the deadline forced the team to erratically create 12 different designs one after the other with the help of rapid prototyping and CAE tools (learning by doing). Per data obtained from the global CCSE organization, usually 7 design iterations are required to come up with an optimal design.

Each design proposal required an average of 1 week to be frozen in the CAD repository system and subjected to CAE simulation to assess the defrosting performance under certain conditions; therefore approximately 12 weeks were needed to come to an optimal design, in other words, a milestone completed 6 weeks after the deadline. Each time a design iteration was completed the management team was satisfied, but as soon as the CAE results came back, the sad news pushed them to impress more pressure over the team to deliver. The design was not enough to meet the climate control performance targets.

As a consequence of compressed timing and continuous pressure to deliver the design without further delays, we obviously never had time to present the evolution of the 12 design proposals in any of the designs review forums available to receive feedback from experts and engineers that already design similar parts. We focused only on reporting the failed results of each design proposal with little or no feedback from the experts; just more pressure to deliver. Neither did we perform a deep dive review of the available failure mode avoidance documents. What happened in this case was that the team was divided in two: on one hand the designers of the duct and on the other, the experts of the climate control performance. Due to a lack of communication between both bands as a result of little time to do so, the team never took a conscious moment to analyze the performance results as a team and determine what was going wrong with the design; neither took time to learn from the flaws of the design. As opposed, the two silos under a great deal of pressure kept iterating with very little incremental improvements and feedback about the design.

After 9 weeks of infructuous work, when the team realized that very little progress had been made, a change in the dynamic of the team was implemented. Passed the 10th iteration, we stopped to focus on building, analyzing and implementing knowledge. . Other teams facing similar design challenges were able to generate a vast pool of knowledge about similar designs and found which critical features should be included in the design. So we analyze all the results consciously and digested the lessons learned previously generated. In doing so, we broke the rhythm of the design iteration, this time it took us 3 weeks instead of 1 week to come up with the solution but the results were positive. With a conscious design frozen, we proceeded to obtain the last blessing from the management after 12 weeks of work.

A graphical illustration of the work harder effect suffered by this team can be analyzed with the data obtained by Repenning and Sterman (2001) in figures 20, 21 and 22. This data yields somehow intuitive and predictable result but helpful enough to illustrate in a simple way how the work harder loop works and why it is undesirable when it becomes a standard in the execution of an organization.

With the deadline to deliver the design just around the corner, the management team starts building enormous amount of pressure pushing the team to work towards closing the gap and deliver the duct design. In response to that, the team steps on the gas pedal to dedicate more time to complete tasks increasing the levels of effort impressed to perform the work (Figure 21). This sudden reaction creates a spike in the performance of the team which in this case is translated in 12 misleading, useless design iterations (Figure 20). Very few times a team is able to turn around that many iterations with one week between each one, but useless after all.

Misleading signals in the development of a project, can lead managers to think that the positive trend in the performance could be maintained by applying continuous pressure over their employees without recognizing the needs to invest on capabilities in order to increase the ability to achieve its objectives. In the duct design example, after some time, the actual performance of the team starts to show signs of erosion due to the effect of burned-out as a result of continuous pressure to do more with less (Figure 20). Very little incremental progress is done and a huge amount of resources and time are consumed to create demister duct design proposals without success.

As the model in figure 19 suggests, when the performance diminishes, meaning multiple design proposals not achieving the desired performance, the gap between the desired performance and the actual performance is increased; therefore the management tries to compensate the loss by further increasing the pressure over the levels of effort impressed in the tasks creating a growing burn-out and exhaustion effect (figure 22). At this point, the team commences to erode its capabilities by losing key talent, reducing employee satisfaction, suppressing learning, enhancing cutting-corners and promoting firefighting among other consequences.

The following figures are adapted from Repenning and Sterman (2001)

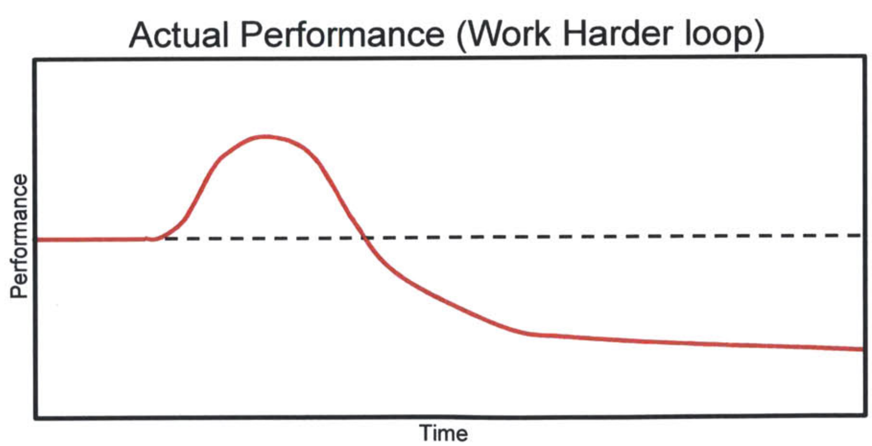

Figure 20: Actual Performance (Work Harder loop). Modified from Repenning and Sterman (2001)

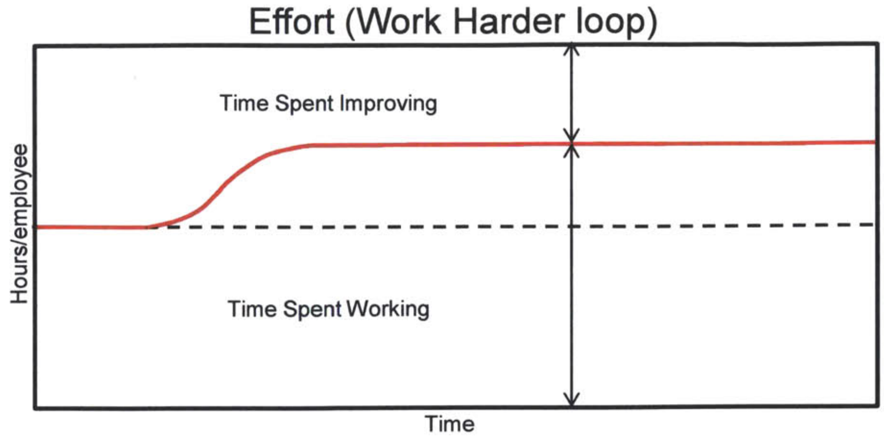

Figure 21: Effort (Work Harder loop). Modified from Repenning and Sterman (2001)

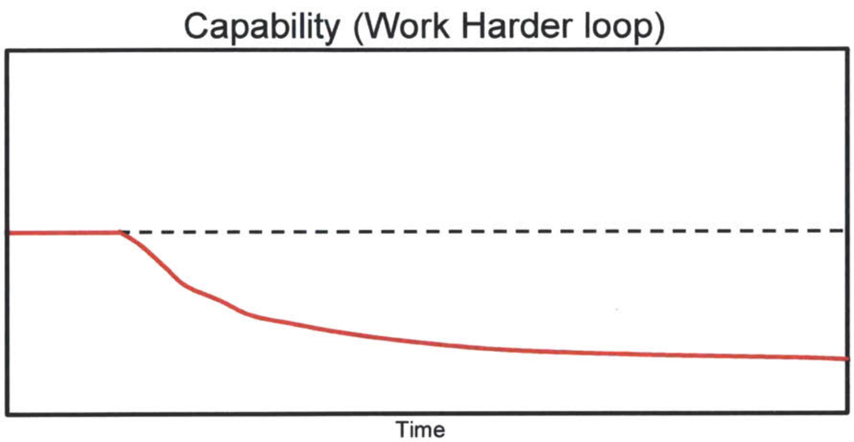

Figure 22: Capability (Work Harder loop). Modified from Repenning and Sterman (2001)

Unfortunately, the PDOM like many others has the potential risk to fall under the **Work Harder Loop** and adopt it as the standard operating procedure as opposed to recurring to it only when the variability inherent to the planning and execution phases demand for problems to be solved now. Based on this argument it is important to keep in mind some of the multiple reasons that can lead the PDOM to fall into this trap. The following is a compilation of ideas extracted from experience and data obtained from literature:

- Failure to allocate the right resources during the planning phase of a project brings problems during the execution. Insufficient or incorrect resources derive in poor quality, low responsiveness, and high costs of execution due to lack of effectiveness and efficiency as a result of firefighting and cutting-corner (Black and Repenning, 2001).

- Lack of leadership to spread a learning behavior culture. As mentioned in chapter one, managers tend to put pressure over their employees to execute *now* therefore suppressing the process of generating and documenting learning (Smith, 2008).
- Managers blaming people for their failure rather than blaming the system where the employees execute push their organizations to fall into this trap (Repenning and Sterman, 2001).
- Continuous pressure to deliver on time increases the stress levels of the organization enhancing employees to cut corners during the execution. This brings poor quality, low responsiveness, lack of effectiveness and efficiency and high costs (Oliva and Sterman, 2010).
- High levels of stress burns employees out diminishing the employee satisfaction levels (Repenning and Sterman, 2001). Employees not satisfied enough to owe the outcome of their work tend to avoid going further therefore suppressing the process of documenting learning under the argument of "Why should I document learning if I don't care for the future of the organization?"
- A common mistake organizations make is designing an incentives program erroneously focused on rewarding firefighting instead of rewarding problem avoidance. As organizations grow more dependent on firefighting and working harder to solve problems caused by low process capability, they reward and promote those who, through heroic efforts, manage to solve troubled projects or keep the line running (Repenning and Sterman, 2001).
- Some cultures are overwhelmed with work since they do not know how to say *no* to increasing demand for services. The PDOM will have to learn to reject new projects consciously to allow the system to learn.

The key element to understand the effect of the work harder loop is given by the fact that the organization in this example does not dedicate any time to improve or invest on its capabilities. The organization is forced to deliver the work by applying a continuous pressure over it, increasing the effort to perform and diminishing the overall quality of the execution.

3.2) The Virtuous Cycle of Building Learning Capabilities

3.2.1) Real Life Example: Demister Duct Design. What can be done differently?

An opposite vision of the vicious cycle of suppressing learning is the dynamic model of building capabilities through the learning process. A counterpart of the example presented in section 3.1 is used to demonstrate the importance of building knowledge. In this case it is also assumed that the PDOM has acquired the responsibility to design, validate, release, and launch a new Top-Hat product within the next two years at the highest levels of execution responsiveness and quality at the lowest cost, setting the bar for the **desired performance.** With the **desired Performance** and the demand for engineering service established, the immediate step is to start executing (working) in order to close the **gap** between the **actual performance** and the **desired performance.**

As the rhythm of the project picks up now the organization has two choices: increase the levels of **pressure to do work** in a more efficiently way each time or to increase the **pressure to improve capability**. In this case the organization decides to increase the pressure to improve capabilities by launching improvement programs, encouraging people to experiment with new ideas and approaches, and investing in training as suggested in chapter two. As a result the organization focuses its efforts to increase capabilities by rising the **time spent on improving.** Finally, as capabilities grow, the actual performance of the organization improves significantly closing the existing gap between it and the desired performance. This complete balancing cycle is defined by Repenning and Sterman (2001) as the **Work Smarter loop** illustrated in the following model.

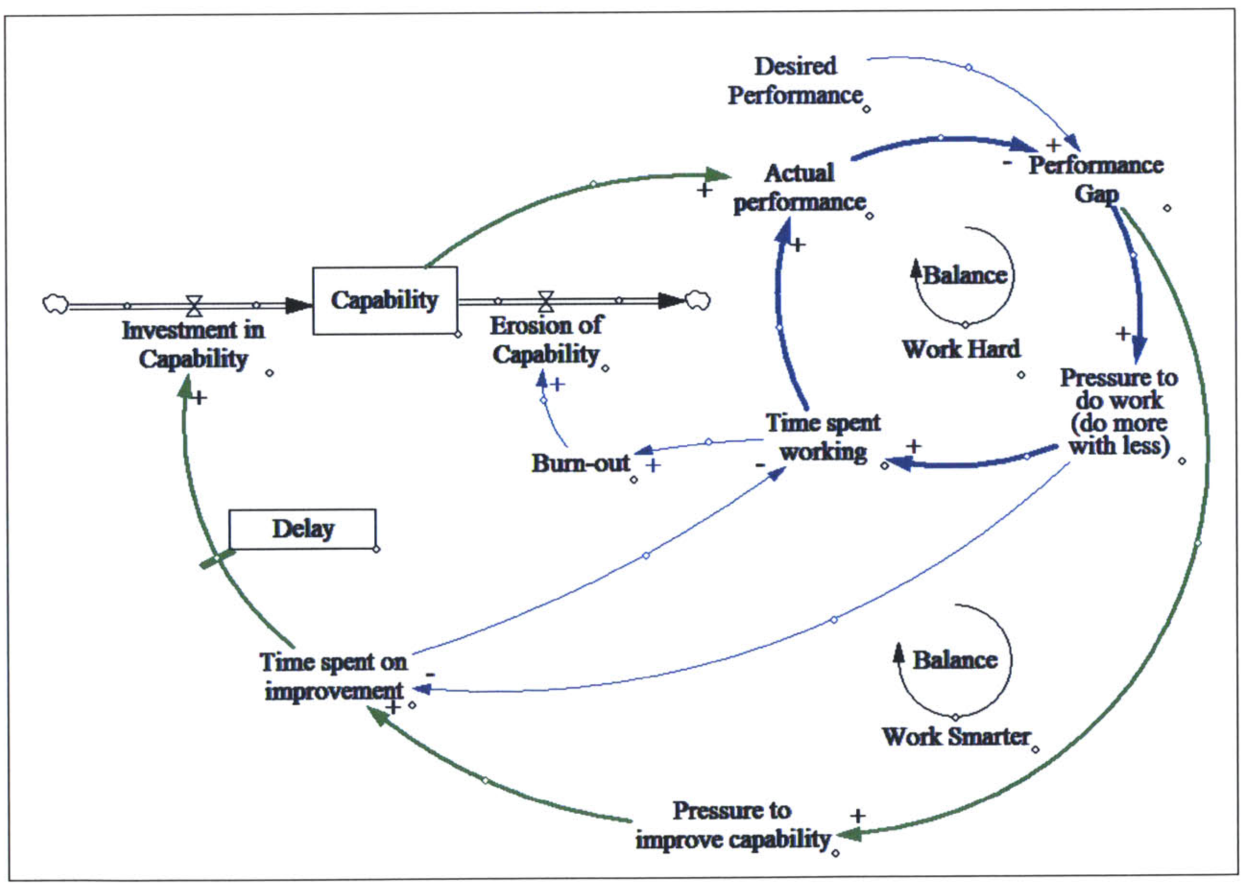

Figure 23: Work Smarter Loop (Adapted from Repenning and Sterman, 2001)

Using the data obtain by Repenning and Stermand (2001) we can see that, as opposed to the work harder loop curves, the work smarter loop yields much more promising information to contribute with the long run success of the organization. The moment the organization wisely chooses to put some pressure to improve its capabilities rather than pressuring to do work, the long lead timing to implement actions to improve capabilities and the resources designated to do so create a negative effect in the performance of the organization (Figure 24). As concluded in chapter two, mentoring and training create a negative effect on the organization´s productivity in the short term which can also explain the effect of figure 24. This scary effect is what most not successful organizations tend to avoid for many reasons like:

- Critical financial conditions not allowing them to afford loses in the short term
- Uncertainty in regards to how low the performance will plumb and questions related to whether the organization will be able to overcome this decrease in performance
- Avoid continuous questioning from the key stakeholders of the organization in regards to negative results. Stakeholders expect improvements not otherwise.
- Management lacking of a long term vision.

The effect of dedicating more time to build capabilities pays off by becoming time spent on creating value to the organization (Figure 25). Slowly capabilities start to increase by reverting the negative trend of the actual performance of the organization therefore increasing the measure of the ability of the organization to achieve its objectives. In the long run, the performance of the organization increases above the level that emerged initially (Figure 26).

The following figures are adapted from Repenning and Sterman (2001)

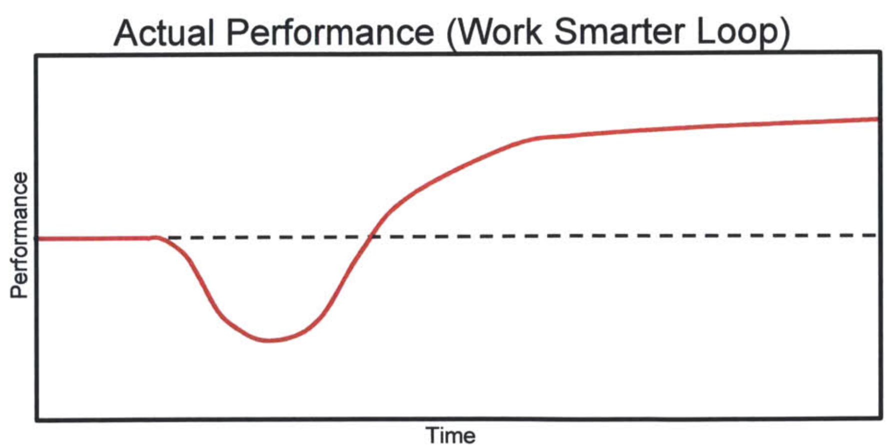

Figure 24: Actual Performance (Work Smarter loop). Modified from Repenning and Sterman (2001)

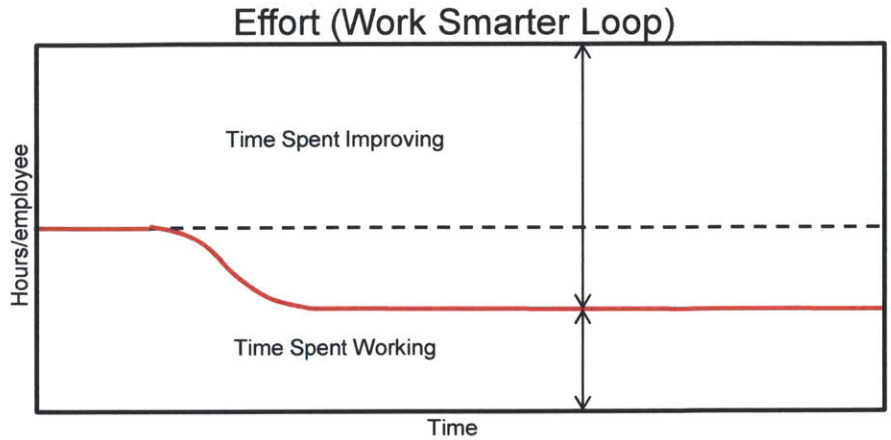

Figure 25: Effort (Work Smarter loop). Modified from Repenning and Sterman (2001)

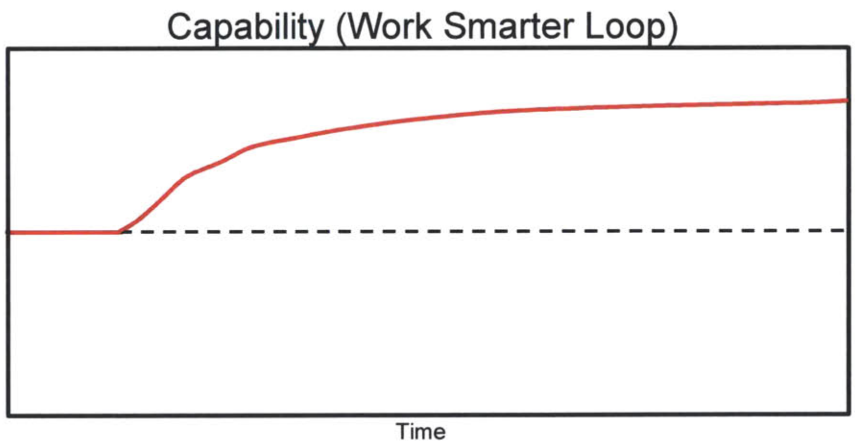

Figure 26: Capability (Work Smarter loop). Modified from Repenning and Sterman (2001)

However, the idea of having only "work smarter loops" in an organization is simply unrealistic. As mentioned in chapter one, there is just so much information available that an organization can use to plan accordingly and confirm assumptions, but there is always information that simply does not exist and therefore, as in any complex system, unpredictable issues will rise inevitably and solutions will have to be implemented "now" with the highest levels of urgency. So ideally, both the work harder and the work smarter loops have to coexist and should complement each other. The nature of the work harder loop allows organizations to obtain benefits faster (short term) as suggested in the results presented in section 3.1 of this chapter. When the work harder loop is implemented usually organizations can obtain a sudden spike in its performance; in other words, the work harder loop helps to address urgent problems by enabling the organizations to find solutions to problems that need to be addressed right now. On the other hand, the process of improving capabilities by working smarter is usually slower and the benefits are obtained long after the implementation of improvement programs (long term). Furthermore, the greater the complexity of the improvement process, the longer it takes to improve (Repenning and Sterman, 2001). This phenomenon is represented as a delay between the time spent to improve and the actual improvement of a given capability. The question now is what are those capabilities that help High-speed organizations to implement both loops successfully? See next section for answers.

3.3) Beat the Vicious Cycle of Suppressing Learning

Certainly, there is no exact recipe to overcome the challenges that the vicious cycle of suppressing learning imposes over an organization; however, Spear (2009) suggests that high-velocity organizations succeed by investing vastly in developing capabilities. A representative example of a high velocity organization is Toyota. This company has successfully created a culture of self-learning, self -improving and self-regulating based on the capabilities described in the next section.

3.3.1) Capabilities of High-Velocity Organizations

What are the organization's capabilities that contribute to overcome the vicious cycle of suppressing learning and improve execution responsiveness and quality?

Capability 1: Use existing knowledge to solve problems as they occur:
"High-velocity organizations invest everything they know so far in designing the desired outcomes of their execution to maximize the likelihood of success. They specify the most effective approach currently known for achieving success at a specific task and build the capacity to detect failure when and where it occurs into the approach to solve problems (Spear, 2009)." High-velocity organizations like Toyota use the hierarchical level framework defined in chapter one to enhance quick problem solving as they occur. These organizations never assume learning is complete. With their increasingly pool of knowledge they use this framework to define:

- System Outcomes: What does the system have to deliver, to whom and by when? Based on what has been learned before, define realistic, achievable and specific outputs of the system. Knowledge gained previously is used to reduce ambiguity around assumptions. Lessons learned are incorporated to define new failure modes that could potentially disturb the accomplishment of the desired outcomes.

- Pathways: What and how is the flow of material, information and communication? Process improvement is key in High-velocity organization. These organizations spend most of their time improving processes based on gained experience and knowledge. Significant and continuous changes are focused on improving the flow of material, information and services based on new failure modes identified and documented in previous experiences.
- Connections: What are the links of adjacent process steps and between the different areas involved? High-Velocity organizations use their time wisely to understand and improve the interfaces involved in each of their processes and within their stakeholders. These organizations have paid special attention to execute as lightweight organizations (see section 1.3.1 in chapter one).
- Methods: How people do the work for which they are responsible? High-Velocity organizations are participative in a way that they care about how their people do their work and how they can improve their performance.

Capability 2: Build knowledge through problem solving:
High velocity organizations use their time mostly to prevent problems from happening. Ideally very little time should be spent to solve problems, but this is unrealistic. High velocity organizations by definition innovate, and innovation itself is about discovering during implementation. Given this, problems are always part of the natural dynamics of complex high velocity organization.

High-Velocity organizations never stop learning as a result of the innovation implementation cycle. As expected during the definition of the system outputs, they create new knowledge by solving problems as they occur (learning by doing). "High-Velocity organizations are adept at detecting problems in their systems at the time and place of their occurrence. Also they contain those problems before they have a chance to spread diagnosing and treating their causes so the problem cannot reoccur (Spear, 2009)." High velocity organizations like Ford Motor Company have developed problem solving disciplines that have spread across the organization. This discipline can be summarized as follows (adapted from the OneFord):

- Identify the current failure modes as they occur
- Perform initial diagnosis of failure
- Implement interim containment actions to contain the problem temporarily
- Perform deep root cause analysis
- Implement permanent corrective action

- Document lessons learned
- Spread learning

One key parameter for successful implementation of this framework is time. Successful organizations are those that can react fast to problem solving.

Capability 3: Share the knowledge with the rest of the organization:
According to Steven Spear in his book The High Velocity Edge (2009), one characteristic of Low-performing organizations is that they make matters worse by suppressing their ability to learn from experience. When something goes wrong during the execution phase and trivial events that apparently would not have an immediate consequences appear, people discover how to contain them using a variety of creative workarounds and firefighting techniques. Usually the problem goes away but the factors that caused it remain in place to cause reoccurrence. Eventually enough little things occur in just the right combination to cause a disaster (Spear, 2009).

"High-Velocity organizations multiply the power of their new knowledge by making it available, not only to those who discover it but also throughout the organization. They share solutions and process of discovery" (Spear, 2009). "Organizational learning is the ultimate goal of the lean product development team that understands that leadership in engineering is a matter of dynamic renovation and evolution (Aguirre, 2008)."

Capability 4: Lead by developing:
High velocity organizations are participative in the sense that these organizations incentivize their employees to actively participate in the problem-solving process and process improvement discipline. As mentioned before, Toyota is the perfect example of a culture where each employee has the responsibility to generate knowledge through problem solving, in other words, the organization encourages its employees to lead their own improvement. Furthermore, such high-velocity organizations work towards diffusing a culture focused on understanding, enhancing and implementing the virtuous cycle of capabilities illustrated in Figure 26.

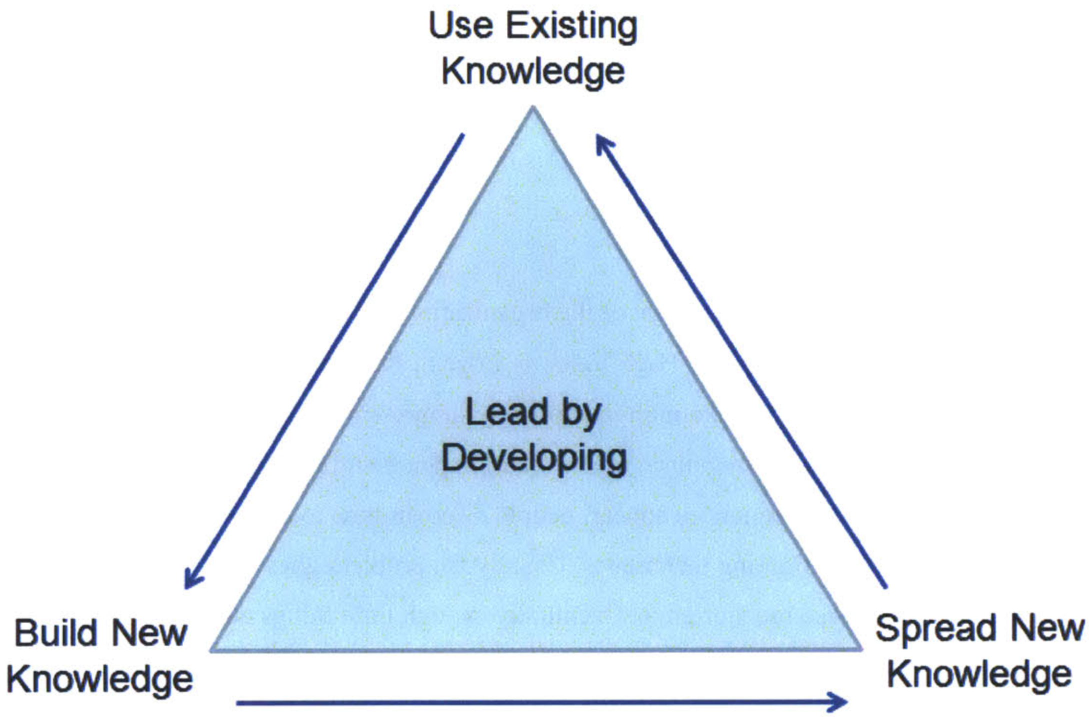

Figure 27: Virtuous cycle of learning capabilities

According to this cycle, the first step successful organizations implement to approach success is to use existing knowledge in the planning, execution and improving phases extracted and documented from previous experiences. Once knowledge has been used to transform assumptions into facts, successful organizations build new knowledge through learning by doing and problem solving (see chapter one). New knowledge generated is finally spread throughout the whole organizations creating and increasing capabilities.

3.3.2) Real Life Example: Demister Duct Design Conclusions of Suppressing Learning

There are multiple success and failure stories that illustrate the application of the virtuous cycle of learning capabilities. The demister duct example presented in section 3.1.1 of this chapter, is a useful representation of a situation where beside lack of communication, suppressing learning led a team to find undesired levels of performance, execution quality and ultimately unnecessary costs.

When the team realized that very little progress had been made in the design of the ducts, a change in the dynamic of the team was implemented and the team finally came up with the optimal design solution through building, understanding and implementing learning. All this unnecessary extra work could have been prevented and the arguments below summarize what could change in the organization to enhance learning

- the organization should truthfully focused its efforts on leading by enhancing learning sharing within it. The effort dedicated in the organization to incentivize knowledge, documenting and spreading it is yet not enough to guarantee long run success
- the process of using knowledge, building new one and spreading it in the organization should be documented properly and available for everyone. The organization failed to close the virtuous cycle of capabilities because the process is not clear.

3.4) Hypothesis Conclusion

Although we can conclude **that focusing on increasing the learning capabilities of an organization improve its performance by enhancing execution quality and responsiveness,** we should highlight that learning is a slow process, usually painful and complex since the results of such policies are perceived in the long run as suggested by the work smarter loop. The work smarter loop example illustrates how learning indeed enables the organization to increase capabilities in the long term by investing in learning, therefore improving the measurement of the ability of the organization to achieve its strategic objectives and the ultimate goal. But as the work harder loop suggests, fast responsiveness can also be achieved in the short term by applying pressure to do the work, only on those tasks that need to be solved now. It is important to establish that this fast responsiveness does not necessarily imply an improvement in quality neither a degradation of it at least not until the burn-out effects over the organizations leads to poor execution. Once burn-out affects the organization then we can imply low quality and increased costs.

Based on the definition of success stated by the PDOM, there is a potential risk of falling under the vicious cycle of the work harder loop due to the continuous pressure to do more with less and to reach the ultimate goal of becoming the BIC organization in terms of responsiveness, quality and cost. This continuous pressure can drive the organization to break the virtuous cycle of learning capabilities by avoiding documenting and spreading new knowledge. Therefore the organization will have to put extra emphasis on operating under both the work harder and the work smarter loops. Work harder loop allows organizations to obtain benefits faster in the short term and should be used to contain problems with urgency, while with the work smarter loop the process of improving capabilities is usually slower and the benefits are obtained long after the implementation of improvement programs.

Unfortunately slow-velocity organizations are commonly trapped in the work harder loop and fail to execute under the work smarter loop (learning) due to different cultural and technical reasons exposed next (not limited to):

- Failure to allocate the right resources in a project
- Lack of leadership to spread a learning behavior culture.
- Managers blaming people for their failure rather than blaming the system
- Continuous pressure to deliver on time
- High levels of stress
- Incentives programs focused on rewarding firefighting instead of rewarding problem avoidance.
- Other inherent cultural aspects

In the effort to explain the effect of learning over the performance of an organization several relevant questions and answers emerged:

What is the common trap organizations fall under preventing them to improve?
Organizations tend to suppress learning by falling under the work harder loop. Failure happens when the work harder loops becomes the operating standard of the organization therefore suppressing learning.

What is the best way to overcome the vicious cycle of suppressing learning?
There is no exact recipe to achieve it. It requires special leadership skills and people attributes to diffuse a new culture in the organization. However, the following recommendations extracted from literature and the results of this chapter can serve as a starting point to achieve success:

- Giving credit to those who work hard to solve problems but privilege those that use the work smarter loop as the standard to build capabilities and prevent recurrence of problems.
- Keeping in mind that a problem is not over when it is solved but when the organization learns from it. Always make some time to allow employees, teams and organizations to learn. Lead by developing your organization´s capabilities. Investing on developing and spreading knowledge across the organization to build new capabilities. See example of demister duct design described in previous pages of chapter three.
- Being inclusive by leveraging the knowledge and expertise of your employees to improve processes. High velocity organizations mostly on what the current employees can offer in terms of process improvements. The most common example is Toyota.

What are the organization's capabilities that contribute to improved execution responsiveness and quality?

The virtuous cycle of learning capabilities is composed of:

- Use existing knowledge to solve problems as they occur
- Build knowledge through problem solving
- Share the knowledge with the rest of the organization
- Lead by developing

As mentioned above, the effects are perceived in the long run.

How these capabilities contribute to achieving the strategic plans of the organization?

Table 9 provides a summary of the enablers presented in this chapter.

Table 9: Enablers affecting the Strategic Objectives

goal	Enablers
BIC Execution responsiveness, quality and cost	Use the *work harder loop* to contain problems now, not as the standard operation of the organization. Simultaneously push your organization to increase capabilities in the long run by spreading new knowledge driven by the work smarter loop.
	Apply pressure to increase knowledge. Push people to learn and to restlessly increase wisdom. Incentivize the *work smarter loop* to foster excellence.
	Create a culture around the Virtuous Cycle of Capabilities to: Use existing knowledge, build new knowledge, spread knowledge and lead by developing your organizations' capabilities.

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Chapter 4: Framework Summary and Thesis Insights

4.1) Framework Summary

The development of this thesis provided an insight on multiple lessons learned about how to plan, execute and improve a relatively inexperienced organization. I would be contradicting the conclusions generated in chapter three if I did not share the knowledge generated from the development of each hypothesis. So let us think about Chuco Perez again. Now that he has been promoted in the PDOM, he is eager to cooperate with the sustainability of the organization; therefore he is willing to apply any suggestions into building his own micro organization, so the following highlights have been compiled to provide a guideline and framework for him:

First, although dedicating enough time to architecting (planning) the inputs of an organization and its links might enhance high levels of execution responsiveness and quality at reduced costs, the data that would let organizations to be more certain about their future simple might not exist yet. The real challenge is to determine the amount of time that should be allocated in order to transform the maximum possible amount of assumptions from not proven to proven; but at the same time making sure that the time allocated for planning is used efficiently. Based on the information generated in Chapter one, this is what I suggest Chucho should consider during the planning phase of his micro organization:

How to plan?

- Identify the essential inputs of your own product development system: Goals, Service, Product, Process, People and Tools.
- Apply a method such as the decomposition framework used in chapter one as a useful tool to design each input at the following levels: System, Architecture, Interfaces/connections and Components.
- Use that same method to clearly identify the links and connections between and within your organization´s inputs.
- Identify which people you want in your team by hiring people that:
    - Owns the outcome
    - Demonstrates full engagement and commitment
    - Builds confidence in others
    - Capable of understanding the tasks to be performed
- Has a loud voice to be heard

- With the people´s characteristics identified, plan the organization's architecture that can enhance a lightweight execution to enable continuous communication between the team and avoid the silo effect.

...

Second, organizations should pay special attention to boost its average productivity in the short and long terms by hiring the best people and by implementing mentoring policies respectively, in order to increase the rookie productivity fraction and the rookie assimilation time; however mentoring can have a dramatic impact in situations where the rookie fraction is high since it lowers average productivity and reduces the time experienced personnel can allocate to their own work.

Usually High-speed growing organizations confront a series of fundamental contradictions that disturb the pace and rhythm of learning and executing. It is important to keep in mind that managers (experienced and inexperienced) will most likely find those during the execution phases of the organization. Some of the contradictions that this analysis encountered are:

- Do more with less
- Solve issues now but delay decisions as much as possible to reduce uncertainty
- Delay decisions today to gather facts and reduce the assumption to knowledge ratio
- Pressure to do work today at a faster rate will increase the time spent working but decrease the actual performance of the organization in the long run.
- Fix problems before they happened and never get credit for it
- Achieve perfection by embracing failure

Based on the information gathered in Chapter two, this is what I propose Chucho should consider during the execution phase of his own inexperienced organization:

How to execute?

- Overcome the rookie factor and the pressure to do more with less:
    - Boost the average productivity by implementing mentoring policies that enhance the rookie productivity fraction and their assimilation time.
    - Understand that mentoring lowers the average productivity and reduces the time experienced personnel can allocate to their own work as they supervise inexperienced, demonstrate proper procedure and answer their questions.

- Learning by doing and in-job-training enable the organization to create robust products/services by creating unanticipated problems through changing the environment in which they perform. Also they can help to reduce the negative effect on the time required by experienced employees to mentor inexperienced.
- Implement mentoring policies that do not adversely affect the time experts need to allocate to train inexperienced. In this regard I propose to replace "shadowing policies" with in-job-training policies.

- Invest on "ilities" like flexibility, agility and adaptability through a lightweight team approach. This will allow avoiding the silo effect by enabling continuous communication between the team.
- Diffuse a mindset and cultural behavior opened to embrace change by:
  - Monitoring customers continually
  - Addressing change in the design
  - Trying things out
  - Exploring the Design Space
  - Building strong teams
  - Making decisions at the last responsible moment
  - Constantly considering risk and embrace uncertainty
  - Not fearing to fail

...

Third, there is no exact recipe to instill a learning culture in organizations. It requires people with certain leadership skills and attributes to diffuse new values. Successful implementations of policies that help organization to improve its performance include both a top-down schemes or work harder loops that yields results in the short term and bottom-up schemes or work smarter loops with long term visions to develop capabilities.

Ideally both loops should coexist in high-velocity organizations. Work harder loops should be implemented as a method to solve issues now. On the other hand, work harder loops should be implemented as the leading culture of the company to improve constantly. The implementation of work smarter loops become difficult since there is a natural delay between the moment these policies are implemented and the moment they yield solid results, however this is what I propose Chucho should consider during the improving phase of his organization:

How to improve?

- The following recommendations can serve as a starting point to overcome the vicious cycle of suppressing learning:
  - Focus your efforts on enhancing the virtuous cycle of learning capabilities :
    - Use existing knowledge to solve problems as they occur
    - Build knowledge through problem solving
    - Share the knowledge with the rest of the organization
    - Lead by developing
  - Giving credit to those who work hard to solve problems but privilege those that use the work smarter loop as the standard to build capabilities and prevent recurrence of problems.
  - Problems are not over when solved but when the organization learns from it.
  - Be inclusive by leveraging the knowledge and expertise of your employees to improve processes.

Finally, table 10 below provides a summary of how the strategic objectives defined in the first pages of this thesis can be enabled during the planning, execution and improving phases of the PDOM.

Table 10: Summary table of enablers affecting the strategic objectives

Organizational goals	Phase	Strategic objectives / Action Plans	Enablers
BIC Execution responsiveness, quality and cost	Planning	Low cost / high value operations	Define the basic inputs of the product development organizations (goals, products, services, processes, people and tools) Define the peoples' DNA Define the team type that should execute according to the design level required. Provide people with the necessary tools and infrastructure
		People Excellence	Define the peoples' DNA Provide people with the necessary tools and infrastructure

		Process Discipline	Define robust, clear and simple processes to achieve desired goals based on the products and services that will become the outcome of the organization Define the team type that should execute according to the design level required
	Execution	Low cost / high value operations	Invest on developing "ilities" in the organization to do more with less increasing efficiency and effectiveness and embrace change (flexibility, agility and adaptive capacity)
		People Excellence	Properly implement a booster policy to mentor and train new hires while performing the job (in-job training). This will reduce uncertainty when facing challenges. Enhance employee satisfaction by reducing stress and burnout.
		Process Discipline	Diffuse a process-centered culture through a mentoring and training culture. Reduce stress and burnout to achieve process discipline
	Controls (Improving)	Low cost / high value operations	Use the *work harder loop* to contain problems, not as the standard operation of the organization. Push your organization to increase capabilities by spreading new knowledge.
		People Excellence	Apply pressure to increase knowledge. Push people to learn and to restlessly increase wisdom. Incentivize the *work smarter loop* to foster excellence.
		Process Discipline	Create a culture around the Virtuous Cycle of Capabilities as: Use existing knowledge, build new knowledge, spread knowledge and lead by developing your organizations' capabilities.

4.2) Thesis Insights

During the development of this thesis I faced several challenges. The following paragraphs are focused on providing insight on those challenges and suggested next steps.

As opposed to what I thought, obtaining qualitative data turned out to be as complicated and ambiguous as to obtain quantitative data. The first issue was to interpret and understand the answers provided from key interviewees. Sometimes interviewers tend to extract from interviews only the information that is consistent to its prejudices and ideals, and tend to disregard information that is opposite to his preconceived concepts. This happened to me when trying to extract the general ideas from the interviews and meeting I had with stakeholders.

Second, the hypotheses formulated in this thesis have multiple answers that depend on the context in which the system under investigation is applied. Given this, it turned complicated to generate objective data and evidence to confirm, or reject the hypotheses. However I understood that in order to generate the data to support the conclusions of each hypothesis it is important to define the system and the ecosystem of the entity under evaluation, and also the implications of cultural difference between the organizations of a company. I learned that cultural differences do affect the performance of an organization but most important I learned that cultural differences will need to be considered serious as part of the dynamics of any future study. Somehow researchers will have to define a quantitative variable to illustrate the effect of cultural aspects in dynamic modeling.

Third, the results generated in chapter two helped me to understand the effect of mentoring and training over a complex organization dedicated to build cars. These products require long lead design development, a complex supplier network, heavy duty equipment to build them and teams composed of hundreds of people. The question is how different the analysis provided in chapter two would be if it was applied to an organization with shorter design lead time development, smaller or null supplier base, and teams composed of fewer people like a software development company? I believe researchers should focus their efforts on differentiating the amount of time required to improve the inexperienced productivity fraction and the assimilation time in both types of organizations, to determine if mentoring and training policies have the same "scary" effect at the initial stages of implementation or not, in either organization. The same question could be applied to those organizations which principal product is an intangible service.

Finally, this thesis should serve as the basis of future works focused on improving the performance of the PDOM and therefore various next steps should be considered as part of this work:

- Further studies should be performed to understand how a lightweight structure should be architected in the PDOM. Badin, Beristain and Zamora (2012) have proposed the creation of a "knowledge-System" architecture organization focused on integrating multiple functions into systems rather than PMT´s (see definition of PMTS in the list of acronyms). The basic idea extracted from its work is illustrated in figure 28 below. What they propose is to migrate from a functional organization divided in 5 PMT´s: Powertrain, Body Interior, Body Exterior, Chassis and Electrical; to an organization based on systems: Door, Instrument Panel, seats/carpet/floor, fascia/lamps/grille. This way, integration of components could be enhanced by creating a focus on designing components interfaces.

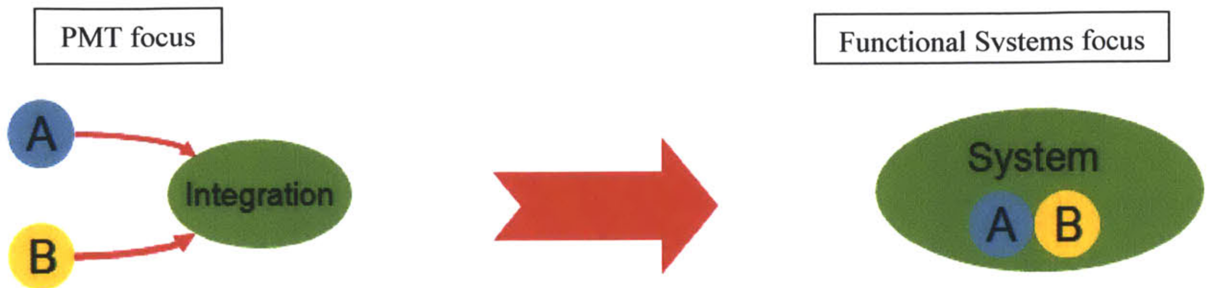

Figure 28: Proposed Knowledge-System Architecture

- The organization´s architecture proposed in figure 5: CCSE "To-Be" organization architecture decomposition is focused on creating a lightweight approach. The next step should evaluate its benefits once implemented.
- Further studies should be conducted to determine how long would it take for a mentoring policy implemented in the PDOM, to improve the average productivity of the organization.
- It would be interesting to study the impact of a re-defined "team leader" program considering a focus on in-job-training rather than shadowing. Then compare this data with the one obtained from the failed version of the "team leader" program.
- It would also be of great interest to somehow document the virtuous cycle of capabilities as a formal process in the PDOM. As a next step it would be important to study how often the organization in his early stages closes the complete cycle. I am convinced that success will not be achieved if this cycle is kept unclosed.
- Finally, it would be important to document the real impact of the framework provided in this thesis on the accomplishment of success in the PDOM.

With this insight I declare this thesis complete.

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Appendix A: Relevant Questions for Hypothesis Development

These questions were generates as a result of my own curiosity, experience and passion about the research topic and enriched from general thoughts extracted from the PDOM SDM meetings.

Planning:

- What are the basic inputs of the Product Development System?
- How these inputs should be designed (planed) to maximize chances of success?
- What characteristics should the employees of the organization have to execute the action plans?
- Based on the incoming responsibilities acquired by the PDOM, what type of organization should execute the plans?

Execution:

- What are the common reasons why young organizations fail to respond to increasing demand for services?
- What is the effect of the inexperience organization during the execution phase on achieving success?
- What is the effect of the "pressure to do more with less" during the execution phase on achieving success?
- How are the "rookie factor" and the "pressure to do more with less" overcome?
- What are some of the "ilities" necessary to sustain the organization in a constantly changing environment?

Improving:

- Why organizations fail to learn (improve)?
- What is the best way to overcome the vicious cycle of suppressing learning?
- What are the organization's learning capabilities that improve the execution responsiveness and quality?
- What are the learning capabilities that other high velocity organizations develop to achieve success?

Appendix B: Why CCSE failed during its early stages?

The following compilation of ideas was obtained through a series of short interviews with key stakeholders of the organization and personal experience. The relevant question in this case was open-ended with the intention to capture as much insight as possible:

Why CCSE failed during its early stages?

General answers:

Lack of motivation

Lack of objectives definition

No Cohesiveness within the team due to unrelated activities

Redundancy in the work performed by core engineering and STA

Little or no interaction with parent organization in US

Coaching and mentoring was sporadic and inconsistent

The overall satisfaction of the organization in the US had decreased. Morale was low due to the industry conditions.

Appendix C: PDOM SDS Meeting general ideas

The PDOM SDM meeting is a forum designed to discuss strategic, technical and organizational topics with the PDOM management team and all the alums and alumni that have been part of the MIT Systems Design and Management program. One of the main topics of the meeting is to discuss the future of the PDOM and how SDM alums and alumni can contribute actively to guarantee success; therefore multiple questions related to the sustainability of the organization are raised in search for answers. The high level ideas extracted from these meetings that inspired the development of this thesis were condenser and documented as follows:

What is the importance of hiring the best people in the PDOM to achieve success?

What is the impact of tolerating uncertainty in the daily execution of the organization?

What is the impact of a relatively inexperienced organization in its own productivity?

How can change be adopted and embraced to become tolerant to variability?

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