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Preface

This thesis marks the end of my master program in Industrial Economics at the University of Stavanger (UiS) and the last stage of becoming a civil engineer. My ambition has been to study complex project management and gain a better understanding of the challenges related to this subject.

The process of writing this thesis has been challenging and exiting. The lessons learned could not have been possible without the great help of many people. First, I would like to thank my supervisor, Dr. Rajesh Kumar, for providing me with essential advice and guidance. Likewise, I want to thank my commanding officer and the Royal Norwegian Navy for allowing me to take some time off in the critical stages of my studies.

I would also like to thank my family for the help and support they have provided me. I am grateful to my brother, Dr. Majid Hajsleiman for valuable inputs and feedback while finalizing this assignment. Finally, I want to thank my wonderful wife, Faten Salman, for her support and patience while being pregnant with our son. This would not have been possible without her help.

This thesis is dedicated to our son Mostafa who is expected to arrive in approximately 25 days. Having hopefully finished the chapter of university studies, I am looking forward to beginning a new chapter with my son and wife.

Special thanks and gratitude to everyone that helped and supported me during these two years of studies.

Hamad Mostafa Hajsleiman

Stavanger, July 2018

Summary

Many industries are experiencing an acceleration in innovation and technology development. This is causing projects to increasingly become more demanding and complex to manage. Influencing factors such as rapid technological advancement, multicultural cooperation and high-tech innovations are providing new elements of complexity to the industries. As projects increase in complexity the likelihood of project success decreases. In light of that new theories, approaches and models are being developed to better understand and accommodate project challenges related to complexity.

Complex project management is a central theme for many industries. However, the discipline does not have a unified framework, thus allowing for various standards to be used. The challenges associated with complex project management is connected to managing a process which often has no clear solution. The process is subject to significant external influence and irrational connection between cause and effect. There is no unified or correct approach when it comes to managing complex projects. It is an evolving process of learning and discovering new tools and techniques that can be used to enhance project performance. To have an advantage in the business market of the 21^{th} century industries are dependent on applying approaches that take into consideration the complexity aspect of project management.

The aim of the thesis is to direct the focus towards central issues related to complex project management. The goal is to study how complex projects are managed and gain a better understanding of the challenges associated with them. The thesis mainly focuses on complexity sources and their impact on project failure. It examines and considers the causes of complexity in projects and searches for answers to why complex projects often fail. The center of attention is on developing an approach for complex project management which incorporates the lessons identified with regards to complexity challenges.

The results in this thesis are used to presents an alternate approach to complex project management focusing on complexity analysis. The approach has been given the name *Continuous Model Adaptation* (CMA) which reflects its adaptive nature. The CMA is a cyclical model consisting of six stages. It proposes complexity analysis and mapping as base for model selection. It relies on this heavily thus highlighting the continued focus on the identification of complexity sources. Furthermore, it implements a review mechanism before each phase-transition of the selected PMLC model. Much information is either lost, not transmitted or misunderstood during phase-transition. The review mechanism is meant to serve as an information control before initiating the next phase.

As every other model, the CMA obviously has its strengths and weaknesses. Part of the thesis emphasis is put on evaluating these strengths and weaknesses.

This thesis highlights the importance of two categories for project success; *the human factor* and *information management and communication.* They make up the foundation on which the CMA is intended to run. Therefore, the CMA requires the proficiency and expertise of an experienced project team that is comfortable working in an environment with incomplete information. The presented approach is intended to promote adaption instead of control. It aims at providing a tool that makes the project team better equipped in confronting complexity sources.

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List of acronyms

Agile Project Management (APM)

Continuous Model Adaptation (CMA)

Complex Project Management (CPM)

EMERTXE Project Management (MPx)

Extreme Project Management (xPM)

International Centre for Complex Project Management (ICCPM)

New Product Development (NPD)

Project Life Cycle (PLC)

Project Management Institute (PMI)

Project Management Life Cycle (PMLC)

Traditional Project Management (TPM)

Queensland University of Technology (QUT)

Introduction

This is the first out of four sections outlined after the IMRaD structure. It contains the introduction to the thesis.

1. Chapter 1 - Introduction

The first chapter introduces the background and purpose of this thesis. Furthermore, it presents the scope and limitations as well as the thesis outline.

1.1. Background

From the Great Pyramid of Giza to the Apollo Program, projects have been used by humans as a tool to achieve a desired end-state. The word *project* is derived from the Latin verb *proicere*, meaning "*before an action*". This meaning captures the essence of what project management is about; a process that has evolved to also include "*the action itself*". Today project management is the primary method used worldwide in a variety of industries to achieve a goal, create a deliverable, or respond to a specific challenge or opportunity. This distinct discipline developed in the 1950s as organizations started to systematically apply project-management tools and techniques to complex engineering projects. [1] On the front run of such development was the United States Military.

In the 21th century projects are becoming more complex due to influencing factors such as rapid technological advancement, multicultural cooperation and high-tech innovations, to mention a few. This is leading to new theories, approaches and models being developed to better understand and accommodate challenges related to complexity. Despite new development many project managers are still struggling with understanding complexity and how it relates to projects. As projects increase in complexity the likelihood of project success decreases.

Complex projects are more prone to suffer from time delays, cost-overruns and deliverable shortcomings. Examples of such failures are many and the list is long. Over the last 15 years research conducted by the Standish Group, which specializes in IT value research, reveals poor track record for software project performance. The research estimated that American companies and government agencies spend $80-$140 billion per year on failed software-intensive projects. The same research concluded that, for IT projects across industries, only 35 percent of projects are successful *(deliver on time, on budget and with full scope)*, 46 percent are challenged *(completed, but late and over budget)* and 19 percent fail *(do not deliver)*. [2]

In their book, *Reinventing Project Management*, authors A. Shenhar and D. Dvir, used collected data for 15 years on more than 600 projects. The results found that 85 percent of projects failed to meet time and budget goals. The primary reasons for the failures was that "project teams failed to appreciate up front the extent of uncertainty and complexity involved (or failed to communicate this extent to each other) and failed to adapt their management style to the situation." [3] In Norway the focus of project management, has during the last decade, shifted towards governance and front-end planning because of large cost-overruns in major public projects. [4] This shift is in part caused by the increasing complexity that we face in today's projects. Increased complexity also presents new challenges for the oil and gas industry as we move into a new era of technological advancement.

The track record for failed complex projects is long and to avoid reoccurring mistakes one must try to understand how to manage complex projects in a more efficient way. Different theories have been presented on this subject highlighting various aspects related to this challenge. Still, many businesses in various sectors lose millions of dollars yearly due to managerial challenges related to complex project management. Are the businesses failing because of flaws in the models, or are they failing in understanding and implementing the models correctly? Which factors are critical in providing success and how can we safeguard them? Such questions and many more like them are now at the center of discussion in the academic community.

With regards to the mentioned challenges, complex project management proves to be an important and central theme for many industries. Exploring this issue to establish well-functioning approaches to complex project management is vital for the industries as well as the costumers. This has the potential to reduce cost overruns, lessen time delays and produce better deliverables.

The unprecedented change in the business environment, and the continuous evolvement of technology, are both creating new challenges as well as opportunities. Companies who manage to adapt and exploit such opportunities will have a considerable business advantage in the 21th century.

1.2. Purpose

The purpose of this thesis is to study how complex projects are managed and gain a better understanding of the challenges associated with them.

This thesis focuses on how to deal with critical influencing factors in complex project management, mainly focusing on *the human factor* and *information management and communication*.

The aim of the thesis is to present a new approach for complex project management with emphasis on *the human factor* and *information management and communication*.

To accomplish that I will focus on the following objectives:

1. Study the relevant literature of complex project management.
2. Present the relevant approaches and models for managing complex projects used today.
3. Identify the main challenges related to complex project management.
    a. Discuss the main causes of complexity in projects.
    b. Analyze why complex projects (often) fail?
4. Identify critical factors for complex project management success and present an approach to safeguard them.
5. Evaluate strengths and weaknesses in the presented approach.

1.3. Scope and limitations

How to manage complex projects is an overwhelming task. This thesis does not go into the details of the various tools and techniques required for complex project management. Instead, it focuses on presenting an overall management approach.

Although, this thesis acknowledges the role of risk in project failure it does not focus on this issue. It does not address the role of risk analysis, risk assessment and risk management in projects.

The different studies and articles used in the research apply slightly different measurements of project success and failure. However, the overall notion of success should be understood as projects that deliver on time, on budget and with full scope. The overall notion of project failure is projects that exceeds time, surpasses budget, has insufficient scope or do not deliver at all.

While presenting various challenges of complex project management the thesis concentrates on identifying the root-causes and their effects on the success and failure of the project. Therefore, it distinguishes between causes and root-causes, thus highlighting the root-causes for project failure.

Central to this thesis is the presentation and evaluation of the proposed approach.

1.4. Report outline

This thesis consists of eight chapters. It is outlined after the IMRaD structure. However, the theme of the thesis naturally requires elements of discussion and results to be presented in the various chapters. The following outline illustrates the essence in each chapter.

Introduction

Chapter one: **Introduction** – *Presents the background, purpose, scope and report outline.*

Methods

Chapter two: **Traditional Projects** – *Introduces the concept of a project, project phases, project life cycle and project management.*

Chapter three: **Complex Projects** – *Introduces the concept of complex project management. Presents an overview of the theoretical framework and highlights the main challenges.*

Chapter four: **How to Manage Complex Projects** – *Presents relevant methods and approaches to managing complex projects.*

Results

Chapter five: **Critical Factors Identified** – *Presents the critical factors discovered related to complex projects.*

Chapter six: **Continuous Model Adaptation (CMA)** – *Proposes the Continuous Model Adaptation; an approach to managing complex projects.*

Discussion

Chapter seven: **Considerations Regarding Complex Project Management and CMA** – *Evaluates the strengths and weaknesses of the CMA.*

Chapter eight: **Conclusion** – *Concludes the thesis and presents suggestions for further work.*

Methods

This section presents the relevant theoretical framework for our discussion. It provides a brief insight into the theory of projects, clarifying important definitions and terminology. The section introduces complex projects and relevant approaches to complex project management.

2. Chapter 2 - Traditional Projects

This chapter gives a brief introduction to the concept of a project and outlines the framework for traditional project management.

2.1. Introduction

Projects usually originate when we identify a need, a problem or an opportunity we want to respond to. It is a form of work which stretches far back in time. Classical examples which can be mentioned is the Great Wall of China, the Roman Aqueducts and the Egyptian Pyramids. These projects presented a deliverable that is still admired in modern day by millions of people. Today's project work varies in size, scope and complexity but many of the core principles used back then remain the same. Projects are often identified as being temporary, unique and that they require progressive elaboration. This is one of the most basic definitions of a project. Other more elaborate definitions exist and by looking at certain definitions of projects we can gain a better understanding of some of the challenges related to them.

Furthermore, projects are normally divided into different phases which make up the Project Life Cycle (PLC). The life cycle creates a differentiation between the various demands related to the project. It allows us to categorize different activities with respect to a time sequence and priority. This lets us know that on the most basic level all projects require *initiation*, *execution* and *closing*. As projects evolve in nature other phases such as *planning,* or *monitoring- and control,* may become necessary.

This creates the need to administer the various phases, which again leads to the discipline known as project management. This discipline can be characterized as the overall activity of overseeing the PLC. At its simplest level, this can be described as the discipline of managing projects successfully. At its higher level, this of course must take into consideration the different methods and approaches for doing so.

2.2. Definition of a project

Defining a project is a kind of paradox since each project in itself is supposed to be unique in character. In project management literature we find many project definitions with slightly different objectives. Each definition reflects a philosophy either connected to how to manage the project or to what the project is. Therefore, two definitions with different emphasis were chosen to be presented. The first one is a business-focused definition focusing on client satisfaction:

A project is a sequence of finite dependent activities whose successful completion results in the delivery of the expected business value that validated doing the project. [5]

The second one is a descriptive definition focusing on the project itself:

A project is a sequence of unique, complex, and connected activities that have one goal or purpose and that must be completed by a specific time, within budget, and according to specification. [5]

Let us break down this definition by looking at the different parts so that we can understand it better.

Sequential means that the project consists of several activities and that they must be completed in some specified order. Specifying a sequence helps create a level of order in the project.

Unique implies that each time the activities of a project is repeated something is always different. This uniqueness is the result of random variations that is not possible to exclude from the nature of a project. These random variations are often beyond our control. Examples of such variations could be delays, or different human factors.

Complex, in this sense, means that the activities that make up the project are not simple. This again is related to the type of project that we are conducting.

Connected activities implies that there is a logical relationship between the pairs of activities. For example, the output of one activity could be the input of another activity.

One goal indicate that projects must have a single goal, and that all members working on the project must strive toward reaching that goal. (However, very large projects often get divided into sub-projects with different sub-goals.)

Specified time means that projects are temporary endeavors, with a beginning and an end. Each project has a specified completion date, either externally specified by a client or self-imposed by management.

Within budget tells us that projects have limited resources. The project budget can only provide a limited amount of people, machines and services due to resource constraints.

According to specification - the deliverable should have the certain level of functionality and quality that is agreed upon with the client.

A project can have many different definitions emphasizing different objectives. Often, we tend to focus more on the project itself and less on client satisfaction. The first definition is what you want to abide by when you present the costumer the deliverable. The second definition is what you want to use as you are conducting the project.

2.3. The project phases and life cycle

Even though projects tend to be different they move through similar phases as a part of the project life cycle. These phases are meant to ensure that difficult issues are not overlooked, time and money not wasted, and resources effectively employed. In traditional project management these phases are divided into four sequential categories. [6]

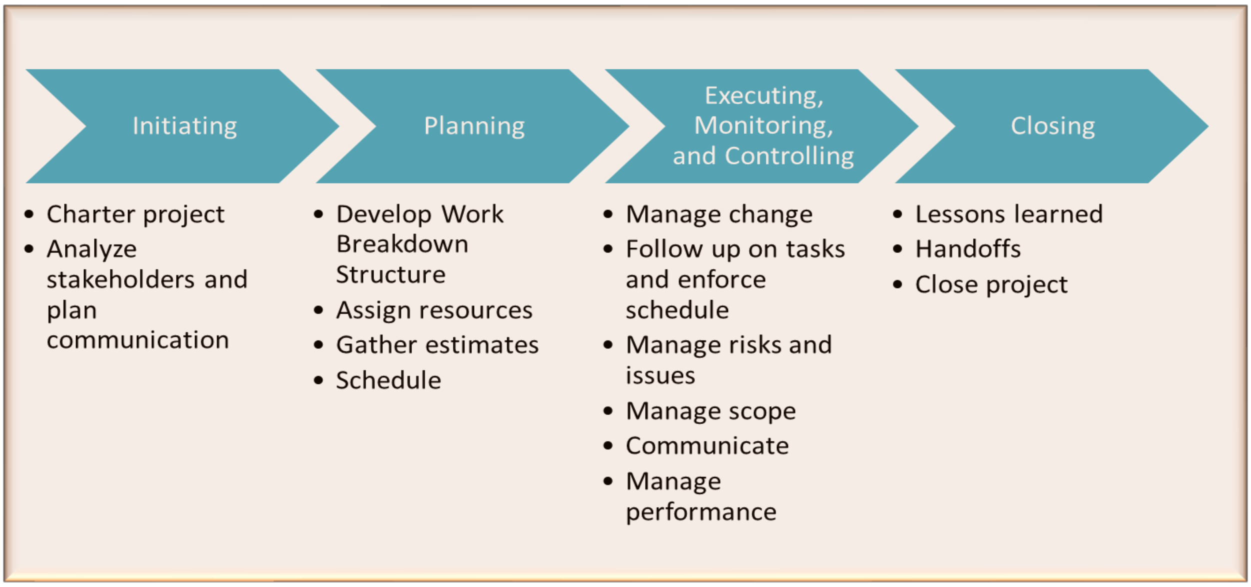

FIGURE 1 – TRADITIONAL PROJECT MANAGEMENT PROCESSES, SEQUENTIAL PROCESS

Initiation and definition: This phase examines if the project is justified with respect to the sponsor's strategic plan, and how it relates to the expected cost and benefits. It is usually done by conducting a feasibility study and defining the project scope.

Planning and development: This phase focuses on issues that will form the basis of project control throughout the execution and control phase. It is sub-divided into three essential elements.

- The creation of all plans to support the project – scope, management, timeline, budget, risk, procurement, contract, etc.
- The organization and mobilization of all the resources required by the project – people, equipment, materials, etc.
- The establishment of an infrastructure to support those resources. Ensure effective communication between the network of project stakeholders.

Execution and control: Implementation of the plans and activities are conducted in this phase. It is important to maintain control over changes to project plan and to minimize those changes as much as possible. This phase of the project has the highest expenditure rate. Therefore, monitoring and controlling the time schedule, quality and budget resources are vital factors for success.

Closure: Important to this phase is completing the documentation and administration requirements of the project. Making final payments to contractors and suppliers. Transfer the finished product over to the custody and control of the owner. Finally, perform a formal project evaluation, to capture new knowledge and learning.

2.4. Project management

British Standards Institution defines project management in the following way:

Project management is the planning, monitoring and control of all aspects of a project and the motivation of all those involved in it to achieve the project objectives on time and to the specified cost, quality and performance.

The definition does not say anything about managing the work on a project. When it comes to definitions sometimes the most important aspect is not what it is, but what it is supposed to do. Robert Wysocki's definition answers this question better:

Project management is a set of tools, templates, and processes designed to answer the following six questions:

- *What business situation is being addressed by this project?*
- *What does the business need to do?*
- *What will you do?*
- *How will you do it?*
- *How will you know you did it?*
- *How well did you do?* [5]

At its core project management is what is needed to be done to achieve the project's goal. This must be applied to many different activities. Examples of such activities are:

- Time Management
- Cost Management
- Quality Management
- Personnel Management
- Contract Management
- Integration Management
- Communication
- Uncertainty Management
- Risk Management

Project management is about integrating all activities in a project in an efficient way. As these activities increase, the complexity in projects increase, and Wysocki's questions become harder to answer. Clear answers no longer exist, and they must be discovered through various group-processes.

3. Chapter 3 - Complex Projects

This chapter provides a theoretical transition from traditional projects to complex projects. Its aim is to establish an understanding of what a complex project is by highlighting the characteristics of such a project. It differentiates between what is *complex* and *complicated*. Furthermore, it presents critical challenges and problems faced in complex projects.

3.1. Introduction

In the previous chapter a very basic understanding of what a project is was presented. That description applies mainly to what is considered traditional projects. On the most basic level traditional projects are often characterized as being more predictable than complex projects, having clearly defined goals with clearly specified ways of reaching them. They can be managed using a so-called *recipe*, or *step-to-step instruction*, making them suitable for control-based approaches. Complex projects on the other hand are characterized by having higher level of uncertainty and ambiguity. Often the risks connected to complex project are also much higher than in traditional projects.

For complex project management the main problem stems from the assumption that the outcomes, envisaged at the inception of the project, can be sufficiently determined early in the project and then delivered as planned. This approach to project management only works for a limited number of projects, mainly small scaled traditional projects. Since they consist of a more predictable nature, they subjugate well to control-based approaches. However, once these projects reach a critical scale and timeframe, which in turn induces more interconnectedness, control-based approaches simply fail to safeguard the project. The high number of complex project failures being observed suggests that project methodologies founded on control systems thinking alone are not appropriate for many of today's projects.

In his paper, *the need for new paradigms for complex projects*, author Terry M. Williams presented a long-awaited topic to the project management society. The concerns raised in the paper were the focal points of The NATO Advanced Research Workshop in 1996 which focused on managing and modelling complex projects. He proposed the three following concerns:

1. That projects are becoming increasingly complex;
2. That traditional project management methods are proving inadequate;
3. That new methods of analysis and management are needed [7]

Furthermore, he stated that *"while many project managers use the term **a complex project,** there is no clear definition about what is meant."*

Many had so far been using the term a complex project to describe projects that are in fact complicated. This had been leading to the development of a project management society not fully understanding the true nature of complex projects.

3.2. Differentiating between *complex* and *complicated*

Before addressing the task of defining a complex project it is necessary to establish one essential distinction. What exactly constitutes *complex* must be explained, and it's not the same thing as *complicated*. There is a clear distinction between these two concepts that must be understood to avoid using the wrong approach.

For example, the process of building an automobile certainly isn't simple, but it's not complex either. It is purely complicated. Complicated things are normally difficult to produce, they can take long time to build, but they are capable of being described categorically with specific instructions down to the very last detail. Because of that the design and construction of the automobile can be accurately and precisely articulated and planned. The automobile can be built even by people who don't fully understand what they are doing, as long as they comply with the instructions given. Any failure is either due to a lack of compliance with the instructions or an inadequacy in those instructions themselves.

On the other hand, complex processes cannot be described categorially down to the very last detail. The independency and interconnectedness between the various components presents an aspect of unpredictability to the process. Important differences between *complex* and *complicated* is the degree of uncertainty and the number of interacting but independent components over which we have little or no control.

Breaking it down more simply we can argue that a complicated process will more likely lead to an expected outcome, while a complex process will more likely lead to an unexpected outcome. This does not mean that an unexpected outcome will be less successful. It rather means that we enjoy less control in influencing the process as we want. Unfortunately, the lack of separation between these two concepts in the academic literature is present. They are frequently mixed, often with some academics referring to complicated processes as complex. This thesis makes the clear distinction between these two concepts due to the fact that they require different remedies.

3.3. Definition of a complex project

Numerous definitions circulate amongst academics, and project managers disagree on what constitutes a complex project. Major users of complex projects such as the construction industry, the new product development (NPD) industry and the software development industry provide slightly different definitions. Although there is no universally accepted definition for complex projects, its essence is captured by the characteristics outlined by the Queensland University of Technology (QUT).

QUT, located in Brisbane Australia, provides a master's program specializing in complex project management, and is also the CPM strategic partner of the Australian Government's Defense Material Organization (DMO).

According to them complex projects are those that:

- ***Are characterized by uncertainty, ambiguity, dynamic interfaces and significant political or external influences; and/or***
- ***Usually run over a period which exceeds the technology cycle time of the technologies involved; and/or***
- ***Can be defined by effect, but not by solution***. [8]

This clarifies that the scale of the project does not necessarily cause it to be complex. Small scale projects can also contain a large degree of complexity.

Another common term often used amongst project managers is *project complexity*. However, the concept received little detailed attention before the year 2000. [9] While complex projects can be understood as to cover the whole project, *project complexity* can be divided into many different components. These make up the different dimensions of complex projects, such as technical-, structural- or communicational complexity.

K. Remington and J. Pollack suggests four types of *project complexities* as useful categories for analysis. Structurally-, Technically-, Directionally- and Temporally Complex Projects. Each source of complexity exhibits distinctly different characteristics, and therefore presents different management challenges. [10] Their suggestion is based on the idea that projects are systems, and that complex projects function as *Complex Adaptive Systems*. This idea draws from Complexity Theory and implements certain concepts to organizations and projects.

3.3.1. Different variations of Project Complexity

"The source of project complexity will influence the project life cycle, including the critical review point and lengths of project phases within the life cycle, the governance structure for the project, selection of key resources, scheduling and budgetary methods and ways of identifying and managing risks." [11]

Structurally Complex Projects

Pollack and Remington acknowledge that such projects are rather complicated instead of complex, but since the dividing line is very unclear they are classified under this category. Therefore, the complexity in these projects stems from the difficulty in managing and keeping track of the number of different interconnected tasks and activities. This is commonly associated with large construction-, engineering- and defence projects. To manage these project, outcomes are decomposed into many small deliverables which can be managed as discrete units. The major management challenges come from project organization, scheduling, interdependencies and contract management.

Technically Complex Projects

The complexity in these projects stems from interconnection between multiple interdependent solution options. This is very common in architectural- and industrial design. Also, IT projects and research and development (R&D) projects experience such complexity. Such projects often have technical or design problems because of products that have never been produced before. They also lack precedents among the different techniques used. The challenges are usually associated with managing technical problems, contracts to deliver solutions, critical design phases and stakeholder expectations.

Directionally Complex Projects

The complexity in these projects stems from ambiguity related to multiple potential interpretations of goals and objectives. This can be found in projects characterized by unclear meanings, hidden agendas and unshared goals. The management challenges are associated with the allocation of adequate time in the projects initiation phase to allow for sharing of meaning and clarifications of agendas. The challenge comes from managing the organizational politics and human relationships of the project. Pollack and Remington argue that the key to success is two fundamental capabilities; *political awareness* and *cultural sensitivity*.

Temporally Complex Projects

This kind of complexity relates to change in external influences that may happen at any time during the PLC. It stems from uncertainty regarding the expectation of change and future constraints. It is characterized by shifting environmental and strategic directions outside the direct control of the project team. Such environmental changes could seriously destabilize the entire project. Examples could be the development of new technologies, civil unrest and catastrophes, or unexpected legislative changes. The challenge comes from managing how to maintain project focus before, during and after the crisis, thereafter adapting to the new environment to the best of the project teams' ability.

These four categories can be used in mapping the projects overall complexity. This allows for the creation of a project profile highlighting which domains require the most attention.

3.4. The Project Landscape

So far, it is seen that complexity in projects is related to the understanding of what is known and unknown about the project. In that regard, the level of clarity in the chosen *objective,* and the *process* of reaching that objective, controls the degree of the complexity faced. Robert K. Wysocki addresses this issue by separating projects into four categories based on how well the goal is defined and the solution is known. This again, allows for four different approaches to project management:

- [TPM] Traditional Project Management
  - *Clear goal, clear solution*
- [APM] Agile Project Management
  - *Clear goal – unclear solution*
- [xPM] Extreme Project Management
  - *Unclear goal – unclear solution*
- [MPx] EMERTXE Projects Management
  - *Unclear goal – clear solution*

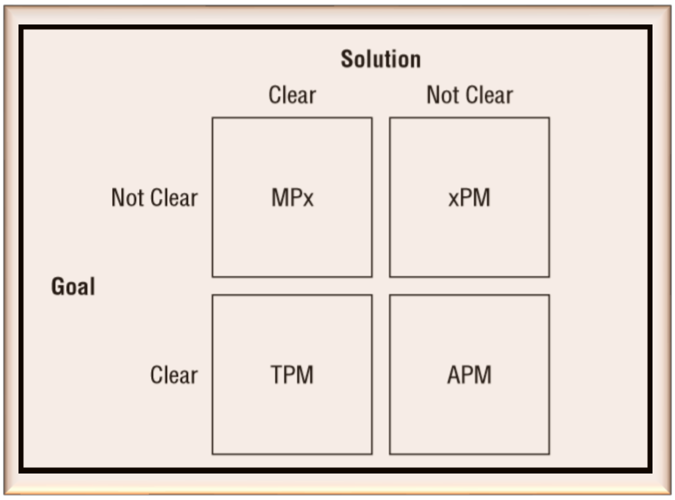

FIGURE 2 – THE PROJECT LANDSCAPE, WYSOCKI 2014, PAGE 312

In his model, *The Project Landscape*, the idea is to categorize the project to a quadrant, and within that quadrant select the best fit PMLC model. [12]

This raises the question; where are complex projects placed in the project landscape? According to Wysocki complex projects fall under all categories, except TPM.

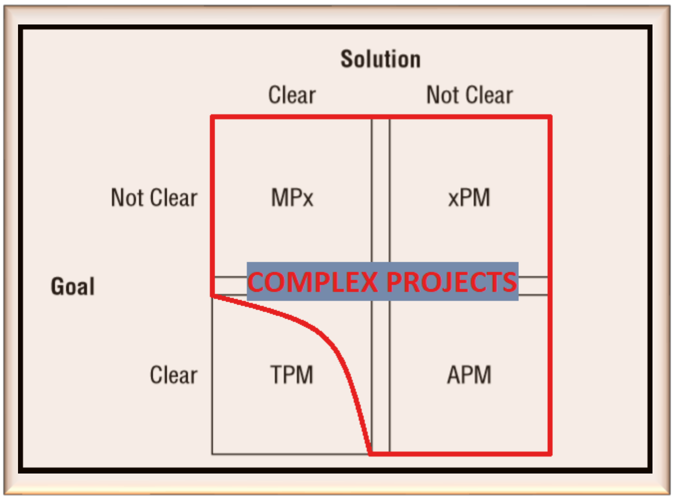

FIGURE 3 – THE COMPLEX PROJECT LANDSCAPE, ADAPTED FROM WYSOCKI, PAGE 312

Apart from TPM, which displays a low degree of complexity, complex projects should be managed by APM, xPM and MPx. A closer look at these management approaches will be presented in chapter four.

3.5. Critical challenges and problems faced in complex projects

The list of challenges and problems related to CPM is long. A closer look will be taken at the main causes of complexity in projects and why complex projects often fail.

3.5.1. What are the main causes of complexity in projects?

There are four critical characteristics that keep reoccurring in what can be regarded as complex projects:

- ***Uncertainty***
- ***Ambiguity (equivocality)***
- ***Significant external influence; such as:***
  - *Political, financial, constitutional, legislative, etc.*
- ***No clear link between cause and effect***

Uncertainty

Galbraith describes uncertainty as "*the difference between the amount of information required to perform the task and the amount of information already possessed by the organization*". [13]

Very often failure of a project can be linked to the uncertainty at the start of the project. Samset explains this phenomenon by illustrating the connection between uncertainty and information in the front-end phase. Showing that strategic decisions are made in a time with high uncertainty and low information. [14]

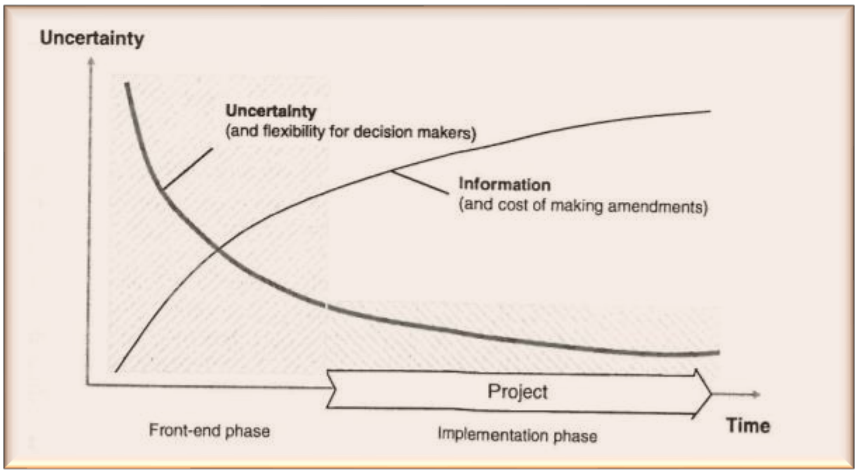

FIGURE 4 – UNCERTAINTY AND INFORMATION IN THE FRONT-END PHASE, SAMSET 2009, PAGE 21

This challenge is related to forecasting and is something all project managers must face. The remedy for this is acquiring more information regarding the issue at hand. The dilemma occurs when there isn't enough time for information-gathering and decisions must be made.

Ambiguity (equivocality)

According to Daft and Lengel; *"equivocality means ambiguity, the existing of multiple and conflicting interpretations about an organizational situation"*. Meaning different interpretation of the same piece of information. [15]

Weick presents an alternative interpretation of ambiguity saying it can also be experienced as "*the lack of clarity*" – caused by ignorance and lack of information. [16]

Both definitions emphasize the source of ambiguity as the existence of conflicting interpretations of the same information.

While gathering more information is meant to decrease uncertainty, ambiguity must be dealt with differently. The approach Daft and Lengel recommend is to "*reconcile the differences of perspective in conflicting interpretations*". The most basic and well-functioning way to do that is through face-to-face interaction.

Significant external influence

Significant external influence on projects have a vital role in determining the project's success. Significant influence can cause unexpected change and create mismatched expectations between stakeholders and shareholders. Often such change is directed towards altering the projects deliverable, main plan, or philosophy. Such influence can come in various forms, but two of the most critical ones are political- and financial influence.

Financial external influence is more likely to occur in the initiation stage of the project, but it can also present itself in later stages. Projects can find themselves in a battle of influence between project managers and project funders. This can cause complexity for project managers as they become presented with lesser options, due to financial shortcomings.

Political external influence can present rules, laws and regulations which limits the projects boundaries. This may alter production and design resulting in additional cost to meet government regulation.

In both cases external influence present unexpected challenges. In CPM project managers must take into consideration that such influence is highly likely to occur even if it does not seem apparent and make the necessary arrangements for encountering it.

<u>No clear link between effect and cause</u>

As the project displays no clear connection between cause and effect, reasoning breaks down and the project team is left with speculation and assumption when it comes to selecting the right project management tools. Anxiety and pressure causes the project team to lose control over the project. This again creates an insecurity in management and how to address the various challenges that arise. Project managers starts to doubt themselves and the cohesiveness of the team starts to dissolve.

Such environments require strong personalities which are comfortable with the challenge of leading under pressure. This requires leaders that are comfortable with leading without having control. Paradoxically, they must accept the loss of control over the project to be able to manage to project efficiently.

3.5.2. Why do complex projects fail?

While *uncertainty, ambiguity, significant external influence* and *the lack of connection between cause and effect* are crucial characteristics of complex projects, they don't necessarily explain why complex projects fail. They simply give an explanation to why projects behave in a complex manner.

Analyzing the underlying causes of *project complexity* in greater detail allows for better understanding of project failure. That way the root-causes can be identified and arranged in an order based on our preference and criteria.

The research conducted by the Standish Group over the last two decades has been referred to numerally regarding project success and failure. In *the Standish Group CHAOS 1994 report* they present a list of ten reasons for project failure after classifying projects into three resolution types:

Resolution Type 1 – Project Success: The project is completed on-time and on-budget, with all features and functions as initially specified.

Resolution Type 2 – Project Challenged: The project is completed and operational but over-budget, over the time estimate, and offers fewer features and functions than originally specified.

Resolution Type 3 – Project Impaired: The project is cancelled at some point during the development cycle.

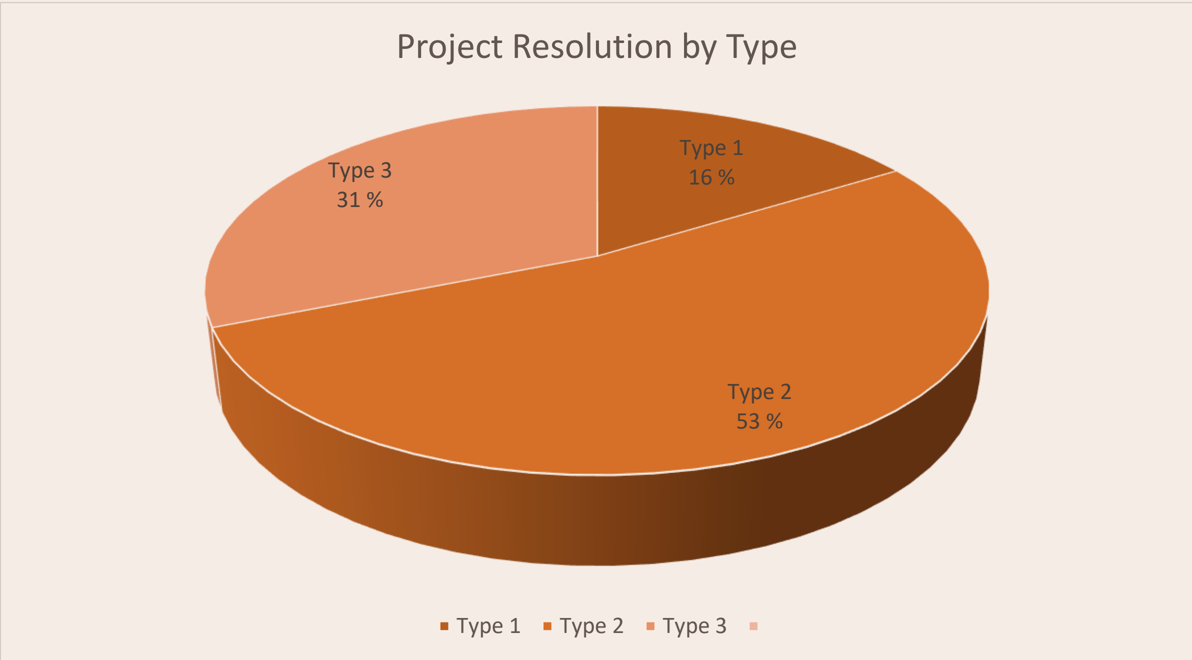

FIGURE 5 – PROJECT SUCCESS, INFORMATION FROM THE CHAOS REPORT 1994, THE STANDISH GROUP

The following is the current prioritized list of the top 10 reasons for project failure as presented in the Report. [17]

Project Challenged Factors	% of Responses
1. Lack of User Input	12.8%
2. Incomplete Requirements & Specifications	12.3%
3. Changing Requirements & Specifications	11.8%
4. Lack of Executive Support	7.5%
5. Technology Incompetence	7.0%
6. Lack of Resources	6.4%
7. Unrealistic Expectations	5.9%
8. Unclear Objectives	5.3%
9. Unrealistic Time Frames	4.3%
10. New Technology	3.7%
Other	23.0%

TABLE 1 – PROJECT CHALLENGE FACTORS, THE CHAOS REPORT 1994, THE STANDISH GROUP, PAGE 4

The top three factors on the list are related to people-to-people communications, either directly or indirectly. The lack of well-timed and clear people-to-people communications is the most common root cause for project failure and accounts for 36.9 % of the total. This includes both written and verbal communications media. Other factors such as *technological* and *unrealistic expectations, objectives and time estimations* make up another considerable reason for failure.

On the other hand, three important factors for project success was identified. Over the time span of 20 years the report shows that they have primarily remained the same.

CHAOS REPORT 1994		CHAOS REPORT 2014	
FACTORS OF SUCCESS	POINTS	FACTORS OF SUCCESS	POINTS
Involvement	19	Executive management support	20
Executive management support	16	User involvement	15
Clear statement of requirements	15	Clear business objectives	14
Proper planning	11	Emotional maturity	13
Realistic expectations	10	Optimization	12
Smaller project milestones	9	Agile process	10
Competent staff	8	Project management expertise	6
Ownership	6	Skilled resources	6
Clear vision and objectives	3	Execution	3
Hard-working, focused staff	3	Tools and infrastructure	1

TABLE 2 – FACTORS OF SUCCESS, THE CHAOS REPORT 2014, THE STANDISH GROUP, PAGE 11

According to The Standish Group the big three pillars of project success are *executive management support*, *user involvement*, and *clear business objectives*.

Two additional critical factors for complex project failure highlighted by Professor Bent Flyvbjerg is *Optimism Bias* and *Strategic Misinterpretation*. He analyzes why in recent surveys nine out of ten major projects has had cost-overruns in the range of 50-100%. (Major project definition: *A project costing over a hundred million dollars or more.*) Flyvbjerg describes failure as underperformance and argues that the underlying factors have two root-causes: [18]

The two root-causes for project underperformance (in major projects)

- **Optimism Bias** – transpires when falling victim to the following two cognitive delusions.
  - **Planning Fallacy** – this is described as the tendency to underestimate the task completion time and cost.
    Planning Fallacy is common when forecasting the outcomes in complex projects.
  - **Anchoring** – this is the consequence of thinking that leads to optimistic forecasts. Anchoring occurs when estimates made at the start of the project serves as "anchors" for later stage estimations.
- **Strategic misinterpretation** – transpires when planners and project champions deliberately and strategically overestimate benefits and underestimate cost.

FIGURE 6 – ROOT-CAUSES FOR UNDERPERFORMANCE (IN MAJOR PROJECTS), FLYVBJERG 2011, PAGE 321-344

The two root-cause that Flyvbjerg identifies are direct results of human failure. As humans we tend to have cognitive delusions about how to solve project challenges. We often tend to underestimate the complexity of the problem and fail to ensure it the necessary time and resources. This indicates that the challenge of managing projects is related to how we function as humans, and not necessarily which approach we choose. Can there be a correct approach, model or method for managing complex projects?

4. Chapter 4 - How to Manage Complex Projects

This chapter presents an overview in the models and approaches generally used for complex project management. It presents a method for mapping complexity by using the Project Complexity Model by Kathleen B. Hass. Furthermore, it highlights the importance of *complexity thinking* and the necessity of combining different approaches.

4.1. Introducing relevant approaches and models

Wysocki introduces five PMLC models as effective tools for responding to the *project landscape*. He further divides them into three categories; Traditional, Agile and Extreme. His approach for project management is to: *1) Classify the project into one of the four quadrants of the project landscape. 2) Choose the best fit PMLC model considering the strengths and weaknesses that each model holds.* Hass introduces a different method focusing more on what she describes as *complexity thinking*. The method applies *complexity thinking* to projects by using *The Project Complexity Model* to select the best fitting PMLC.

4.2. Management models corresponding to the Project Landscape

Excluding the *Traditional* approach discussed in chapter one, what remains is two approaches to complex project management; *Agile*, which presents itself in the iterative and adaptive models, and *Extreme*, which accounts for xPM and MPx.

4.2.1. Agile Project Management

APM is an approach based on delivering the product iteratively and incrementally throughout the PLC by continuously revising the plan after each cycle run. Success criteria's regarding this approach is to *eliminate waste, amplify learning, decide as late as possible*, and *empower the team*. In doing so one must use small co-located teams of highly skilled professionals who are fully assigned to the project and are able to work without supervision. It requires the exhibition of trust between team members, flexibility among managers, and empowerment from the stakeholders.

APM is further divided into Iterative- and Adaptive PMLC models. The process-group diagrams are visually the same for both. The main difference lies in the discovery part of the Adaptive models which sets them apart from the Iterative models.

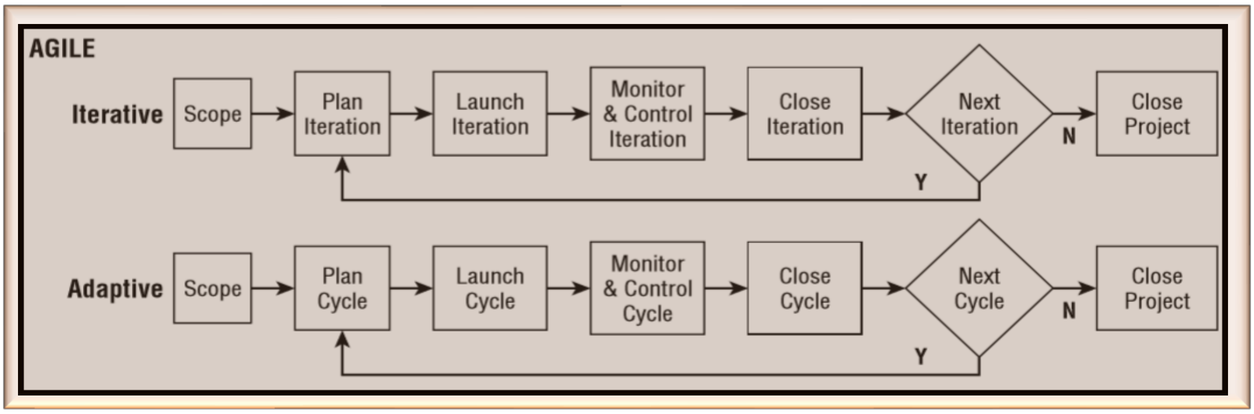

FIGURE 7 – THE AGILE APPROACH FOR PROJECT MANAGEMENT, WYSOCKI 2014, PAGE 59

- Iterative: Best applied when the requirements are unclear, incomplete or subject to change. This is typical for technology development projects.
- Adaptive: Best applied when the business problem or opportunity have an unclear solution and the schedule is aggressive. This is typical for NPD, new technology development and complex engineering projects.

In the Iterative models most of the solution is clearly known making it easier to identify the requirements at the function level. This means that the functions of the solution are completely known but the features are not. As the features are discovered, the functions can be built into the solution through a number of iterations.

In the Adaptive models both the features and the functions of the solution are unknown, and they must be discovered through repeated cycles. Each cycle aims to learn from the preceding one thereby building the foundation for the next one to come in an attempt to converge on an acceptable solution.

APM was first codified through the *Agile Manifesto* introduced by Jim Highsmith and Martin Fowler in 2001. The manifesto (which had 15 other signatories) introduced four critical discoveries in software development which since then has been the guiding principles in all Agile PMLC models: [19]

Manifesto for Agile Software Development

We are uncovering better ways of developing software by doing it and helping others do it. Through this work we have come to value:

- **Individuals and interactions** - over processes and tools.
- **Working software** - over comprehensive documentation.
- **Customer collaboration** - over contract negotiation.
- **Responding to change** - over following a plan.

That is, while there is value in the items on the right, we value the items on the left more.

Kent Beck	*James Grenning*	*Robert C. Martin*	*Alistair Cockburn*	*Ron Jeffries*	*Jeff Sutherland*
Mike Beedle	*Jim Highsmith*	*Steve Mellor*	*Ward Cunningham*	*Jon Kern*	*Dave Thomas*
Arie van Bennekum	*Andrew Hunt*	*Ken Schwaber*	*Martin Fowler*	*Brian Marick*	

FIGURE 8 – "THE AGILE MANIFESTO", HIGHSMITH & FOWLER ET AL. 2001, HTTP://AGILEMANIFESTO.ORG

The principles which were originally introduced for software development project models, has been adapted for alternate PMLC models for use on any other project, such as Evolutionary Waterfall Development, Adaptive Project Framework and Prototyping.

4.2.2. Extreme Project Management - xPM and MPx

Both xPM and MPx utilize the same PMLC models, however they differentiate between the iteration planning and interpretation of the deliverables from each iteration. This is directly related to whether the goal or the solution is known. Projects that have a goal in search of a solution use xPM, while projects that have a solution in search of a goal use MPx.

Typical xPM projects are R&D projects which aims at pushing the boundaries and reaching goals often outside what was thought possible. The results often introduce groundbreaking technological discoveries.

Typical MPx projects are projects that seek to find business value to a solution by integrating new technology into a current product, service, or process. The question that must be asked is: *"Is there a goal which this solution can reach that gives it a justifiable business value?"* A good example was the creation of the Post-it notes (from the 3M Company). The glue was created by accident in search of a stronger adhesive. Five years later after its creation the adhesive was integrated to the yellow Post-it notes we use today.

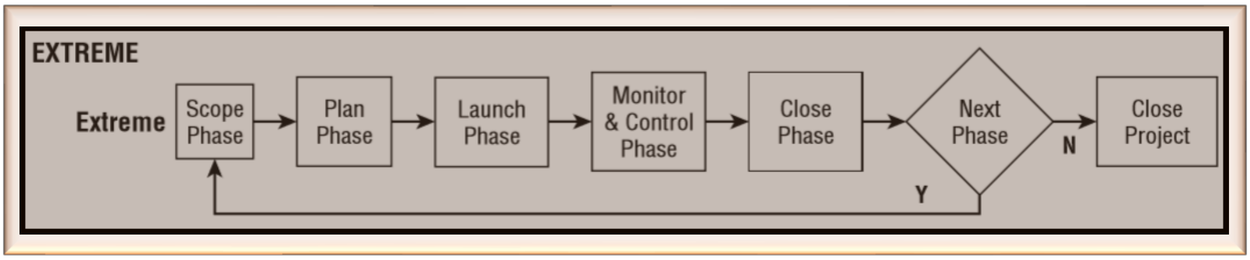

FIGURE 9 – THE EXTREME APPROACH FOR PROJECT MANAGEMENT, WYSOCKI 2014, PAGE 441

- Extreme: Best applied when the objective is unclear, and the solution is undefined. This is typical for R&D and complex NPD projects.

Extreme Project management is least structured and requires the most creativity. It has the highest levels of uncertainty and complexity. Unfortunately, it has the highest failure rates among project types. Because of that it has the most complex PMLC of the five models. The feedback loop continuously repeats the scoping phase, controlling that the project is moving in the right direction.

The figure on the next page displays an overview of the different the process-groups and shows the PMLC models in connection to each other. It is obvious that they are designed to manage different levels of complexity. As the complexity increases the models keep redirecting the feed-back loop to revise the earlier stages of the project. The need to keep *"starting over and over"* and going back to earlier stages is imperative to accommodate the agreed-upon project deliverable.

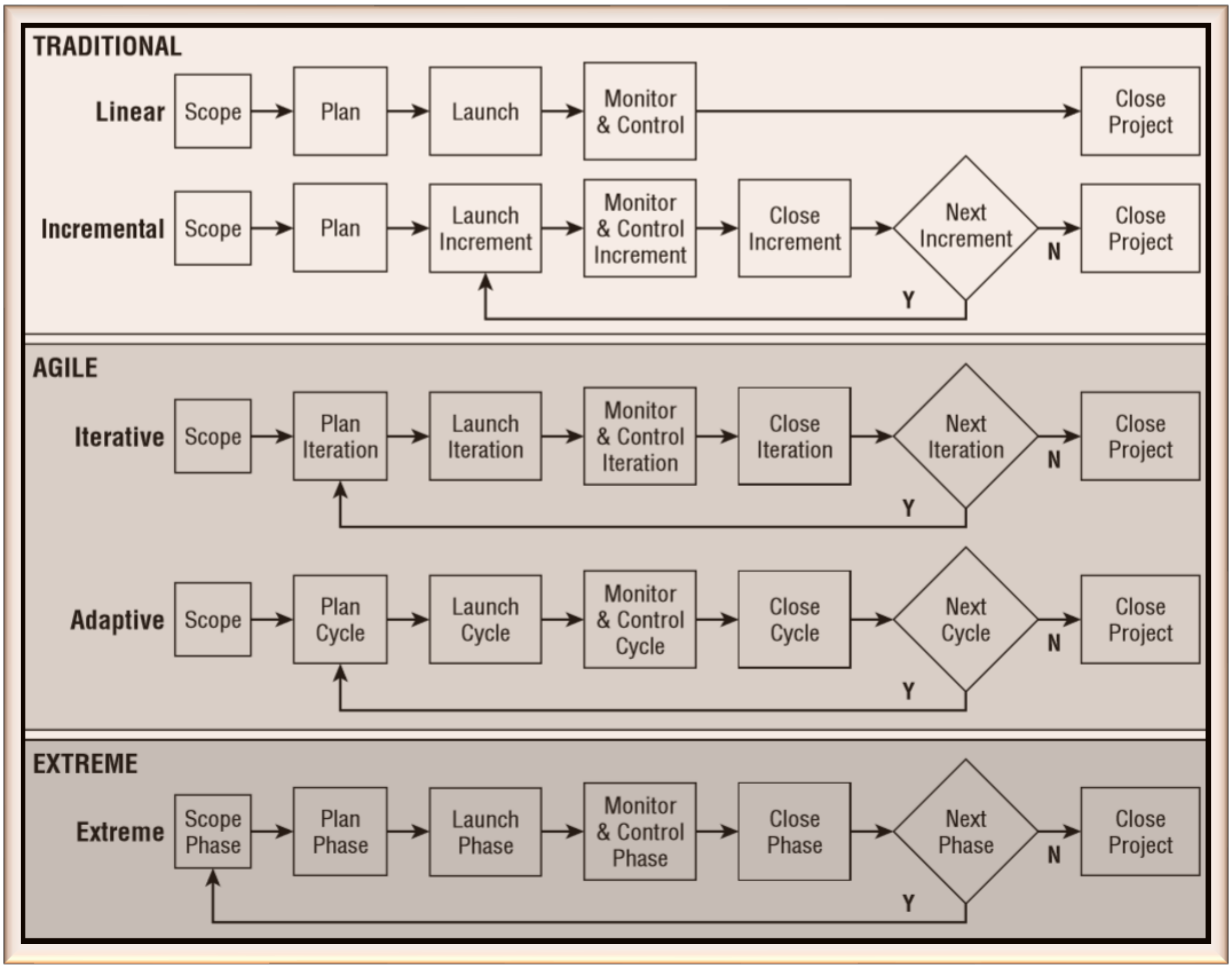

FIGURE 10 – TRADITIONAL, AGILE AND EXTREME PROJECT MANAGEMENT, WYSOCKI 2014, PAGE 441

This relates directly to what was mentioned in the beginning of chapter 3 and possibly the main challenge identified when it comes to CPM: *"The assumption that the outcomes, envisaged at the inception of the project, can be sufficiently determined early in the project and then delivered as planned."*

4.3. The Project Complexity Model by Kathleen B. Hass

In 2009 Kathleen B. Hass presented a new approach in her book, *Managing Complex Projects – A New Model*. Her ground-breaking work in project complexity earned her the *PMI's David I. Cleland Literature Award*. The approach uses the *Project Complexity Model* to diagnose project complexity before choosing the appropriate model for dealing with the various dimensions of complexity. In doing one must use complexity thinking as an analytical tool to manage the project.

4.3.1. Complexity Thinking

Complexity thinking identifies business organizations and projects as complex systems and uses *Complexity Theory* to understand and work with the nature of organizations and projects. This requires a paradigm shift from long established business models based on *Control Theory*. *Control Theory* is based on manipulating the inputs of a system to obtain a desired effect on the outputs. *Complexity Theory* is based on dynamic systems that are constantly evolving, reorganizing or heading towards chaos. The idea is that systems exist on a spectrum between *equilibrium* and *chaos*. Equilibrium will paralyze the system and lead to its extinction. On the other hand, chaos will cause the system to not function properly. The goal of complexity thinking is to continuously be at the edge of chaos – which is the most creative and productive state for a system to be in. Being able to do so requires a special group of people that think in a special way.

Complexity thinking goes back to how our brain is built and how we are able to think. Our two brain hemispheres process information very differently which creates a tendency for some cognitive processes to be specialized to one side of the brain. This is known as lateralization of the brain function. Complexity thinking is mainly connected to the right hemisphere. In his book, *Right-Brain Project Management: A Complementary Approach*, B. Michael Aucoin explain how the tools for mastering complex projects come from the right part of the brain. [20]

The table (adapted by B. Michael Aucoin) shows examples of different processing styles:

Left Brain	Right Brain
Verbal communication, uses words	Uses visual, spatial, tactile communication
Relies on logic	Processes emotions, offers intuition
Prefers to execute known rules	Seeks new associations, creative thought
Operates sequentially	Is comfortable with disconnected information
Prefers predictable behavior	Is comfortable with some ambiguity
Executes known patterns	Learns new unknown patterns
Prefers what is explicit, concrete	Prefers abstract concepts, metaphors
Operates with complete information	Operates with incomplete information
Unable to make decisions independently	Comfortable with critical decision-making

TABLE 3 – BRAIN PROCESSING STYLES ACCORDING TO HEMISPHERES, AUCOIN 2007, PAGE 41

As individuals we are different in how we process information. It is important for companies to recognize these differences and build project teams of people that are able to make use of right-brain processing styles when dealing with complex projects. This of course is easier said than done. While left-brain activities are helpful for TPM methods, CPM is dependent on individuals that use right-brain activities.

4.3.2. Applying the Project Complexity Model

The Project Complexity Model is designed to help the project team identify where to focus its efforts. It offers the framework for analyzing different dimensions of project complexity. The validity of the model is research based as it uses the Standish Group's *Recipe for Project Success: The CHAOS Ten* and the knowledge areas of PMI's *Project Management Body of Knowledge Guide.* [21] This is meant to strengthen the team's choice of project management tools and techniques for the actual project. The model is simple and fairly easy to use. Applying the model can be broken down into four steps. In section one of the APPENDIX the figures and tables of each step can be viewed in greater detail.

First:

- ✓ Select the boxes that best describe our project, only choosing one box in each category.
- ✓ All conditions in the box must be fulfilled to select it.

Second:

- ✓ Use the *Project Complexity Formula* to categorize the project into one of the following three categories: Highly Complex, Moderately Complex, or Independent.

Third:

- ✓ Visualize the overall complexity by developing a "spider-chart". This allows for easier communication of the overall complexity to the involved members of the project.

Fourth:

- ✓ Select an appropriate Project Cycle approach for the project.

These four steps are components which are meant to identify the correct type of complexity thinking required for the project. For implementing complexity thinking to projects Hass recommends a three-step solution:

1. **Assign project leaders based on the project profile.**
2. **Select the project model based on the project profile.**
3. **Select appropriate management techniques based on complexity dimensions.**

4.4. The Necessity of Combining Different Approaches

Since the challenges of CPM varies, each company must find a way to address the challenges they face. In doing so, the company becomes dependent on mixing different models to create their own project management culture or philosophy. One company that enjoyed success in that regard was design- and NPD company IDEO. The award-winning company drew mainly from the combination of three models; Stage Gate Systems, APF and the Prototyping model.

The Stage-Gate System:

The stage gate system is a multistage model primarily used for NPD. The stages highlight the prescribed, multifunctional, and parallel activities that must be performed, while the gates function as checkpoints for quality control. Between each of the stages the gates emphasize the need for a go/kill decision. Gates serve as checkpoints for the projects "*must meet*" requirements and are helping tools for what comes next. [22]

Adaptive Project Framework:

APF is a model with cyclical structure that emphasizes adaptation through discovery and learning. Each cycle learns from the previous one and attempts to converge on an acceptable solution for reaching the project goal. The major distinction is that APF is actively searching out solutions in contrast to the other Agile PMLC-models which are basically passive.

Prototyping:

The Prototyping model uses an iterative process where the prototype evolves as the project team learns more about the solution. The project team gets closer to the final solution by getting client feedback before each prototype is developed. The model doesn't tell you when to move to the closing phase. That is decided by client satisfaction and project funds.

IDEO's successful combination of different approaches highlights the necessity of merging models to achieve the desired outcome. Companies should be aware of this idea when dealing with complex projects.

Results

This section introduces two important categories for CPM success and failure. It highlights the root-causes in each category and explains their effect on complex projects. Furthermore, it presents an adaptive approach to CPM based on the results.

5. Chapter 5 - Critical factors identified

So far, the various challenges presented in CPM are numerous and the solution lies not in the models and various approaches but in the aspects that the models and different approaches are meant to safeguard. In that regard, there are many factors that must be taken into consideration and a separation between causes and root-causes must be made. There can be many causes to CPM failure or success, but focus should be on the root-causes.

The root-causes can be classified into two categories; *The Human Factor* and *Information Management and Communication*. In most projects analyzed the failures can be categorized into one of these two categories. This does not exclude other causes that can fall into different categories. It rather emphasizes that failure and success of a complex project is highly linked to *the Human Factor* and *Information Management and Communication*.

Understanding these two components and implementing tools and techniques to safeguard them is essential for all complex projects to succeed.

5.1. The Human Factor

Sometimes project managers tend to understand a notion but at the same time have a hard time defining it. This dilemma applies to the *Human Factor* in CPM. Defining it is a delicate task because of the various characteristics (*such as psychology, empathy, creativity, emotions, mental state, intuitiveness, persuasiveness, courage, etc.*) and the intricacy involved between them. At the same time there is a recognition that these characteristics are vital for both the success and the failure of the project. What constitutes the *Human Factor* in project management is factors that are directly related to the human nature involved in managing the project such as analysis, decision-making, rationale, emotional intelligence and creativity, to name a few.

According to Ciccotti the main factor most often ignored in project failure is the *Human Factor*. [23] Virine and Trumper present several complex projects from 1991-2005 that failed due to irrational choices caused by mental errors. One example was the inaccurate structural analysis for the Sleipner North Sea Oil Platform. The failure led to the loss of the platform at a value of 1 billion USD. [24]

Examples of failure directly related to the *Human Factor* has been consistent in CPM. Unfortunately, we often tend to undervalue or down-play its role because we don't fully understand it. Traditionally, researchers have been more interested in numbers and models, than human relations and interactions. Therefore, researchers naturally often look for reasons outside the human domain to explain the shortcomings of the project. In CPM, success and failure of the project can be directly linked to the *Human Factor* in a number of ways.

Firstly, *Complexity Thinking*, *working at the edge of chaos* and *Right-brain activity* are all interconnected. For one to function, it is dependent on the influence of the other. A team that aspires to be in the most productive and creative state must be able to *work at the edge chaos*. In the spectrum between equilibrium and chaos the team must use *Complexity Thinking* to strive towards chaos, but not fully reach it. This again requires a high-volume usage of the right-brain processing styles. The successful combination of *Complexity Thinking*, *working at the edge of chaos* and *Right-brain activity* will yield higher potential for mastering complex challenges in a project. These three concepts are all parts of *the Human Factor* and play and important role in conducting the project successfully.

Secondly, destructive cognitive processes such as *Unrealistic Expectations*, *Strategic Misinterpretation* and *Optimism Bias* have repeatedly proven to be major sources to complex project failure. Flyvbjerg explains that project planners tend to systematically underestimate costs and overestimate benefits. One would expect that project planners with years of experience working on major projects would be immune to such "basic" misapprehensions. Instead projects repeatedly fail because of this problem. Cognitive delusions are a part of *the Human Factor* that even the best project planner can fall victim to if not addressed in a proper manner.

Thirdly, *significant external influence* is another subject that should be addressed through *the Human Factor*. In most projects one cannot escape the various types of external influence. However, when the project is influenced by external parties the impact can be reduced by using diplomacy, emotional intelligence, creativity, cleverness, etc. to undermine the external influence. In that case, the *Human Factor* will not eliminate the external influence but be an important contributor to its reduction.

Lastly, *the lack of connection between cause and effect* in complex projects make it difficult to understand and respond to the changing environment. When the project is displaying irrationality, the need for humans becomes greater than the need for functioning models. Irrationality cannot be managed by premade models, and requires a cognitive analytical process directly related to the team. This makes *the Human Factor* an essential part of the solution discovery process.

5.2. Information Management and Communication

Previous commercial director of Virgin Atlantic, and head of top management development at Scandinavian Airlines, Jonathan Wilson, highlights the importance of swift information-flow in the organization: *"In the new business climate an understanding of chaos and complexity theory will be key to winning performance… The key cause of the changing-of-change in business is the acceleration of the flow of information and the exponential increase in the number of connections within and between organizations."* [25] Meaning, it is not enough to understand the chaos and complexity the organization is facing, more importantly one has to be able to distribute that understanding correctly, efficiently and swiftly throughout the entire organization. How we organize determines to a large extent our ways of communication. Consequently, information management and communication in complex projects should to a large extent be based on these four objectives:

- Reducing *Uncertainty*
- Clarifying *Ambiguity*
- Ensuring well-timed and clear people-to-people communication. *(The lack of well-timed and clear people-to-people communications is the most common root cause for project failure and accounts for 36.9 % of the total.)*
- Enabling communication that allows the team to *work at the edge of chaos*

These four objectives are the root-causes which can make or break the project in the communication domain. The first three are intended to preserve the project, keep it functioning and ensure that necessary information is exchanged. The last one aspires to elevate the project to a higher-level of creativity and productivity. When one of the four objectives is removed studies show that projects are more prone to failure. In many cases the problem is not the absence of the correct tools and techniques, or inadequacy in management, but the lack of time and lack of focus spent on reaching these goals. The focus on these objectives should always be a priority however the center of attention must be directed towards phase transition.

The focal point of the project team should be to enable precise and efficient information-flow between the different phases in the project. One of the essential sub-points in the planning phase is to ensure effective communication between the network of project stakeholders. According to

Gardiner the intensity of information-transfer between the various project phases is fluctuating. This is illustrated in the figure:

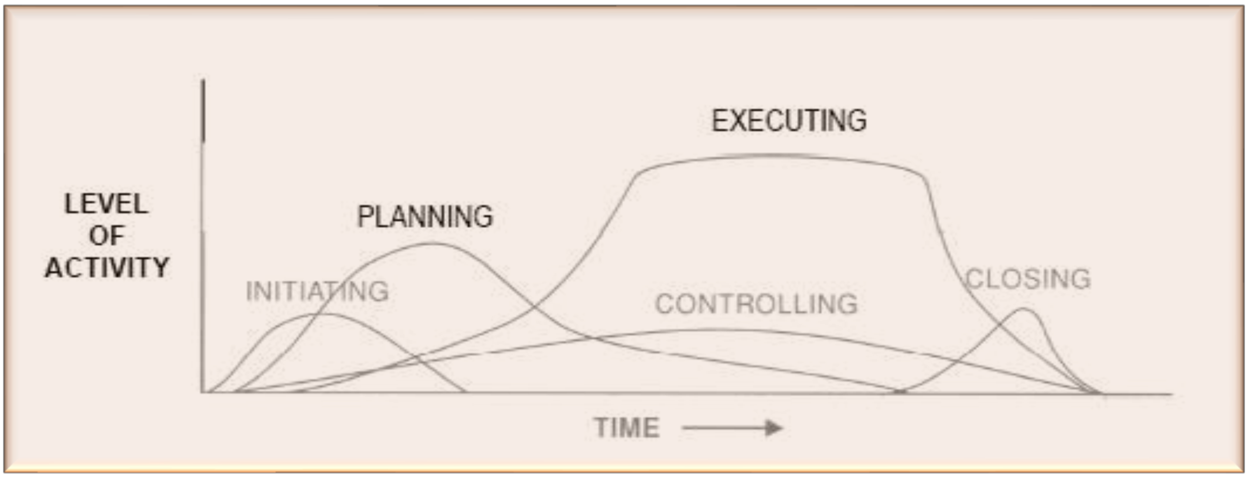

FIGURE 11 – INFORMATION FLOWS IN A PROJECT, PMBOK® GUIDE, PMI 2000

Effective information management between different project phases is central for the projects overall success. Hence, two important factors must be emphasized:

- Managing the overlapping information-flow between phases.
- Facilitating good information exchange between people during execution and control, given that this phase has the highest level of activity.

Each phase has its own objective and requires a certain level of information activity. The execution- and control phase is essential since it covers the longest timespan with the highest activity. However, since the different phases are strongly interdependent, project management works best when information is available and able to flow freely between all phases at all time. [6]

The ideal situation is to allow information to flow freely between all phases at all time. But it is often in the transition between phases that information is susceptible to distortion and negligence. Therefore, an information management mechanism should be in place to at least guard that the necessary information is exchanged to the next phase prior to its initiation.

6. Chapter 6 - Continuous Model Adaptation (CMA)

To overcome the challenges associated with complex projects, organizations must choose an approach that promotes adaptation. Chapter 3 and 4 emphasizes this necessity by highlighting an important connection; *increased complexity requires increased adaptation*. Furthermore, chapter 5 highlights that this is heavily dependent on *the Human Factor* and *Information Management and Communication*. Eventually, each company must go through a juncture of trial and error before uncovering a project management doctrine that works for them.

Chapter 6 proposes an alternate approach for CPM, the *Continuous Model Adaptation* (CMA), which is an iterative process between project initiation and project closure. The premise behind CMA emanates from pursuing the three following goals:

1. Provide additional freedom in changing and combining models.

Encouraging and providing additional freedom in changing and combining models is necessary to help serve the *Technical Complexity*.

2. Encourage an ethos (mindset) based on adaptation.

A mindset based on adaptation is necessary to help serve the *Temporal Complexity*.

3. Encourage more focus on *the Human Factor* and *Information Management and Communication*.

The Human Factor and *Information Management and Communication* is necessary to help serve the *Directional*- and *Structural Complexity*.

6.1. The CMA Approach

The CMA is cyclical model based on a combination of elements from Wysocki and Hass. It mainly consists of six stages. The iterative process happens between Complexity Analysis (*Stage 2*) and PMLC Model Execution (*Stage 5*). The model is intended to allow for continuous change partly by adapting to the various challenges presented. In *Stage 5*, it applies a review mechanism between each phase-transition. In the review mechanism, a decision is made on either to initiate the next phase in the PMLC model or go back to Complexity Analysis. This creates the possibility of numerous iterations based on the team's preference. At its most basic level, the CMA can be conducted as a 6-step process without adaptation which is executed only once from start to finish. As the complexity increases, the CMA can run through various iterations with several complexity analysis' and different variations of PMLC models. This is dictated by the review mechanisms between each phase-transition. Ideally the project team are looking to remain in *Stage 5* of CMA for as long as possible. Alternatively, the possibility to go back to Complexity Analysis and thereafter change model is always present. This of course has its strengths and weaknesses which will be discussed in the next chapter.

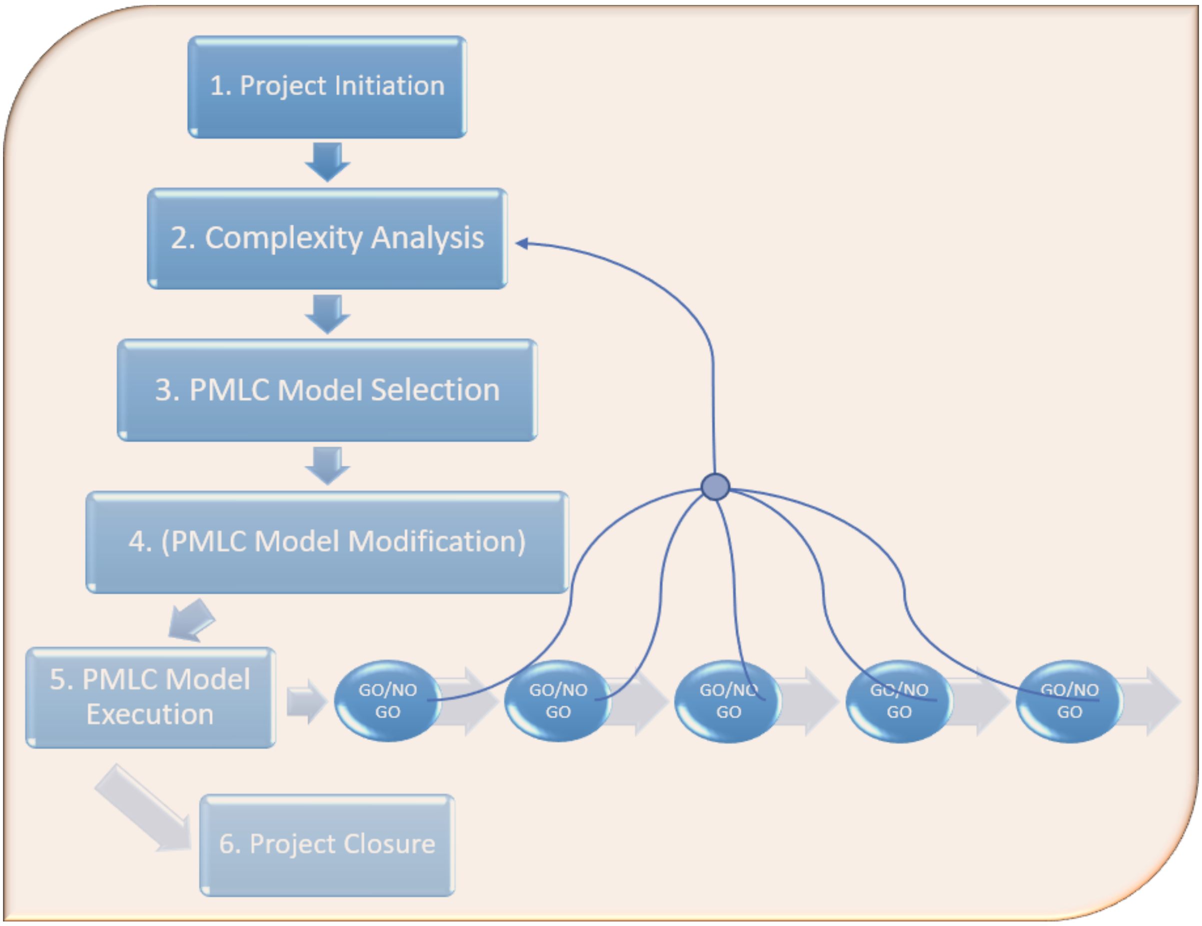

FIGURE 12 – CONTINUOUS MODEL ADAPTATION (CMA)

Here follows a further explanation the six stages of CMA with primary focus on stage 2-5 (the iteration stages):

Stage 1 – Project Initiation

This is the formal stage of initiating the project. The company, business or client identifies a problem or opportunity they want to respond to. Decision is made to conduct a project. Necessary requirements and resources to commence the project are provided.

Stage 2 – Complexity Analysis

There is no commanding blueprint to conducting the complexity analysis and what it should entail. However, the client must always be included to participate in the process. The main objective for the project team is to acquire the most realistic representation of the overall project complexity. The CMA recommends using the following steps:

- Identify the sources of complexity related to your project. The project team should not be limited to the four sources presented by Pollack and Remington.
- Create a grading system (preferably from 0-3) related to each source. The grading system should be based on research or project experience connected to the actual complexity source. (See model in section one of the appendix for such guidelines.)
- Always include *unknown complexity* as a dimension in your analysis. This might sound absurd, but this is just the project team's expectation of complexity sources that has yet to be identified or discovered. It is intended to help with two aspects. First, it makes the project team cognitively aware of hidden complexity sources. Second, it forces the project team to take into consideration the need for time to address unexpected challenges.
- Finally, map the result in a spider-chart. This makes it easier to communicate to the project team and other involved parties where the focus should be directed. The figure shows the results from two hypothetical projects, A and B, with correspondingly mapped complexity sources.

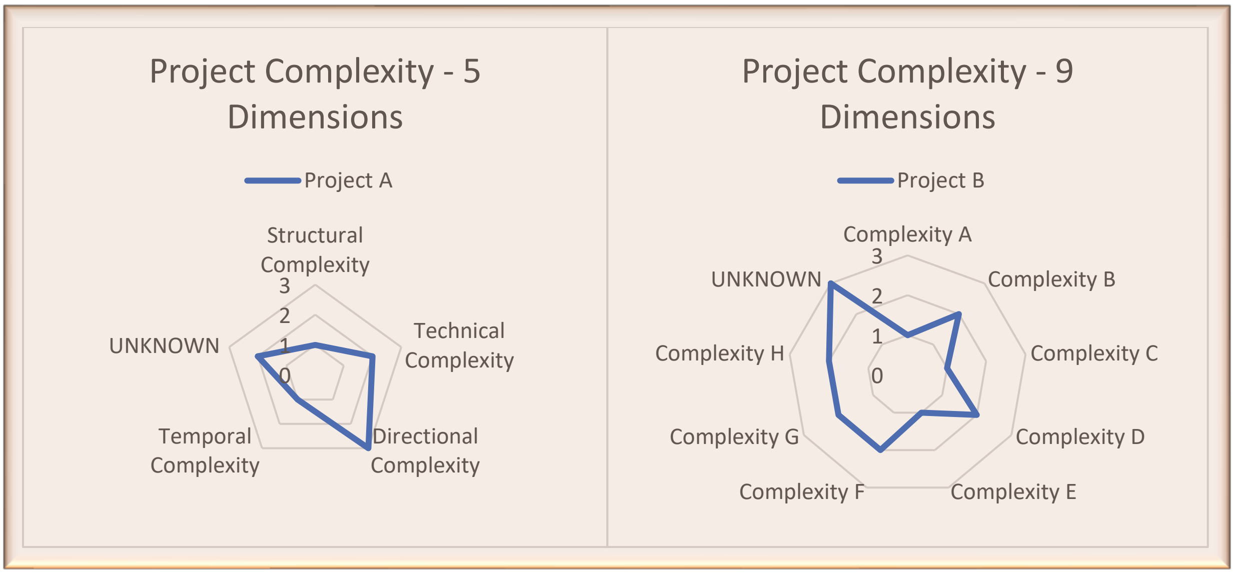

Figure 13 – Spider-Charts Displaying Different Results of Project Complexity in Two Projects

Optionally, the project team can use the Project Complexity Model by Hass to produce the complexity mapping.

Stage 3 – PMLC Model Selection

CMA recommends model selection based on a combination of the results of the Complexity Analysis in *Stage 2* and Wysocki's Project Landscape. The combination of these two elements will provide the team with the necessary foundation on which to build the project. The team has the option of choosing between Linear, Incremental, Iterative, Adaptive, or Extreme PMLC models presented in chapter 4. For complex projects the choice would obviously be between an Iterative, Adaptive, or Extreme PMLC model.

Stage 4 – PMLC Model Modification (Optional Stage)

This stage is optional as the team must decide if the selected model requires additional modifications before *Stage 5* is initiated or resumed. This might not be necessary, however depending on the project complexity, model modifications might be required. Such a decision revolves around the learning and experience gathered while conducting the project. If the project complexity changes in a PMLC model where the team is enjoying advancement, they have the option of keeping the same PMLC model and modifying it.

Another requisite to this stage is to decide on additional supply of individuals with critical expertise to the project. The dynamics of adding new personnel to the project after its initiation can be a double-edged sword. The expertise can prove to be favorable to the project, while the late addition can be destructive to the group dynamic. This is also constrained by the projects funds and resources.

Stage 5 – PMLC Model Execution

This stage is the heart of the CMA and where the chosen PMLC model is executed. Here the project is conducted, and the aim of the team should be to remain in this stage for the longest period possible. The stage implements the practice of using a review mechanism before each phase-transition.

The review mechanism works as a control system for information management and communication. The client must always be included to participate in the process. It is to be performed before each phase transition and be concluded by a GO/NO GO decision on whether to initiate the next phase or go back to Complexity Analysis.

CMA recommends the following Review Mechanism:

- Strive to gather all participants of the project team for a face-to-face sit-down. Geographical barriers will require video conference. (Face-to-face communication is most effective in clarifying ambiguity.)
- The format of the review can differ but should focus on being quick, to the point and result in a GO/NO GO decision.
- The GO/NO GO decision must include:
    - Discussion around the uncertainty related to the project.
    - Discussion around the ambiguity related to the project.
    - Discussion around the complexity related to the project.
- Conclude the review with a decision on whether to initiate the following phase or conduct a new Complexity Analysis.

Stage 6 – Project Closure

This is the formal stage of closing the project. Final payments, documentation and administration is completed. The deliverable is handed over to the contracted client for custody and control. Final project evaluation is performed to capture new knowledge and learning.

The proposal of using the CMA does not guarantee a recipe for success. It is a basic tool for projects that need adaptation. It implements a mechanism that intends to continuously review the necessity for change between each phase-transition of the PMLC model. The success of the CMA is dependent on the people that use it and how they communicate. Hence, the CMA, *the Human Factor* and *Information Management and Communication* are all complementary parts of the machinery that drives the CPM process.

Discussion

This section discusses strengths and weaknesses regarding CMA. It emphasizes important considerations regarding CPM. It also presents the conclusion and suggestion for further work.

7. Chapter 7 – Considerations Regarding Complex Project Management and CMA

This chapter presents considerations regarding CPM and discusses the strength and weaknesses of the CMA. It also presents similarities and differences between CMA and APF.

7.1. The contradiction of deconstructing complexity

In my initial research-stages I was under the idea that my mission was to find a method or a model of deconstructing complexity. This notion stuck with me for quite some time as I plunged into the details of project management tools and -techniques. Surely, there had to be an approach that could connect the dots and provide the solution to project complexity. My lack of knowledge in this field lead me down the path to what I would later find out was reductions theory. This is the foundation for many of the value-creation disciplines such as strategic planning, budgeting, business analysis, and likewise - project management. Reductions theory provided the base on which project management was built and the classical notion of how to conduct a project. You begin by identifying the problem - which gives you an overview of the requirements needed. You continue by decomposing the problem into logical pieces or sections that can be made into deliverables, work packages or activities. You assign these to task-units according to their expertise and experience. As the deliverables, work packages and activities are finished you begin integrating them to assemble the final solution.

For reductions theory to function it requires that complex systems must be completely understood in terms of their components. It is known that this is not the reality for complex systems. Therefore, this leads to an incompatible management style. When project management tools and -techniques that are built on a reductions foundation are used for complex projects we experience failure. This linear and control-based approach does not provide the necessary solutions to the challenges. While complicated challenges can be addressed with a reductionist foundation, complex systems require a different approach. Ergo, if you are looking for the deconstruction of complexity you are heading down the path of failure. The contradiction of deconstructing complexity is an absoluteness one must accept.

When heading into the unknown the long-established models and traditional techniques become inadequate to help understand what is going on. In complex projects slight variations amplify to unknowable and unpredictable results. The focus should not be on controlling the project and predicting the outcomes. Instead one should try to see patterns, remain aware of the whole and try to facilitate for the desired outcomes.

7.2. Heading into the unknown

The track-record presented in the beginning of the thesis shows that complex projects has had a devastating effect on companies. To summarize: American companies and agencies spend $80-$140 billion per year on failed software-intensive projects. For IT-projects across industries, only 35% are successful. Different studies found that in general 85% of projects failed to meet time and budget goals. The primary reasons that were given was the project teams inability to value up-front the extent of uncertainty and complexity involved. They failed to communicate this extent to each other and they failed to adapt their management style to the situation. This highlights how the primary reasons are mainly connected to human- and communication error.

The top three factors presented by The CHAOS Report for project failure are all related to the lack of well-timed and clear people-to-people communication. Furthermore, unrealistic objectives, -expectations and -time estimations were also presented in the report as being major factors of project failure. Unrealism being a direct consequence of human error. The importance of unrealism is also pointed out as a root-cause for failure by Flyvbjerg. His presentation of *Optimism Bias* and *Strategic Misinterpretation* explains why nine out of ten major projects has a cost-overrun in the range of 50-100%.

Having said that, one must be critical to selecting out factors and presenting them as main causes for complex projects failure. The various studies and reports cited in this thesis does not provide enough empiricism to conclusively determine the main causes of failure in complex projects. This challenge is related to the disagreement of what constitutes a complex project in the academic community. According to Witty and Maylor there is no widely accepted definition of complex projects that is research-based. They argue that there must be an establishment of standards in this area. In that regard they have criticize the *College of Complex Project Managers* and their competency standard. [26] They accuse them of having significant flaws in defining *complex*, hence invalidating the process by which the College and its standard have emerged, and the content of the standard. So far, it is too soon to determine through research-based empiricism the main causes of complex project failure.

However, the repetitiveness of some of the factors in various studies and in various projects as reoccurring problems lets us classify them into categories. When taking into consideration which crucial factors that should be safeguarded in CPM – they emerge in two categories which are *the Human Factor* and *Information Management and Communication*. The question that arises is how to apply them successfully into the CPM process to reach the desired goal?

7.3. Strengths and weaknesses concerning CMA

The CPM process should be driven by adaptation. By proposing the CMA, one aims for better integration of *the Human Factor* and *Information Management and Communication* at the vulnerable stages in the project.

One of the strengths of the CMA is the freedom it provides to the project team. Drummond and Hodgson warn against rigidly applying command and control-based approaches to detecting warning signals and responding to them. Such control-based approaches to (complex) project management can be counterproductive and limiting. [27] The multiple options of selecting and changing the PMLC model at various stages of the project provides the team with the opportunity of adapting to changing environment.

However, the same opportunity intended to enhance adaptation can cause confusion and chaos to the project. Allowing multiple changes at various stages of the project can cause the project team to lose control over the long-term objectives. One of the weaknesses of the CMA is that it doesn't provide clear guidelines or criteria for what constitutes a model change. Furthermore, it doesn't even specify what validates such a change. That responsibility is left to fall on the shoulder of the project manager and the team. They must decide whether the decision of model change can be justified.

Another strength of the CMA is overseeing the complexity by analysis throughout the entire project. It helps in the detection of emerging complexity sources thereby allowing the team to direct its focus towards the challenge. It is a useful tool for uncovering complexity sources, however the weakness lies in not presenting any solutions. This is mainly connected to each complexity source requiring an idiosyncratic approach. Presenting a universal solution would simply not work.

"The key to recognizing complexity is to analyze it. The key to managing complexity is to understand where the complexity originates and ensure that a strategy is put in place up front to manage each element of complexity identified by the analysis." **- Simon Henley, Fellow and Deputy Chair of the International Centre for Complex Project Management (ICCPM), former Director of Service Strategy for Rolls Royce** [28]

The intention of the Complexity Analysis stage in the CMA is to address what Henley is referring to. Therefore, after detection, a strategy must be made to address the newly discovered challenges.

A possible weakness of the Complexity Analysis is no commanding blueprint and what it should entail. The proposed steps recommended by the CMA model may not be effective to produce the correct complexity mapping for the project. The grading system (preferably from 0-3) can be subject to criticism. What is important is not the number behind the grade but the reasoning that makes up the number. Whether the team chooses to use the number *"3"* or the description *"highly complex"* is up to them. The criteria for what defines each grade should be described in a table and agreed upon. In the end a value of measurement must be used to describe the complexity source. Optionally, the stage offers the use of the Project Complexity Model by Hass to produce the complexity mapping. This makes it easier for the team given that the criteria are predefined. What they must be aware of is how well the criteria corresponds with the complexity they are facing.

An additional strength is the use of *unknown complexity* as a dimension in the analysis. This raises the cognitive awareness of the team in the search for hidden connections. (This is not the same as the phenomenon "Black Swans" describes by professor Taleb. His description relates more to risk and external influence. *Unknown complexity* relates to undiscovered interconnectedness between various project components.) It encourages the team to allocate time and resources to upcoming challenges. However, allocating more time and resources to challenges that does not appear would be inefficient. It would be a waste of time that could have been used on other areas in the project.

Not being bound to predefined complexity sources can be a weakness and a strength. By not abiding to Remington and Pollacks four sources of complexity the team is given more options to suit their needs. Accomplished teams will experience this as an asset, while unexperienced teams will view this as difficult task to solve.

Sadly, the Complexity Analysis of the CMA allows for an overall weakness to emerge. The team may unknowingly neglect other important aspects of the project due to continuous focus on complexity. By being in a state of mind preoccupied with constant attention directed towards complexity sources, other management aspects of the project may suffer. Therefore, timing is crucial and the decision of whether or not to conduct a Complexity Analysis becomes essential.

The optional stage of PMLC model modification is regarded a strength as it allows the team to tailor the chosen model to its project. This decision should be related to the learning and experience gathered throughout the project. Modifying a model, or only using a part of it when it is designed to work in its entirety, can backfire. The team should be encouraged to choose entire models only making minor modifications to adapt to their project.

This stage also provides the option of additional supply of individuals with critical expertise to the project. This can have devastating effects on the project. New individuals can damage the already existing group relations. It can cause tension between team members and hinder communication. Such a decision should obligate an evaluation based on the necessity and benefits of the expertise required. However, for some project challenges this might be necessary and is something which the team should consider.

Implementing a review mechanism between phase-transition in the execution stage of the CMA has its positives and negatives. One of its strengths is to provide information-control between the phase-transitions of the project. In general, much information is either lost, not transmitted or misunderstood during phase-transition. The review mechanism aims at safeguarding *Information Management and Communication* during this vulnerable transition. More importantly, convincing the project team to conduct a face-to-face sit-down will be an influential contributor to clarifying ambiguity. As the project increases in complexity the communication requirements should change. When ambiguity and uncertainty are low, the predominant form of communication is one-way driven and mainly written. This generates status reports, project plan updates, etc. and other written reports. These are distributed through the organizations information canals for the project team's consumption. Such communication works if the complexity is low. Because high complexity projects are frequently changing, there is low tolerance of written communication. As complexity increase, the team must give way to two-way communication, which generates other forums for verbal and face-to-face communication. The review mechanism aims at reducing uncertainty and clarifying ambiguity by allowing the entire team to meet face-to-face before initiating the upcoming phase.

However, conducting meetings before each phase-transition can take up much of the time dedicated to project work. Also, gathering the entire team at once can be tiresome and difficult to achieve. The meetings could potentially drag out and cause lengthy discussions without guaranteeing positive results. Another weakness of the review mechanism is the lack of commanding structure in its format. While it highlights what should be discussed it does not specify the criteria's for deciding to conduct a new complexity analysis. It rather proposes to keep the meeting quick, to the point and result in a GO/NO GO decision. This could potentially keep pushing the team out of the execution stage and into the analysis stage. The result would be spending much of the project analyzing and searching for complexity sources without doing any actual work. Again, the decision must be validated through the project team's reasoning.

On the other hand, not having a commanding structure could allow the review mechanism to be created to suit the project team's needs. The team can agree on the format and the criteria's they believe will safeguard the interests of the project. The review mechanism is a great opportunity to clear up misunderstandings and confusion. However, the team should be aware of not depending on this for information exchange. Doing so would provide less information exchange during the actual project work. It can harm the project because the team would be under the impression that misunderstandings will be resolved during the meeting.

The overall weakness of the CMA is that it could lead to unnecessary change when the project team is facing difficulties. The danger is falling into a loop of constant model change and unnecessary complexity analysis. This combination gives it the potential for being chaotic and disorganized. Much of the CMA's success is embodied by the decision making it requires at various stages. Therefore, it is reliant on a project team with highly notable qualifications, expertise and proficiency.

7.4. Similarities and differences between APF and CMA

The APF was first introduced in 2001 and is a relatively new model. It has enjoyed good results in the management of complex projects. The CMA has similarities to the APF in a number areas. Both models are designed especially for managing complex projects. Both are dynamic in their approach by using model selection and allowing the best-fit PMLC model to triumph. They are both client focused, and client driven to some degree. Both models are actively searching out solutions instead of passively awaiting the emergence of the final solution.

Despite having many similarities, they distinguish themselves by two fundamental differences. First, the CMA proposes complexity analysis and mapping as base for model selection. It also relies on this more heavily than the APF, thus highlighting the continued focus on the identification of complexity sources. Second, the CMA uses a review mechanism before each phase-transition of the selected PMLC model. Originally, the APF must run through the entire cycle of the selected PMLC model before considering a change. These two differences provide a higher rate of model selection and aimed focus on complexity sources. Having said that, neither the APF nor CMA guarantees you a recipe for success. The aim is to make the project team better equipped in confronting complex challenges and discovering ways to become better accustomed to change.

8. Chapter 8 - Conclusion

Complex project management is a central theme for many industries who are in pursuit of creating value. An accelerating development in innovation and technology are resulting in projects becoming more complex. These projects are more prone to suffer from time delays, cost-overruns and deliverable shortcomings than traditional projects. In the transition from TPM to CPM, industries are in search of new models and approaches to manage the complexity encountered in projects.

The purpose of the thesis was to study how complex projects should be managed and gain a better understanding of the challenges associated with them. To gain a better understanding my approach was to examine and consider the causes of complexity in projects. Thereafter I would be searching to find answers to why complex projects often fail. Taking that into consideration I would present a management approach based on my findings. Finally, I would evaluate the strengths and weaknesses in the approach and present my outcome.

The results discovered was somewhat expected and somewhat surprising. The challenges associated with CPM differ from TPM because of the unclear path of reaching the solution. The main challenge is connected to managing a process which has no clear solution and is troubled with complexity, uncertainty and ambiguity. Furthermore, the process is often subject to significant external influence and displays of irrational connection between cause and effect. The reasons for complexity can be classified into different variations of complexity sources. Different variations of sources derive as a result of the project being complicated, having interconnected and interdependent solution options, ambiguity related to multiple interpretations of goals and objectives, or uncertainty related to external influence. Another aspect of the challenge is connected to the academic community and the different understandings of what constitutes a complex project. Due to the disagreement on the definition of *complex* different management standards emerge. Therefore, more research-based studies are needed to conclusively determine the reasons for why complex projects fail. However, several studies indicate two components as critical in that regard; *the Human Factor and Information Management and Communication*. Complex projects failure can be linked to the negligence of these two categories and the dependence on control-based linear approaches derived from reductionist theory.

When dealing with complex projects one needs to use an approach that provides adaptation and stimulates complexity thinking. The *Continuous Model Adaptation* approach aims at achieving this while taking into consideration the results identified in this thesis. The CMA distances itself from the linear control-based approaches and encourages working at *the edge of chaos* while implementing control mechanisms at the vulnerable stages of the project. Such approach requires the proficiency and expertise of an experienced project team that is comfortable working in an environment with incomplete information. The main weakness of the CMA is its proneness of becoming chaotic due to the lack of clear guidelines. The main strength of the CMA is the freedom it provides to the project team in adapting to the changing environment. It does not in any way offer guaranties for successful CPM. This aspect is related to the management of the root-causes highlighted in *the Human Factor and Information Management and Communication*.

There is no unified and correct approach when it comes to managing complex projects. Providing the clear solution to CPM is an unrealistic objective. Managing complex projects should be an evolving process of learning and discovering new tools and techniques that can be used to better enhance project performance. The aspiration is to have made the CMA one of many such tools applicable in that regard.

8.1. Suggestions for further work

Suggestion for further work is to implement the use of the CMA on actual complex projects. It is only by executing the CMA on an actual project that defects and shortcomings of the approach can be identified. By analyzing the use of the CMA in various projects over time one can determine the actual strengths and weaknesses of the approach. The analysis or study to be conducted can decide on the validation, disapproval or the possible improvement of the CMA.

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APPENDIX

Section one – Applying the Project Complexity Model

The Project Complexity Model offers the framework for analyzing different dimensions of project complexity. This is a summarized version of how to apply the model. Each figure and table is places under the corresponding steps on the following pages.

Step one:

- ✓ Select the boxes that best describe our project, only choosing one box in each category.
- ✓ All conditions in the box must be fulfilled to select it.

Step two:

- ✓ Use the *Project Complexity Formula* to categorize the project into one of the following three categories: Highly Complex, Moderately Complex, or Independent.

Step three:

- ✓ Visualize the overall complexity by developing a "spider-chart". This allows for easier communication of the overall complexity to the involved members of the project.

Step four:

- ✓ Select an appropriate Project Cycle approach for the project.

These four steps are components which are meant to identify the correct type of complexity thinking required for the project.

Step one:

Complexity Dimensions	Project Complexity Profile		
	Independent	Moderately Complex	Highly Complex
Time/Cost	< 3 months < $250K	3–6 months $250K–$750K	> 6 months > $750K
Team Size	3–4 team members	5–10 team members	> 10 team members
Team Composition and Performance	• Strong project leadership • Team staffed internally, has worked together in the past, and has a track record of reliable estimates • Formal, proven PM, BA, and SE methodology with QA and QC processes defined and operational	• Competent project leadership • Team staffed with internal and external resources; internal staff has worked together in the past and has track record of reliable estimates • Contract for external resources is straightforward; contractor performance is known • Semi-formal methodology with QA/QC processes defined	• Project manager inexperienced in leading complex projects • Complex team structure of varying competencies (e.g., contractor, virtual, culturally diverse, outsourced) • Complex contracts; contractor performance unknown • Diverse methodologies
Urgency and Flexibility of Cost, Time, and Scope	• Minimized scope • Small milestones • Flexible schedule, budget, and scope	• Schedule, budget, and scope can undergo minor variations, but deadlines are firm • Achievable scope and milestones	• Over-ambitious schedule and scope • Deadline is aggressive, fixed, and cannot be changed • Budget, scope, and quality have no room for flexibility
Clarity of Problem, Opportunity, and Solution	• Clear business objectives • Easily understood problem, opportunity, or solution	• Defined business objectives • Problem or opportunity is partially defined • Solution is partially defined	• Unclear business objectives • Problem or opportunity is ambiguous and undefined • Solution is difficult to define
Requirements Volatility and Risk	• Strong customer/user support • Basic requirements are understood, straightforward, and stable	• Adequate customer/user support • Basic requirements are understood but are expected to change • Moderately complex functionality	• Inadequate customer/user support • Requirements are poorly understood, volatile, and largely undefined • Highly complex functionality

TABLE 4 – PROJECT COMPLEXITY MODEL (PART 1), HASS 2009, PAGE 44

Complexity Dimensions	Project Complexity Profile		
	Independent	**Moderately Complex**	**Highly Complex**
Strategic Importance, Political Implications, Multiple Stakeholders	• Strong executive support • No political implications • Straightforward communications	• Adequate executive support • Some direct impact on mission • Minor political implications • 2–3 stakeholder groups • Challenging communication and coordination effort	• Mixed/inadequate executive support • Impact on core mission • Major political implications • Visible at highest levels of the organization • Multiple stakeholder groups with conflicting expectations
Level of Organizational Change	• Impacts a single business unit, one familiar business process, and one IT system	• Impacts 2–3 somewhat familiar business units, processes, and IT systems	• Large-scale organizational change that impacts the enterprise • Spans functional groups or agencies • Shifts or transforms the organization • Impacts many business processes and IT systems
Level of Commercial Change	• Minor changes to existing commercial practices	• Enhancements to existing commercial practices	• Groundbreaking commercial practices
Risks, Dependencies, and External Constraints	• Considered low risk • Some external influences • No challenging integration issues • No new or unfamiliar regulatory requirements • No punitive exposure	• Considered moderate risk • Some project objectives are dependent on external factors • Challenging integration effort • Some new regulatory requirements • Acceptable exposure	• Considered high risk • Overall project success depends largely on external factors • Significant integration required • Highly regulated or novel sector • Significant exposure
Level of IT Complexity	• Solution is readily achievable using existing, well-understood technologies • IT complexity is low	• Solution is difficult to achieve or technology is proven but new to the organization • IT complexity and legacy integration are moderate	• Solution requires groundbreaking innovation • Solution is likely to use immature, unproven, or complex technologies provided by outside vendors • IT complexity and legacy integration are high

TABLE 5 – PROJECT COMPLEXITY MODEL (PART 2), HASS 2009, PAGE 45

Step two:

Highly Complex	Moderately Complex	Independent
Level of change = large-scale enterprise impacts *or* Both the problem and the solution are difficult to define or understand, and the solution is difficult to achieve. The solution is likely to use unproven technologies. *or* Four or more categories in the "highly complex" column	Two or more categories in the "moderately complex" column *or* One category in the "highly complex" column and three or more in the "moderately complex" column	No more than one category in the "moderately complex" column *and* No categories in the "highly complex" column

TABLE 6 – PROJECT COMPLEXITY FORMULA, HASS 2009, PAGE 46

Step three:

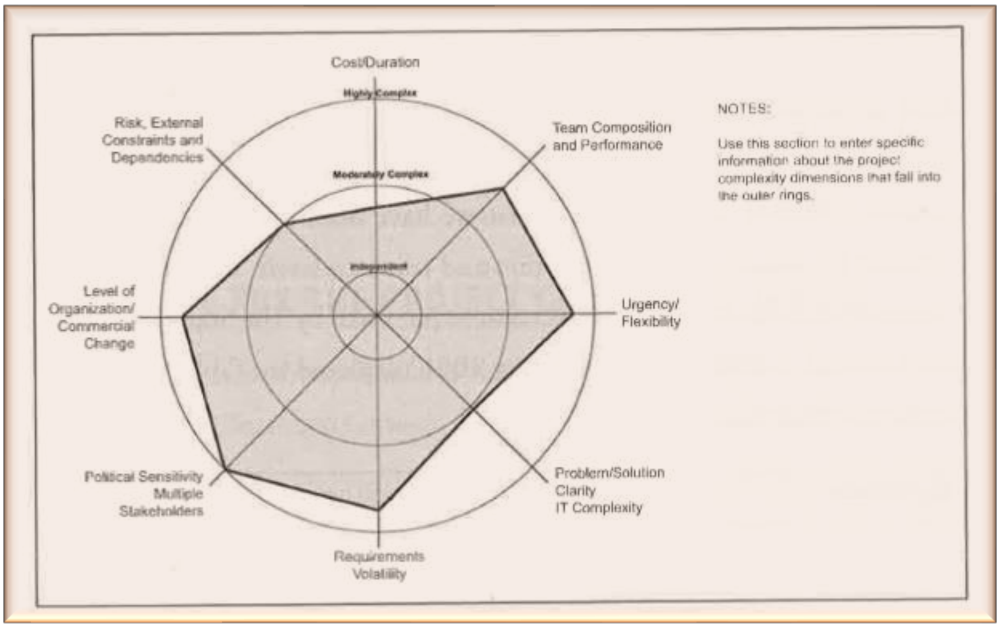

FIGURE 14 – SPIDER CHART DEPICTING OVERALL PROJECT COMPLEXITY, HASS 2009, PAGE 48

Step 4:

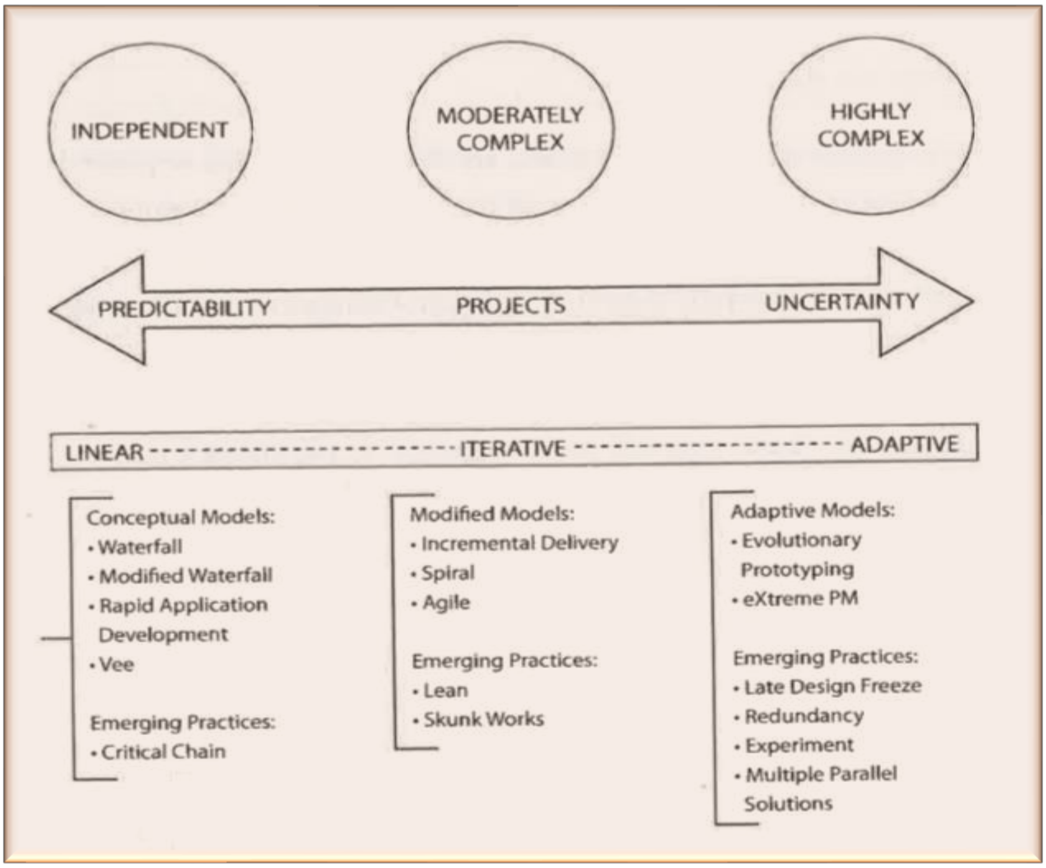

FIGURE 15 – PROJECT COMPLEXITY MAPPED TO PROJECT CYCLE APPROACHES, HASS 2009, PAGE 95