Tailoring PMI and OGC Frameworks for IT Project Portfolio Management

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STATEMENT OF INTEGRITY

I hereby declare having conducted my thesis with integrity. I confirm that I have not used plagiarism or any form of falsification of results in the process of the thesis elaboration. I further declare that I have fully acknowledged the Code of Ethical Conduct of the University of Minho.

University of Minho, 28 February 2019

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Signature: ____

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ABSTRACT

Private non-profit organizations that are dedicated to developing research and development (R&D) projects with the University, through a context of interface between Universities and companies, are currently recognized in Portugal as Technological Interface Centres.

These organizations develop applied research projects between TRL 4 and 8 for companies in close collaboration with the research units of the Universities.

As with any organization with no budget coming from the state, its main strategy is to efficiently and effectively manage the project portfolio to ensure control of execution costs as well as the expected quality of projects delivered to customers and partners.

The currently available project portfolio management frameworks are not sufficiently clear as to how processes or practices suggested to practitioners should effectively be applied. In the specific field of Information Technology (IT), there is at least one framework for supporting portfolios management, but the level of detail in the adoption of the practices is (insufficiently) generic.

This thesis intends to configure an IT project portfolios management framework, based on the coordinated (extended subsets) adaptation of the two main frameworks currently in the area: PMI and OGC.

This configuration required the alignment between PMI and OGC frameworks, through a map of dependencies between processes, as well as the mapping between artefacts and processes.

As a case study to test this framework, a Portuguese organization was chosen, formally recognized as a Technological Interface Centre, where two portfolios of IT projects in R&D contexts were characterized and analysed in light of the framework's techniques.

keywords: portfolio, R&D project, OGC, PMI, frameworks, Information Technology.

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RESUMO

As organizações privadas sem fins lucrativos que se dedicam a desenvolver projetos de investigação e desenvolvimento junto das Universidades, através de um contexto de interface entre Universidades e empresas, são atualmente reconhecidas em Portugal, como Centros de Interface Tecnológicos.

Estas organizações desenvolvem projetos de investigação aplicada entre TRL 4 e 8 para as empresas, em colaboração estreita com as Unidades de Investigação das Universidades.

Como em qualquer organização, sem orçamento proveniente do Estado, a sua estratégia principal é gerir com eficiência e eficácia o portfólio de projetos, de modo a garantir o controlo dos custos de execução, bem como a expetativa de qualidade dos projetos entregues aos clientes e parceiros.

As *frameworks* de gestão de portfólio de projetos atualmente disponíveis não são suficientemente claras em relação à forma como processos ou práticas sugeridas aos profissionais devem efetivamente ser aplicados. No domínio específico das Tecnologias da Informação (TI) existe, pelo menos, uma framework de suporte à gestão de portfólios, mas o nível de detalhe na adoção das práticas é (insuficientemente) genérico.

Com esta tese pretende-se configurar uma *framework* de gestão de portfólios de projetos de TI, a partir da adaptação coordenada (*extended subsets*) das duas principais *frameworks* atualmente existentes na área: a do PMI e a do OGC.

A referida configuração exigiu o alinhamento entre frameworks do PMI e OGC através dum mapa de dependências entre processos, bem como o mapeamento entre artefactos e processos.

Como estudo de caso para experimentar a referida *framework*, foi selecionada uma organização portuguesa, formalmente reconhecida como Centro de Interface Tecnológico, onde dois portfólios de projetos de TI em contextos de I&D foram caracterizados e analisados à luz das técnicas da referida *framework*.

Palavras-chave: portfolios, projetos de I&D, OGC, PMI, *frameworks*, Tecnologias de Informação.

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ACRONYMS / ABBREVIATIONS

AP - Authorize Portfolio

APM - Association for Project Management

BPMN - Business Process Modelling Notation

CIT - Technological Interface Centre

CMM - Capability Maturity Model

CMMI - Capability Maturity Model Integration

CMMI- ACQ - CMMI for Acquisition

CMMI-DEV- CMMI for Development

CMMI-SVC - CMMI for Services

DP - Define Portfolio

DPC - Develop Portfolio Charter

DPCMP - Develop Portfolio Communication Management Plan

DPMP - Develop Portfolio Management Plan

DPPMP - Develop Portfolio Performance Management Plan

DPR - Define Portfolio Roadmap

DPRMP - Develop Portfolio Risk Management Plan

DPSP - Develop Portfolio Strategic Plan

DSRP - Design Science Research Process

ESA - European Space Agency

I/O - Input and Output

IBM - International Business Machines

IN - Input

IPMA - International Project Management Association

IRR - Internal Rate of Return

IT - Information Technology

IT PfM - Project Portfolio Management of Information Technologies

IT PfM framework - framework for IT project portfolio management

KA - Knowledge Area

MoP - Management of Portfolios

ACRONYMS / ABBREVIATIONS

MPI - Manage Portfolio Information

MPR - Manage Portfolio Risks

MPV - Manage Portfolio Value

MSC - Manage Strategic Change

MSD - Manage Supply and Demand

NASA - National Aeronautics and Space Administration

NPV - Net Present Value

OGC - Office of Government Commerce

OGC PfM framework - Management of Portfolios from Axelos

OMG - Object Management Group

OP - Optimize Portfolio

OUT - Output

PCM - Portfolio Communication Management

PDFB - Balance

PDFC - Categorize

PDFP - Plan

PDFP - Prioritize

PDFU - Understand

PDLBM - Benefits Management

PDLFM - Financial Management

PDLMC - Management Control

PDLOG - Organizational Governance

PDLREM - Resource Management

PDLRM - Risk Management

PDLSE - Stakeholder Engagement

PDP - Portfolio Delivery Plan

PfM - Project Portfolio Management

PG- Process Group

PGM - Portfolio Governance Management

ACRONYMS / ABBREVIATIONS

PIS - Process Improvement Stage

PMAJ - Project Management association of Japan

PMBOK - Project Management Body of Knowledge

PMC- Portfolio Management Cycle

PMCP - portfolio management cycles practices

PMI - Project Management Institute

PMI PfM framework - The Standard of Portfolio Management from Project Management Institute

PMKA - Portfolio Management Knowledge Areas

PMPG - Portfolio Management Process Groups

PP - Portfolio Processes

PPM - Portfolio Performance Management

PPO - Provide Portfolio Oversight

PRM - Portfolio Risk Management

PSM - Portfolio Strategic Management

R&D - Research and Development

RUP - Rational Unified Process

SEI - Software Engineering Institute

SPEM - Software & Systems Process Engineering Meta-Model Specification

SPEM - Software Process Engineering Metamodel

SQuaRE- Systems and software Quality Requirements and Evaluation

TRL - Technology Readiness Levels

UK - United Kingdom

UML - Unified Modelling Language

WBS - Work Breakdown Structure

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CHAPTER 1

INTRODUCTION

Summary: This first chapter initiates with the context and motivation that led to exploring the research theme of this thesis. After, the research design is structured in in three parts; starting by the formulated research question and associated objectives, then the description of the followed research method (based on design science research) and lastly the activities planned for the time period prescribed. This chapter closes with an outline of the structure of this document and a synthesis of its contents.

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CHAPTER 1: INTRODUCTION

"Effective management of single projects is no longer sufficient. In today's business market, proactive management of the whole project portfolio has become increasingly important for achieving long-term success and competitive advantage. At the front end of projects, opportunities are discovered, ideas are created, and the foundation for later project, portfolio, and, eventually, corporate success is laid".

Heising (2012, p.582)

1.1 Thesis Scope

Given the fact that projects represent a significant investment for organizations, our attention must be focused on the value of such projects for those organizations. Projects are no longer managed in isolation, but as core business activities increasingly subject to a high level of precision and responsibility (Rajegopal, McGuin, & Waller, 2007b).

In this context, projects must be managed and aligned with organizational strategy in order to maximize resources, ensure quality and support decisions regarding the priority of development. The agility to make project decisions in line with the organization's strategy, thus avoiding wasted investments, is a discipline of the portfolio management of projects (Laslo, 2010).

An organization's investment project portfolio represents its current strategy in that it represents its structure, processes and products (Kopmann, Kock, Killen, & Gemünden, 2017). However, due to globalization, organizations tend to consider innovation and product development projects as crucial to the longevity of their organizations (Kester, Griffin, Hultink, & Lauche, 2011; McNally, Durmuşoğlu, & Calantone, 2013).

In today's organizations, the application of method to project selection and management is prominent, thus increasing knowledge in project portfolio management (Kaiser, Arbi, & Ahlemann, 2015).

As Information Technology (IT) organizations have developed, senior management have tended to ignore the perspective of the portfolio, focusing only on the individual management of projects (Rautiainen, Schantz, & Vahaniitty, 2011) .

However, IT projects have peculiarities that distinguish them from other projects (Russell, 2003): (1) difficulties in surveying the client's requirements for the project; (2) high probability of change to the project requirements throughout its execution; (3) complexity in determining project costs due to the impossibility of accurately determining the resources required; (4) in traditional IT project lifecycle models such as the spiral model, it is often difficult to determine the exact execution time; and, (5) high risk of delays in the implementation of IT projects, exceeding the planned allocation, surplus costs and failure to obtain results.

These peculiarities, plus the development of IT projects in a context of 'Technological Interface Centre' organizations suggests the need for a specific approach to project portfolio management (PfM).

This thesis presents the tailored of a framework for IT project portfolio management (IT PfM framework), with the application of principles, concepts, processes and portfolio practices, by conducting a case study in a Technological Interface Centre (CIT).

This IT PfM framework is based on two recognized standards for project portfolio management: "The Standard for Portfolio Management" from the Project Management Institute (PMI), version 2013 (PMI, 2013c) and "Management of Portfolios (MoP)" from Axelos, the Office of Government Commerce (OGC) until 2013, version 2011 (Axelos, 2011).

In this thesis, the term "PMI PfM framework" represents "The Standard of Portfolio Management" from PMI (PMI, 2013c), while the term "OGC PfM framework" represents "Management of Portfolios" from Axelos (Axelos, 2011).

This research adopts the "Design Science Research" as its Research Design, and the" Case Study" method in order to formulate answers for the research question, by means of the IT PfM framework's experimentation. The terminology used for the characterization of the projects and experimentation in the case study has the typical professional characteristics of projects funded in Portugal.

In this thesis, the author refers to herself as “the researcher” in several instances in order to clarify the position of who is analysing methodological issues in alter concern research design.

The CIT is positioned as the interface (to promote the necessary synergies between the academic and business worlds) between units of knowledge (higher education) and the market (companies). For the purposes of the study, the research work takes place in a CIT focused on IT projects.

1.2 Research Motivation

The main motivation for the development of the theme of this thesis stems from 15 years of professional experience in the management of Research and Development (R&D) projects, and from my experience of approximately 10 years in managing R&D project portfolios in the same CIT organization.

Confirmation of my principal motivation is based on the following observations, which can be drawn from the study carried out in the review (chapters 2 and chapter 3):

(1) various organizations enter into projects which have been proposed and approved and yet have not achieved the promised benefits. Common examples of these cases include the lack of an appropriate project, particularly one, which is not synchronized with the organization's goals, which carries excessive risks or may have been approved due to political pressure from sponsors. These projects waste scarce resources which could be better directed towards projects that can bring more concrete benefits to organizations (Yelin, 2007);

(2) it is important to recognize the value of the adoption of methods, techniques and tools which contribute to the implementation of an organization’s strategies and to promote the necessary changes and give support to achieve strategic objectives, such as project portfolio management (Cobbold, Lawrie, House, & Street, 2001; Moore, 2009);

(3) projects must be managed and aligned with corporate strategy in order to maximize resources, ensure quality and, above all, to support decisions regarding the priority of development;

(4) in today's world, on a weekly basis, organizations must justify the existence of our/their projects, with senior management taking responsibility for adjusting portfolios, authorizing new projects, accelerating, stopping, increasing, reducing, and even eliminating projects based on new priorities imposed by strategy and the business environment (Gartner, 2013);

(5) "*…one negative side of poor portfolio management is that strategic criteria are missing in project selection*" (Cooper, Edgett, & Kleinschmidt, 2001 p.5). This translates into a lack of strategic direction in the projects selected; projects not strategically aligned with business strategy; numerous strategically unimportant projects in the portfolio; and R&D spending that does not reflect the strategic priorities of the business. The end result is a scattergun approach to R&D and new product effort that does not support the company's strategy" (Cooper et al., 2001);

(6) poor portfolio management means deficient "go/kill" and project selection decisions. Therefore, high return projects, because they have to compete for scarce resources, often take too long and may fail to achieve their full potential (Cooper et al., 2001);

(7) often, poor portfolio management means that projects are selected with a lack of focus. If there is no formal selection method, decisions are not based on facts and objective criteria, but rather on the decisions of an executive without objective criteria (Cooper et al., 2001).

1.3 Research Question and Objectives

The process of PfM for IT must necessarily be focused on continuous and consistent fulfilment of identification, selection, prioritization, control and monitoring of higher return projects and their contribution to the organization's strategic objectives (Calderini & Moura, 2004) and involve the following issues:

(1) defining objectives, namely defining what the portfolio expects to achieve; (2) understanding, accepting and negotiating conflicts between projects; (3) monitoring and controlling portfolio performance; and, (4) monitoring and controlling portfolio performance.

The project selection for a portfolio involves the simultaneous comparison of a number of projects in a specific dimension; that is, prioritizing by comparing characteristics to obtain the desired sequence of projects (Archer & Ghasemzadeh, 1999).

For the prioritization of projects, various models, methods and approaches may be applied. Knowledge of criteria identifying, eliminating, minimizing and diversifying risks; and, or characteristics helps to typify the projects.

A schematic of researcher's research would start by defining the research question, which guided the state of the art for this work, in the form of a literature review. Associated with the main research question (RQ), the researcher sets three related research objectives (RO) which are analysed throughout this document, in each dedicated contributing chapter, respectively.

At this point, the following research question can be posed:

RQ: How to manage IT project portfolios in CIT Organizations?

In the IT PfM framework, a set of decisions (strategy, methods, resources, etc.) should be considered. With knowledge of the characteristics of PfM, it should be possible to develop a framework to manage portfolios of IT projects in CIT organizations.

The scientific community has addressed the issue of studying different methods of identification, selection, prioritization, control, and monitoring of project portfolios (Archer & Ghasemzadeh, 1996; Koh & Crawford, 2012; Levine, 2005; Menke, 2013; Mikkola, 2001; Rad & Levin, 2006), but no focus has been placed, on the particular, issues of PfM for IT projects in the context of CIT organizations (Reyck et al., 2005). How to manage project portfolios in CIT organizations seems limited in the discussion (Menke, 2013; Mikkola, 2001).

Therefore, in this thesis, the researcher has developed a tailored IT PfM framework using the PMI PfM framework and OGC PfM framework as a base. The PMI PfM framework is considered to be the most complete framework currently available for PfM (McDonald & Sarbazhosseini, 2013; Young & Conboy, 2013), while the OGC PfM framework is particularly relevant for IT PfM (Williams, Young, Young, & Zapata, 2014).

As input to answering the research question mentioned above, achievement of the following objectives is proposed:

RO.1. Identify and analyze processes and artefacts of the PMI PfM framework and OGC PfM framework

For necessary knowledge of processes and artefacts, the researcher analyse the dependencies between processes, process groups and areas of knowledge of the PMI PfM framework. In order to analyse how to execute the processes from a particular PMI PfM framework it is necessary to know the artefacts and, specifically, the dependencies between processes and artefacts (input and output artefacts by processes).

Practices and artefacts in OGC PfM frameworks are also identified as the dependency analysis between practices and artefacts.

RO.2. Tailor PMI PfM framework and OGC PfM framework for the IT domain

Given that, the processes defined by the PMI PfM framework are the most complete, and that, the OGC PfM framework has a wider variety of artefacts, and is born out of IT projects, mapping between PMI artefacts and OGC artefacts is developed using Software & Systems Process Engineering Meta-Model Specification (SPEM).

Given that mapping occurs between artefacts and processes in the tailored IT PfM framework, processes from PMI PfM framework and artefacts from OGC PfM framework are used. The research results are validated using a real-world case study.

RO.3. Experiment the tailored IT PfM framework in a real-world CIT Organization

After tailoring, the IT PfM framework is experimented in the context of a CIT organization, within a particular department, in order to adapt it to the context of the organisation's IT projects, with TRLs between 4 and 8 and project types designated as 'applied research'.

1.4 Research Design

Design Science Research

Research in Design Science can be described as a form of research involving the design of some human activity or the creation of an artefact. These artefacts can be designed for any purpose, e.g. to address certain human needs, either existing or planned (Carvalho, 2012).

March and Smith (1995) and Winter (2008), in the context of the scientific field of Information Systems using science design, hold that this research work is limited to the construction and evaluation of artefacts (constructs, models, methods or instantiations).

In this context, technologies are used to obtain and process information supporting human purposes (Carvalho, 2012; March & Smith, 1995).

For the development of this thesis, the process of research classified as design science research is used, where important unsolved problems are addressed in unique and innovative ways; in other words solving problems more effectively and efficiently in PfM for IT projects.

The development of the DSRP (Design Science Research Process) model included six steps: problem identification and motivation, objectives of a solution, design and development, demonstration, evaluation and communication (Peffers *et al*., 2006).

In the problem identification stage, the research-specific problem is defined, taking into account an initial exploratory phase of finding the theme based on the identified problem. By identifying the problem, artefacts that contribute to scientific knowledge can be developed as can subsequent solutions for organizations.

The next step, after the survey of the state of the art is defined, is to define the objectives of the work being studied, i.e. the thesis.

In the following step, that of design and development, the researcher designs and constructs artefact(s), which, in the case of this thesis, is the IT PfM framework.

The demonstration step addresses the issue of using and experimenting the IT PfM framework to solve one or more instantiations of the problem, one portfolio with two subportfolios in the CIT organization.

In the evaluation step, the researcher checks and experiments to see if the artefact developed, the IT PfM framework, supports the solution to the problem.

Finally, in the communication step, the author must communicate and disseminate the problem, its relevance, the artefacts, their usefulness and the results obtained to other researchers and professionals, as shown in Figure 1.

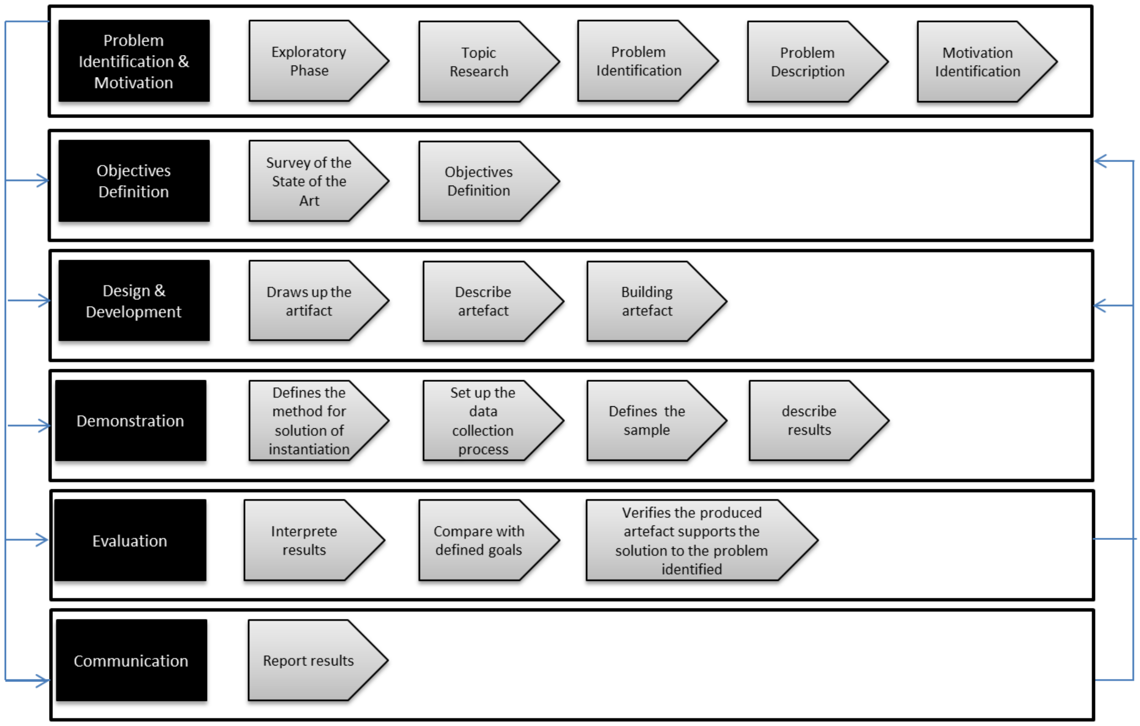

Figure 1. Design Science Research Activities «adapted by Peffers et al. (2006)»

The nature of the research can be characterized as applied research, being necessarily objective in order to generate knowledge for practical application and directed to specific problem solving (Silva & Menezes, 2001), as previously presented.

The research approach that the researcher has adopted is qualitative, i.e., in the PfM: where identifying, selecting, prioritizing, controlling and monitoring are the current activities, resulting from the use of a quantitative approach.

For the evaluation of other features, and due to its subjective nature, the qualitative approach may be the most appropriate in understanding the phenomena under scrutiny and their relationship with the environment.

In this context, the research concerned is intended to take place where it can manage projects, programs and portfolios, i.e., where there is field research, which is the phenomenon to be studied and therefore consists of observing the facts as they occur spontaneously. In this study, the locale under observation is a CIT organization, which has as its mission the development of R&D projects for organizations and industry.

Research Method: Case Study

Case study can be understood as the "exploitation of a limited system or a case (or multiple cases), which involves in-depth data collection and multiple sources of information in one context." The idea of a limited system is related to the definition of time and space, and an event, an activity or individuals who can understand the ‘case’ (Creswell, 1998).

The case study identifies opportunities, challenges and problems that professionals in the field face daily, which are relevant to the IT field (Dubé & Paré, 2003).

IT research using the case study is feasible because: (1) the researcher can study information technologies in a natural environment, thus learning about the state of the art and generating theories of practice; (2) the method allows the researcher to answer "how?" and "why?" questions, that is, it allows an understanding of the nature and complexity of the processes that occur; and, (3) it is an appropriate means to research an area where few previous studies have been conducted (Benbasat, Goldstein, & Mead, 1987).

In an approach to validate the IT PfM framework, the researcher uses the steps for case studies, where the researcher selects the portfolios that she would like to experiment the IT PfM framework on (Kitchenham, Pickard, & Pfleeger, 1995), in a given CIT organization, within a particular department. The experimentation of the IT PfM framework in more departments would oblige the organization to cease operations in these departments, which, of course, is not possible because of the organization's business commitments.

Evidence-based software engineering suggests four stages (Kitchenham, Budgen, & Brereton, 2011): (1) constructing the research question; (2) tracking down evidence to answer the question; (3) critically appraising the evidence, and; (4) using the evidence to address the question.

For the purposes of this thesis a qualitative case study is used, given the highly personal nature of the research, that is, in the form of a participant-observer study (Kitchenham et al., 2011).

Thus, the researcher is encouraged to include her own personal perspectives in the interpretation. How the case and the investigator interact is assumed to be unique and not necessarily reproducible for other cases and researchers (Stake, 2010).

1.5 Structure of this Document

This document is structured in seven chapters. All chapters are preceded by a chapter cover that presents a table of contents to aid clear understanding and access to the main headings of the chapter. Following the chapter cover, a small summary of the chapter is presented, aiming to briefly summarize the main chapter content. After the summary, the chapter starts with an introductory section and ends with a concluding section, between whose sections come the sections relevant to the chapter’s theme.

The seven chapters of this document and their main content are:

Chapter 1: Introduction. This chapter introduces the research PfM frameworks, the motivation, question and objectives, research design and document structure. The research frameworks are the “Standard for Portfolio Management” from PMI, PMI PfM Standard, and the “Management of Portfolios” from Axelos, OGC PfM Standard (OGC until 2013).

Chapter 2: IT Technological Interface Centres. This chapter introduces Technological Interface Centres, the nature of organization where the IT PfM framework is to be experimented. In turn, the types of R&D projects that are executed in the CIT organizations are characterized by means of classification in TRLs for IT projects. The characterization of the portfolio of IT projects necessitates knowledge of the concepts of Life Cycles and Maturity in the IT domain.

Chapter 3: Project Portfolio Management. In this chapter, a review of the literature and a consolidation of concepts such as project, program and portfolio, and portfolio management are presented, and in this latter case, due to its being the central theme of the thesis, the review of literature. Finally, and after the conclusions have been drawn from several models, deep knowledge of the PMI PfM framework and OGC PfM framework is justified.

Chapter 4: Alignment studies with PMI and OGC Portfolio Frameworks. In this chapter, the framework development work begins with the creation of the dependencies model of the processes from the PMI PfM framework, as well as, the mapping between the processes and artefacts required and generated by the PMI PfM framework themselves. Subsequently, the same work is carried out at the level of mapping between practices and the artefacts required and generated by the OGC PfM framework.

Chapter 5: Tailoring the IT PfM Framework. In this chapter, the development of tailoring the IT PfM framework based on the PMI PfM framework and the OGC PfM framework is described using processes from the PMI PfM framework and artefacts from the OGC PfM framework, by means of mapping between artefacts from the PMI PfM framework and artefacts from the OGC PfM framework. In turn, a traceability map of the most commonly used artefacts from the OGC PfM framework is carried out using the areas of knowledge from the PMI PfM framework.

Chapter 6: The Case Study Analysis. In this chapter, a characterization of the CIT organization and its project portfolio are analysed. For the R&D project portfolio, a set of criteria are used for the definition of sub-portfolios: 'Portfolio-A' and 'Portfolio-B'. The chapter ends with considerations of both sub-portfolios.

Chapter 7: Conclusion. This chapter presents conclusions drawn from the work carried out. It presents a guideline for future work and research with a view to expanding and solidifying knowledge on the implementation of PfM in IT.

CHAPTER 2

IT -TECHNOLOGICAL INTERFACE CENTRES

Summary: In this chapter, IT Technological Interface Centres and, R&D projects are characterized. According to Technology readiness levels (TRLs), the R&D projects are classified. The criteria used for portfolio creation and management are aligned with the Life Cycles and Maturity in the IT domain.

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CHAPTER 2: IT TECHNOLOGICAL INTERFACE CENTRES

"*Research and Development has been recognized as most important for future competitiveness to survive in this competitive and highly turbulent environment.*"

Banwet & Deshmukh (2006, p. 879)

2.1 Introduction

Recently, the information technologies has gone beyond the implementation of IT applications to an era of IT enabled change. The trend toward increasing IT utilization continues, and the challenge remains how to better manage IT projects to maximize their economic (Reyck et al., 2005), business (Bennington & Baccarini, 2004) and communication (Coombs, 2015) benefits. The IT projects are challenging: they require a high level of skill (Altahtooh & Emsley, 2015), and they may be a high risk (Collins & Schragle-Law, 2010). This maximization involves a structured investment in R&D activities as an important strategy to support the development of the IT industry.

Dynamism and diversity characterize the IT sector. In this sector, new technologies are generated every day. Thus, sustaining the competitiveness of organizations in this sector seems to be related to the development of innovative technological competencies. These innovative skills, in turn, should be related not only to the products and solutions that are generated for the market, but also to the internal practices of these organizations (Marins, 2005). Therefore, developing projects efficiently and responding correctly to the right projects is a challenge for PfM.

The positive correlation between R&D investment and business performance measures, such as growth and profitability, has been consistently demonstrated in many studies (Alessandri & Pattit, 2014; Department of Trade and Industry, 2005; Forrester Research, 2005; Franko, 1989; Ito & Pucik, 1993). Realizing the vast economic and technological benefits derived from R&D activities, Portugal has positioned R&D as one of the main drivers of the national development agenda (FCT, 2017).

Organizations focused on R&D are often of public nature, such as: universities and other higher education organizations, public research centres, and public non-profit organizations. However, private non-profit organizations, such as the collective research centres performing industry specific R&D, have also a considerable impact (Teirlinck & Spithoven, 2005).

These private non-profit organizations, with a focus on R&D in Portugal, are organizations that promote the transfer of technology to society, and, since May 2017, these are currently recognized as Technological Interface Centres (CIT) (Diário da República, 2016).

R&D activities in a project are an important source of knowledge and technological innovation. The knowledge generated by R&D activities is used to improve production processes and to develop value added products and services (Asmawi & Mohan, 2011).

The Innovation Agency (ANI) in Portugal adopted Technology Readiness Levels (TRL) to characterize R&D projects (Caldeira, 2006). According to ANI, the R&D projects between the TRLs 0 to 2 are the basic research projects, between the TRLs 2 to 8 are the applied research and demonstration projects, and between the TRLs 8 to 9 are the projects of commercialization, i.e., projects with TRLs 8 to 9 are out of an R&D project (ANI, 2017).

2.2 CIT Organizations in the IT Domain

In contrast with other European countries, the CIT organizations in Portugal do not benefit from financial support from the State. In fact, CIT in Portugal have been financed by services provided to companies and by competitive funding projects, which is reflected in the planning of their activities, since these have been oriented to respond to specific requests from external entities (clients and partners), not aligned with any medium and long-term strategic vision for the CIT organization (Migueis, 2017).

CIT organizations operate based on services with high technical-scientific knowledge, for example, projects based on design, project management and engineering. Through innovative activities in IT, the CIT's mission is also to support various economic activities (Barras, 1986), as well as contributing to the diffusion of innovative technological activities (Dosi, 1988; Steinmueller, 2001).

A public R&D institute is an institute owned and financed by the government and controlled by the polyarchy[1]. The CIT organizations are private R&D institutes owned and financed by a private company and controlled by the market (Perry & Rainey, 1988).

The market characteristics are a factor more important at the private R&D organizations than at the public ones, but the diffusion factor is more important at the public organizations, than at the private ones. The “technological characteristics” factor and the technological success factor are important (or not important) at both types of organizations to the same degree (Lee & Om, 1996).

In Portugal, since 2017, private R&D organizations are known as the Technological Interface Centres (CITs). CITs are private organizations that connect ('interface') higher education institutions and enterprises, which are dedicated to the valorisation of products and services and the transfer of technology (Inovação, 2017).

CITs are non-corporate entities of the national scientific system that promote technological transfer and innovation in companies, namely through certification processes, quality improvement, production efficiency, support for innovation activities, access to developing technologies, and training of human resources (ANI, 2017). In order to ensure the sustainability of their business, CITs must develop the right R&D projects for the efficient performance of these organizations.

CITs are interface organizations between higher education institutions and companies, aiming at the valorization and transfer of technology. This type of entities, both in Portugal and in other European countries, have an important role

[1] The board has temporary mandates regulated.

in several aspects of business innovation, namely: (1) in the development, integration, adaptation and preparation of scientific and technological knowledge for the various business segments (large, medium, small and micro, more advanced or mature); (2) raising awareness and mobilizing actors for R&D and innovation activities, both upstream and downstream (especially SMEs in more mature sectors); (3) dissemination and demonstration of innovations and their impact; and, (4) in supporting the development and qualification of enterprises, in particular through the testing and evaluation of new technologies, in the training of human resources and certification processes, which are essential for the integration of international value chains (Migueis, 2017).

In Europe, there are a number of institutions characterized as CIT, namely in the United Kingdom (UK), Netherlands, France or Germany. The Catapult centres (Catapult, 2017) are a network of world-leading centres designed to transform the UK's capability for innovation in specific areas and help drive future economic growth. They are a series of physical centres where the very best of the UK's businesses, scientists and engineers work side by side on late-stage R&D – transforming high potential ideas into new products and services to generate economic growth (Catapult, 2017). In Netherlands, TNO – innovation for life is an example, its *"…mission is to connect people and knowledge to create innovations that boost the competitive strength of the industry and the well-being of society in a sustainable way*" (TNO, 2017).

An organization of the CIT type in Portugal is characterized by: (1) to be legally constituted and have legal and fiscal autonomy; (2) to operate in an economic area where there is a market failure by traditional agents (companies); (3) to have a staff with technical and scientific expertise who is responsible for the main share of the entity's activity; (4) should set out a clear and inclusive research and innovation strategy for the needs and requirements of enterprises and socio-economic partners, as well as to be a "beacon" of potential technological advances; (5) to operate in a network, with the aim of proposing an integrated multidisciplinary offer; (6) to develop strong and durable relations with the entities of the scientific system in order to ensure the renewal of scientific and technological competences and to contribute to advanced training; and, (7) developing a culture of international openness (with particular relevance to the

European plan), with the aim of broadening and consolidating its knowledge base, partners, customers and thus their sustainability (Diário da República, 2016).

CIT organizations work in specific areas of knowledge, namely Information Technology. Private non-profit CIT organizations in the IT Domain are an important segment both for the national innovation system and for the country's economy, since they operate in a large competitive niche that is the development of software and solutions, working between organizations (their creators and others) of the productive sector and the research system (high educator), occupying an important space, until then little inhabited, when undertaking projects in collaboration (but also in competition) with universities and other research institutions (Ritz, 2008).

2.3 TRL Methods in the IT Domain

R&D projects, which are classified into basic research, applied research and product development, are being carried out by industries, academia and R&D organizations (Nagesh & Thomas, 2015). In this thesis, projects classified are considered as ‘applied research’ in CIT organizations.

Another way to categorize projects is in internal or external projects. In CIT organizations, the projects are developed to produce customized products and services to meet the specific needs of their client and partner organizations. These projects are classified as external projects (Hobbs & Besner, 2016).

Under another focus, partnerships can be seen as a mechanism to facilitate technological innovation by merging knowledge, bringing together organizations with different traditions, expectations, disciplinary roots and cultures to create a new innovation community (Lynn, Reddy, & Aram, 1996).

In many cases, tomorrow's priority R&D projects tend to emerge based on today's priorities, current projects, and what is learned through operational experience. That is, from today's work, important insights can be gained for the definition of the future projects portfolio. This is clearly due to the cumulative effect of knowledge and skills promoted by the experienced learning of the successive generation of technologies.

Therefore, it is advantageous for companies to maintain close and constant linkages between production and the R&D unit that serves them, not only to access valuable technologies to be generated by the R&D unit, but also to prevent risk of spillovers to rival companies, associated with the development of R&D by third parties (Nelson, 2006; Teece, 1988), especially in the area of IT, where projects have a long history of failing (Standish Group, 1999).

In the 1980s, the National Aeronautics and Space Administration (NASA) instituted seven Technology Readiness Levels (TRL) to assess the risk associated with development technology (see Table 1). In the 1990s, this metric evolved into the nine levels that exist today and had become widely used throughout NASA as a systematic metric/measurement system to assess the maturity of a specific technology and enable a consistent comparison of maturity between different types of technologies (Eisman & Gonzales, 1997; John, 1995).

Table 1. Technology Readiness Level (TRL) definitions (NASA, 1990)

TRL	Definition
1	Basic principles observed and reported
2	Technology concept and/or application formulated
3	Analytical and experimental critical function and/or characteristic proof-of-concept
4	Component and/or breadboard validation in laboratory environment
5	Component and/or breadboard validation in relevant environment
6	System/subsystem model or prototype demonstration in a relevant environment
7	System prototype demonstration in a space environment
8	Actual system completed and “flight qualified” through test and demonstration
9	Actual system “flight proven” through successful mission operations

In the United States Department of Defence, there was a considerable interest in using TRLs as part of risk assessments for entire systems, including both hardware and software. According to the current United States Department of Defence orientation, TRLs are an approach to meet the requirement for technology readiness assessments prior to the entry of the Developing and Demonstration System (United States Department of Defence, 2011).

After the formulation of the TRLs by NASA (NASA, 1990), the version of Department of Defence appeared in 2011 (United States Department of Defence, 2011), the version of European Space Agency (ESA) in 2015 (ESA, 2015), the version of the European Commission in 2014 (Commission, 2014), the version of Oil & Gas Industry 2014 (Centre for Oil and Gas, 2014), among others.

In this thesis, the researcher adopt the European Commission version (Commission, 2014), also is adopted by Innovation Agency in Portugal:

- TRL 1 – basic principles observed;
- TRL 2 – technology concept formulated;
- TRL 3 – experimental proof of concept;
- TRL 4 – technology validated in a lab;
- TRL 5 – technology validated in a relevant environment (industrially relevant environment in the case of key enabling technologies);
- TRL 6 – technology demonstrated in a relevant environment (industrially relevant environment in the case of key enabling technologies);
- TRL 7 – system prototype demonstration in an operational environment;
- TRL 8 – system complete and qualified;
- TRL 9 – actual system proven in an operational environment (competitive manufacturing in the case of key enabling technologies or in space).

ANI considers that applied R&D projects should be located between TRLs 4 to 8 (Migueis, 2017), that is, between TRL 4, technology validated in lab to TRL 8, system complete and qualified.

2.4 Life Cycles and Maturity in the IT Domain

The IT industry is characterized by rapid innovations and great competitiveness among companies. IT organizations must develop high-quality software products on time and low cost to survive.

To guarantee the process of developing quality software there are currently standards, approaches and procedures that are used by software companies, such as: ISO/IEC 25000 (ISO, 2014), ISO/IEC 12207 (ISO, 2017), Capability Maturity Model Integration (CMMI) or Rational Unified Process (RUP).

ISO/IEC 25000 series of standards

ISO 25000: 2014 series of standards, Software Product Quality Requirements and Evaluation (SQuaRE) was created to organize, enrich and merge the series covering two main processes: specification of software quality requirements and evaluation of software quality, supported by the process measuring the quality of the software.

ISO 25000 provides a guide for the use of the international reference series called Systems and software Quality Requirements and Evaluation (SQuaRE). The standard establishes criteria for the specification of quality requirements for software products, indicators and their evaluation, and includes a quality model for linking customer quality definitions with attributes in the development process (ISO, 2014).

ISO/IEC 12207

ISO/IEC 12207: 2017 provides processes that can be used to define, control, and improve software life cycle processes within an organization or project. The main purpose of the standard is to establish a common framework for the life cycle and software development processes, in order to help organizations understand all the components involved in the acquisition, development and supply of software (ISO, 2017).

CMMI - Capability Maturity Model Integration

CMMI consists of the best practices and models directed to the development and maintenance of software products and services, covering the whole life cycle of the software product, from its conception to its delivery and maintenance (SEI, 2010).

Teams from industry, government, and Software Engineering Institute SEI, at Carnegie Mellon University, support these models. The CMMI is an evolution of the CMM (Capability Maturity Model) and seeks to establish a unique model for the process of corporate improvement, integrating different models and disciplines.

The Capability Maturity Model Integration (CMMI) was formed to solve the problem of organizations using multiple CMMs. With the mission of combining three maturity models (Capability Maturity Model for Software, Electronic Industries Alliance Interim Standard, and Integrated Product Development Capability Maturity Model) into a single improvement framework, the CMMI accommodates multiple disciplines and is flexible enough to support staged and continuous representations. The purpose of this model is to provide guidance for improving an organization's processes and the ability to manage the development, acquisition, and maintenance of products and services. Moreover, it helps to set process-improvement objectives and priorities, and guides the organization to ensure stable, capable, and mature processes (SEI, 2002).To apply to the CMMI, an organization should take three steps (SEI, 2010). Firstly, it should select a part of the organization to be involved in the process improvement program. This selection should not only consider the size of the group but also the homogeneity of organizational processes, products to be developed and work practices. . Secondly, the organization should select the most appropriate model. The latest version of the CMMI (CMMI Product Team, 2010), published in 2010, presents three models:

- CMMI *for Development* (CMMI-DEV): focuses on activities for developing products and services.

- CMMI *for Services* (CMMI-SVC): focuses on activities providing quality services to the customers and end users.
- CMMI *for Acquisition* (CMMI-ACQ): focuses on activities for initiating and managing the acquisition of products and services.

To select the appropriate model, it should be taken into account the primary focus of the organization and its projects, the processes necessary to satisfy the business objectives and the life cycle processes on which the organization concentrates. Thirdly and lastly, the organization should select the representation that fits its concepts of process improvement. The continuous representation is concerned with selecting a particular process area to improve and the desired capability level for that process area. There are four capability levels: incomplete, performed, managed and defined. The staged representation uses maturity levels to characterize the overall state of the organization's processes relative to the model. It is, therefore, concerned with selecting multiple process areas to improve within a maturity level. There are five maturity levels: initial, managed, defined, quantitatively managed and optimizing (SEI, 2010).

Both of these representations have the same content but are organized in different ways. Thus, it only is described the staged representation:

(1) Level 1 - *Initial:* An organization at this level does not have a stable environment to support processes; therefore they are *ad hoc* and chaotic. The success of a project does not depend only on a better use of the processes, but rather on the skills of the people in the organization. The products and services produced usually exceed the budget and schedule planned.

(2) Level 2 - *Managed*: At this level of maturity, products and services are in line with the standards and procedures developed by the organization. The organization has skilled people and key stakeholders involved in the projects; processes are monitored, controlled, and reviewed; and are compared to the process description. Moreover, the status of the work products is visible to management through the use of, for example, milestones. The process discipline helps to ensure that, in times of stress, the existing practices are maintained.

(3) Level 3 - *Defined*: The key aspect of this level is the organization's set of standard processes. These standard processes are described in great detail

in standards and procedures, and bring consistency to the organization. Although projects use the organization's standard processes, they are modified to suit the specific project or organizational unit. Furthermore, the standard processes are managed, taking into consideration the interrelationships of the process activities and detailed measures of the process, its work products, and its services.

(4) Level 4 - *Quantitatively Managed:* This level is characterized by the predictability of process performance, and the establishment of quantitative objectives for quality and process performance. To define the quality and process performance objectives, it is taken into consideration the needs of customers, end users, organization, and process implementers. The performance of projects and sub-processes is statistically controlled, predictions are based on statistical analysis, and the quantitative objectives are used as criteria for managing the organization's projects.

(5) *Level 5 - Optimizing:* Based on the quantitative understanding of the business objectives and performance needs, the organization is continuously improving its processes through an incremental and innovative process, and technological improvements. The organization's quality and process performance objectives are continually updated as business objectives change and are not only used as criteria in the management projects but also in managing improvements on processes. By collecting and analyzing data afterwards from multiple projects, organizations identify shortfalls or gaps in performance that generate measurable improvement in performance and that are used to drive organizational process improvement. Moreover, the organization uses a quantitative approach to understand the variation inherent in the process and the causes of process outcomes.

RUP - Rational Unified Process

The Rational Unified Process (RUP) is a process that wants to solve the problem of software engineering: ensuring the production of high-quality software within the planned time and cost and that meets end user requirements. The RUP captures the "best practices" of software development, i.e., practices that have been identified as responsible for the success of projects in the software industry (Krutchen, 2004).

In RUP, the software project life cycle is divided into four phases: “Conception”, “Elaboration”, “Construction” and “Transition” (see Figure 2). At the end of the four phases, a version of the product is produced, which can be evolved, by passing again through the four phases (IBM, 2003).

The "Conception" phase is the first phase of the cycle and its main objectives are to define the scope of the project, identify the critical use cases for the system and propose an architecture that meets them.

The "Elaboration" phase aims to stabilize the system architecture, so, at this phase; all risks related to the system architecture are identified, choosing the most critical use cases or scenarios. In addition, it must be ensured that the requirements are stable enough to guarantee a reliable estimate of the cost and that the project completion deadline can be achieved. At the end of this phase, an evolutionary prototype of the system and detailed plans for the “Construction” phase iterations are also produced.

In the "Construction" phase, the emphasis is on completing the product started in the “Elaboration” phase. At this phase, the remaining scenarios of all use cases should be completed, producing test versions of the software for users.

The final phase, "Transition", aims to make the final version of the system available in the end user environment.

Each phase is divided into iterations, which are small developments, where only a part of the system's functionality is developed, going through all the disciplines of the process.

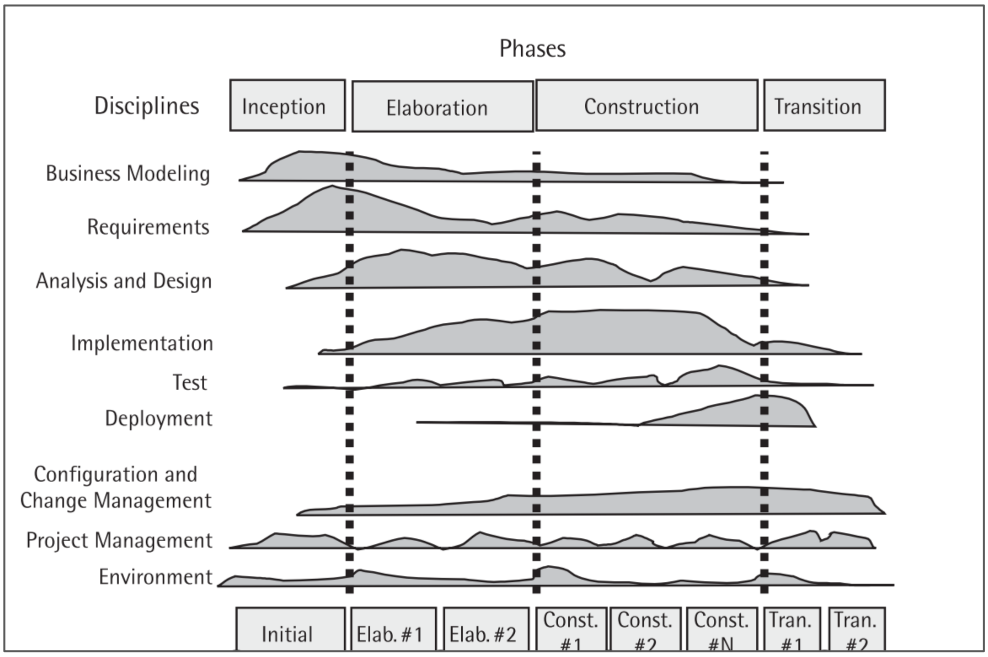

Figure 2. The relationship between RUP phases and disciplines (IBM, 2003)

Figure 2 shows the RUP disciplines: Business Modelling, Requirements, Analysis and Design, Implementation, Test, Deployment, Configuration and Change Management, Project Management and Environment.

2.5 Conclusions

Globalization and the elimination of "frontiers" have intensified the organizations' competitiveness. This change has forced the opening of companies as regards the development of skills to remain in the market. In order to ensure lower costs, the relationship between companies and the national scientific system has become more relevant so that these same organizations can help companies to develop more innovative processes and products.

CIT organizations in the IT domain develop R&D projects for clients and partners companies with several objectives: (1) to create innovative products; (2) to evolve existing products into innovative technologies in order to respond to more demanding end users; and, finally, (3) to dematerialize organizational processes, responding with technological complexity.

These R&D projects must be developed to respond to the specific needs of their clients and partners, with the required quality and with controlled costs. Ensuring the right projects are executed according to the CIT organization's strategy, as well as managing several projects at the same time, imply, therefore, that resource allocation is a relevant theme of project portfolio management in CIT organizations.

In this thesis is proposed an IT PfM framework considering projects classified as 'applied research' and located between TRLs 4 to 8.

The software maturity models, such as CMMI, were a reference in the creation of the reference models: P3M3, OLMM and PPM analysed in this thesis. The phases of RUP are used as criteria in PfM.

CHAPTER 3

PROJECT PORTFOLIO MANAGEMENT

Summary: As a base state of the art in the form of a literature review from where to build on, this chapter covers three perspectives directly related to the thematic of the project portfolio management. Initially, it browses through project, program and portfolio concepts, as the fundamental, transversal topic that connects all perspectives. Following, it surveys from the PMI PfM framework and OGC PfM framework, as base frameworks in IT project portfolio management.

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CHAPTER 3: PROJECT PORTFOLIO MANAGEMENT

"The trend towards increasing use of IT continues and the challenge remains on how to better manage IT projects in order to maximise their economic benefit."

Reyck (2005, p. 524)

3.1 Introduction

From the 1990s, a new proposal for project management was presented to replace the traditional model (Garfein, 2005). The introduction of this new proposal in organizations was perceived in two phases. The first phase was seen as the "wave" of expansion, which occurred between 1995 and 2005, where the focus was largely motivated due to the interest driven by the Project Management Body of Knowledge Model (PMBOK). This phase was characterized by a focus on individual projects, which sought efficiency, and a vast expansion in the number of certified professionals in project management. The second phase started in 2005, searching for more project management efficiency, which can be reached through an appropriate PfM, the implementation of a proper structure, and construction of skills in the maturity of project management at the organizational level (Garfein, 2005). The PfM gives organizational conditions to sustain their competitive advantage, consisting of an obvious opportunity. This stage was most evidently concerned with projects in a broader context, in which the relationship between these was shown as important (Rabechini, Maximiano, & Martins, 2005).

The project management perspective is focused on one single project. Differently, the program management perspective is focused on the management of a set of related projects through the sharing of a common objective or client, or also projects that have interdependencies or shared resources.

The PfM perspective aims to develop more strategic projects for the organization. While project management and program management are traditionally focused on doing "the projects correctly", the PfM is concerned with doing "the right project" (PMI, 2013c).

To manage multiple projects successfully, organizations need to maintain control over a varied range of specialist projects, balance often conflicting requirements with limited resources, and coordinate the project portfolio to ensure that optimum organizational outcome is achieved (Dooley, Lupton, & O'Sullivan, 2005). In the optimal portfolio perspective, organizations are focused on finding projects that are aligned with its strategic objectives, since projects add higher value to the business and/or stakeholders.

Uncertain and changing information, dynamic opportunities, multiple goals and strategic considerations, interdependence among projects, and multiple decision-makers and locations characterize the portfolio decision process.

The portfolio decision process encompasses or overlaps a number of decision-making processes within the business, including periodic reviews of the total portfolio of all projects (looking at all projects holistically and against each other), making go/kill decisions on individual projects on an on-going basis, and developing a new product strategy for the business, complete with strategic resource allocation decisions (Cooper, Edgett, & Kleinschmidt, 2000).

A key point in PfM is the balancing of portfolios, i.e., investments in the projects should maintain the balance between risk and return, growth and maintenance in the short and long-term (Schelini & Martens, 2012). The volume of investments in each risk category would give on grounds of maturity of the organization, since lower risk projects usually have a lower return level, but are more attractive because they have more guaranteed results, while higher risk projects have a higher level return and are fundamental to the growth of the portfolio (Gawenda, 2008).

Often, poor PfM means that projects are selected loosely. If there is no formal selection method, decisions are not based on facts and objective criteria but rather on decisions of an executive without objective criteria (Cooper et al., 2001).

The top management of organizations commonly support the application of formal PfM methods (Jugend, Silva, Salgado, & Cauchick, 2016; Kahn, Barczak, & Moss, 2006; Teller, Unger, Kock, & Gemünden, 2012), as well as, adoption of frameworks for project evaluation and decision criteria (Martinsuo & Poskela, 2011).

3.2 Project, Program and Portfolio Concepts

Project vs. Program

Traditionally, project management has been concerned with the management of an 'individual project' (Andersen & Jessen, 2003). Gaddis (1959) defines a project as:

> "…*an organisation unit dedicated to the attainment of a goal – generally the successful completion of a development product on time, within budget, and in conformance with predetermined performance specifications"* (Gaddis, 1959, p.89).

The International Project Management Association (IPMA), in 2006, defined a project as a time and cost-constrained operation to realize a set of defined deliverables (the scope to fulfil the project's objectives) up to specified quality standards and requirements (IPMA, 2006).

The PMI, in 2013, stated a project could be defined in terms of its distinctive features, such as projects that require temporary works to create unique products or services (PMI, 2013a).

In 2009, OGC defined a project as a temporary organization that is created for the purpose of delivering one or more business products according to an agreed Business Case (Commerce, 2009) .

In the 6th edition, the Association for Project Management (APM) defined a project as unique, transient endeavours undertaken to achieve a desired outcome (APM, 2012).

Thus, project's definition can highlight two intrinsic concepts: a reference to temporality, i.e., every project has a beginning and an end well established; another, is the singularity (Junior, 2008).

In summary, a project has three basic attributes: uniqueness of a project's mission; a temporary nature with the starting and closing times set; and uncertainty affecting a project, such as environmental changes and risks. On top of that a value creating nature, as in Figure 3.

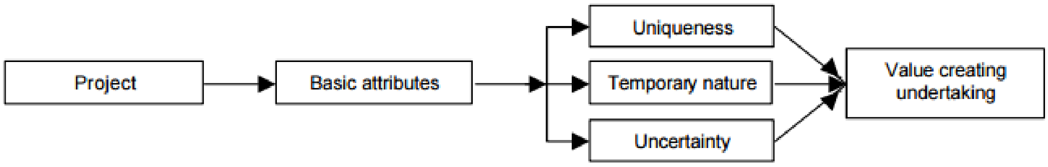

Figure 3. Definition of a project (Ohara, 2002, p.19)

A program can be defined as:

> *"…a framework for grouping existing projects or defining new projects, and for focusing all the activities required to achieve a set of major benefits"* (Pellegrinelli, 1997, p.142).

A portfolio of projects is a group of projects and/or operational activities, which share common resources. The program has common outputs and the portfolio has common inputs.

Kilford (2008) defined a program as a temporary, flexible organization, created to coordinate, direct and oversee the implementation of a set of related projects and activities in order to deliver outcomes and benefits regarding the organization's strategic objectives. The program is more fluid and is directed at a goal or set of objectives, rather than specific deliverables. It is focused on outcomes rather than outputs. It is about business and management as well as technical management.

In 2002, Pellegrinelli said the program had become a preferred vehicle for making the rapid, complex, enterprise-wide changes required for sustained organizational performance and vitality. In such a role, programs are constantly subject to influences and developments, emanating from within the organization, from the external environment and from the organization's response to that changing environment.

The Project Management association of Japan (PMAJ), in 2002, defined a program as an undertaking in which a group of projects for achieving a holistic mission is organically combined. Multiple projects are, in the strict sense, treated separately from programs since their respective projects have weak relations with each other or are independent.

The IPMA, in 2006, defined a program as a set of related projects and required organizational changes to reach a strategic goal and to achieve the defined business benefits. A program is set up to achieve a strategic goal.

The program has been defined by the APM as a group of related projects that together achieve a beneficial change of a strategic nature for an organization (APM, 2012).

In 2013, Axelos defined a program as a temporary flexible organization structure created to coordinate, direct and oversee the implementation of a set of related projects and activities in order to deliver outcomes and benefits concerning the organization's strategic objectives (Axelos, 2013b).

Being a combination of multiple projects, programs present complexity arising from the interfaces between projects as well as blending and overlapping of project life cycles. In addition to the fundamental attributes of single projects, such as basic attributes of programs, periods until completion tend to be longer and uncertainty is likely to be higher because they may confront environmental changes (Ohara, 2002), as Figure 4 shows.

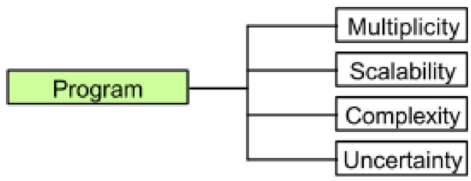

Figure 4. Basic attributes of Program (Ohara, 2002, p.34)

Project Management vs. Program Management

In 2002, the PMAJ defined project management as total framework of practical professional capability to deliver a project product meeting a given mission, by organizing a dedicated project team aware of due diligence, effectively combining the most appropriate technical and managerial methods and techniques and devising the most efficient and effective work breakdown and implementation routes.

Project management is the application of knowledge, skills, tools, and techniques of project activities to meet the project requirements (PMI, 2013a).

In 2012, in the 6th edition, the APM defined project management as the process by which projects are defined, planned, monitored, controlled and delivered such that the agreed benefits are realized (APM, 2012).

Traditionally, the practical and theoretical developments about project management were connected with the individual projects and the organization considered the projects in an isolated way (Evaristo & Fenema, 1999). Over time, however, questions have arisen concerning the projects developed at the same time inside organizations, such as:

- risk that the lack of coordination and overall control will negatively impact efficiency and effectiveness (Merwe, 1997);
- confusion over responsibility for managing multiple demands on staff (Senior & Fleming, 2006).

As a consequence, there has been an increasing awareness of the requirement for a new perspective on the management of projects, distinct from that applied in a single project context (Lycett, Rassau, Danson, & Danson, 2004).

In this context emerges the concept of program management, but in the literature there are several different definitions for program management.

Pellegrinelli (1997) defines program management with a more operational role in the organization, i.e., it focuses on coordinating activities, for instance, scheduling and deploying resources in accordance with skill levels, the needs and priorities of individual projects. The program organization has, appropriately, a relatively low level of influence on the definition and internal management of individual projects.

In 2002, Pellegrinelli improved the definition of project program management as a strategic function of the organization instead of the operational function.

Lycett et al. (2004) defined program management as the integration and management of a group of related projects with the intent of achieving benefits that would not be realized if they were managed independently.

In 2007, Rajegopal, McGuin and Waller defined program management more globally and focused on achieving the strategic objectives of the organization as operational initiatives enabling the realization of business value, and of groupings of activities and projects allowing the implementation of the strategy and seeking its program outcome. In 2005, Project Management Association of Japan defined project program management as:

> *"… a framework of capability for an organization to flexibly adapt to changes in external environment, by devising ways to cope with such changes, for achieving a holistic mission. This capability involves integration activities to enhance holistic value and to achieve the mission by optimizing relationships between project"* (PMAJ, 2005, p.31).

In 2013, PMI defined program management as:

> *"… is the application of knowledge, skills, tools, and techniques to a program to meet the program requirements and to obtain benefits and control not available by managing projects individually"* (PMI, 2013c, p. 6).

The program management is a managerial approach to the realization of complex organizational or societal outcomes or strategies comprising the definition, coordination and supervision of projects and their alignment with embedding within on-going activities, and the engagement, communication and preparation necessary for the organization to absorb and utilize the deliverables from projects and so achieve the desired benefits and outcomes.

Depending on the organization's size, complexity, and sophistication, it may initiate or manage multiple projects interacting simultaneously. Groups of projects sometimes constitute the program, which is a group of related projects managed in a coordinated way to obtain benefits and control not available from managing them individually. Programs may include elements of related work outside of the scope of the discrete projects in the program (PMI, 2013b, 2013c).

In 2012, APM defined program management as:

> *"…is the coordinated management of projects and change management activities to achieve beneficial change".* (APM, 2012, p.14)

All the definitions referred above, PMI and APM, demonstrate similarities and differences. The main common points are that a program usually covers a group of projects; that its management must be coordinated; and that it rates a synergy, which will generate more significant benefits than projects could do individually.

A detailed critical analysis of program management is then, presented and a number of issues highlighted that concern: (1) an excessive control focus; (2) insufficient flexibility in the context of evolving business strategy; and, (3) ineffective co-operation between projects within the program. The cause of these issues is traced back to the two underlying and flawed assumptions, namely that: (1) program management is in effect a scaled-up version of project management; and, (2) a one size fits all approach is appropriate (Lycett et al., 2004).

Pellegrinelli (1997) advocates the use of the program approach as a way of managing the interdependence between projects and the requirement to learn and respond to changing circumstances associated with strategy implementation. The program provides some of the flexibility required by project initiatives based, or where projects form the units of work for organizations.

Lycett (2004) considers in the management the existence of three key stakeholder relationships associated with the program:

(1) the management of the relationship between the program manager and the project managers within the program;

(2) the management of the relationship between the constituent projects of the program and the wider business context;

(3) the management of the relationship between the individual project managers within the program.

An alternate view(s) that programs may have an indefinite time horizon is more realistic if constrained by the belief that they should only continue so long as they are justified regarding business benefit.

McElroy (1996), Pellegrinelli (1997) and G.Britain (2011) emphasize in particular the importance of three features of programs:

(1) to create benefits through a better organization of the projects and their activities; in themselves, they do not deliver in the projects' objectives;

(2) to evolve in response to the business' needs in an uncertain competitive, political and technological environment, in a way straddling the vague and changing, and the fixed and tangible;

(3) to take a wider view to ensure that the overall business benefits from projects' activities, not just the project client.

The advantages cited by organizations using (a) program(s) include (McElroy, 1996; Britain & Commerce, 2011; Pellegrinelli, 2011):

(1) greater visibility of projects to senior management and more comprehensive reporting of progress, while project reporting systems focus on performance against the plan or specific objectives, program reporting can better address strategic performance by tracking progress relative to competitors;

(2) better prioritization of projects; each project's role within the organization’s overall development is specifically identified and managed, and resources can be more easily re-allocated to critical projects even after funds have been assigned to individual projects;

(3) more efficient and appropriate use of resources; dedicated or ring fenced resources, which tend to be more productive, can become cost-effective within a program context;

(4) projects driven by business needs; project and line managers' personal agendas, such as the desire to apply the latest technology, utilize existing staff or fulfil personal research interests which can be kept in check;

(5) better planning and coordination; incidence of work backlogs and duplication of core functionality and components can be reduced; explicit recognition and understanding of dependencies; re-engineering due to inadequate interface management with existing systems and other projects can be minimized.

Portfolio

The origin of the concept of portfolio appeared in the seminal article Portfolio Selection, with Markowitz (1952) being considered the birth of the Modern Portfolio Theory. Markowitz (1952) was the first who considered the wish of the diversifying investments (Rubinstein, 2002).

Archer and Ghasemzadeh (1999) define a project portfolio as a group of projects are carried out under the sponsorship and/or management of a particular organization. These projects must compete for scarce resources (people, finances, time, etc.) available from the sponsor, since there are usually not enough resources to carry out every proposed project which meets the organization’s minimum requirements on certain criteria such as potential profitability, etc. (Archer & Ghasemzadeh, 1999).

A Portfolio is an organization of projects, by date and value, which an organization takes responsibility, or is planning to take responsibility, so, it:

> *“…is a Big Visible Chart.”* (Rothman, 2009, p. 23)

In the publication, the portfolio is defined as a collection of projects, programs, and even other jobs (regular operational activities of the organization), with the objective of achieving the strategic objectives of the organization.

In 2006, IPMA defined a portfolio as a set of projects and /or programs, which are not necessarily related, brought together for the sake of control, coordination and optimization of the portfolio in its totality.

In 2013, PMI defined a portfolio saying it:

> *"…is a collection of projects and/or programs and other work that are grouped together to facilitate the effective management of that work to meet strategic business objectives"* (PMI, 2013b, p.38).

In 2012, in the 6th edition, the APM defined a portfolio as a group of projects and programs carried out under the sponsorship of an organization. The portfolios can be managed at an organizational, programmatic or functional level (APM, 2012).

Axelos (2013a) with P3M3 defined portfolios as the totality of an organization's investment in the changes required to achieve its strategic objectives.

In 2015, in the first edition from ISO 21504, the ISO defined portfolio as collection de portfolios, programs or projects grouped together to facilitate portfolio management, and respond to the strategic objectives of an organization (ISO, 2015).

Project management promises a system which can deliver the goals of the project (Peter W G Morris, 1997), through the planning and control of variables including resources, cost, productivity, schedule, risk and quality (Hodgson, 2002). Practitioners and academics have been showing an increasing interest in the use of project management for strategic purposes (Shenhar, 2001). This new approach to project management requires the conciliation with the program and portfolio perspectives.

Portfolio Management

In the initial study field of portfolio management, in the financial sector, the main idea was to promote the balance of higher risk and lower risk investments, so that the resources would be invested in lower risk projects, and another part would be invested in higher risk projects.

Considering *Modern Portfolio Management* was initially developed for investments in 1981, McFarlan developed the foundation for the modern field of portfolio management from IT (Information Technology) projects.

McFarlan (1981) says management must also make use of a risk-based approach, for the portfolio selection and management of IT projects. The author observed unbalanced portfolios could take the organization undergoing disruptions, or leave "gaps" for competitors.

Cooper, Edgett and Kleinschmidt (1997) define Portfolio management as a dynamic decision process, whereby a business's list of active new product projects is constantly updated and revised. Rajegopal et al. (2007a) completes the definition as the process for identifying and selecting the right projects and programs, given the organization's ability to accomplish these projects established against the financial and human resources available. It can also be defined as how to optimize the overall investment portfolio, programs and approved projects related to business strategy.

In 2001, Cooper, Edgett e Kleinschmidt defined portfolio management as:

> *"…a dynamic decision process, whereby a business's list of active new product (and R&D) projects is constantly up-dated and revised. In this process, new projects are evaluated, selected and prioritized; existing projects may be accelerated, killed or de-prioritized; and resources are allocated and re-allocated to the active projects. The portfolio decision process is characterized by uncertain and changing information, dynamic opportunities, multiple goals and strategic considerations, interdependence among projects, and multiple decision-makers and locations"* (Cooper et al., 2001, p.4).

PMI (2013c) defines portfolio management as the centralized management of one or more portfolios, which includes identifying, prioritizing, authorizing, managing, and controlling projects, programs, and other related work, to achieve specific strategic business objectives.

Axelos (2013a) with P3M3 defined portfolio management linked strategies, i.e., portfolio management is a coordinated collection of strategic processes and decisions that together enable the most effective balance of organizational change and business-as-usual.

In 2012, in the 6th edition, the APM defined portfolio management as selection and management of all of an organization's projects, programs and related business-as-usual activities taking into account resource constraints (APM, 2012).

At the operational level, Martinsuo and Lehtonen (2007) defined portfolio management a group of projects that share and compete for the same resources and are carried out under the sponsorship or management of an organization. The portfolio (or multi-project) management requires the sharing of resources, components or platforms across a multitude of projects during project implementation. Furthermore, Rautiainen, Schantz and Vahaniitty (2011), submit forward that the portfolio management is the:

> *"…process for achieving balanced resource allocation in terms of value maximization, strategic alignment, risk level, and the number of ongoing projects is called new product development portfolio management".*(Rautiainen et al., 2011, p.1)

In summary, the portfolio management is a set of closely related processes with the limited capacity of the available resources in the organization, and the consequent need, with frequent updates, to promote prioritization of projects according to business strategy in order to generate the most value. This value is ensured through the realization of projects on-time and balanced in accordance with pre-established criteria such as the level of risk the organization is willing to assume (Filho, 2012). The portfolio management enables organizations to become more adaptable outside individual projects (Stettina & Hörz, 2015).

Calderini e Moura (2004) define the following pre-conditions in the adoption of a process of portfolio management:

(1) Organizational strategy: the strategic objectives should be defined and appropriately disseminated within the departments, in order to enable the alignment of the portfolio with the organization' strategy;

(2) Business leader's involvement: the involvement of top executives who should be able to take a less siloed view of the portfolio;

(3) Team skills: a project team with relevant finance and strategy skills. However, most IT professionals have sufficient knowledge to calculate the net present value (NPV) or return on investment (ROI) of a project.

Moore (2009) says the portfolio management aims to help organizations achieve superior performance, making the actual strategy through organizational transformation. The portfolio management should be supported by the implementation of projects that implement the strategy of an organization, thus contributing to the realization of what was planned, i.e., to achieve the strategic vision.

Axelos (2013a) states that senior managers should answer the following questions, and making any changes in the organization will contribute to the efficiency of portfolio management:

- are being delivered projects at the moment (and those in the pipeline) that bring us closer to our organization's Strategic Objectives?
- are these the best changes to get us there?
- are we allocating our precious resources in the right areas?

The PMI (2013a) shows the organizational context of the projects portfolio management, as it can be seen in Figure 5.

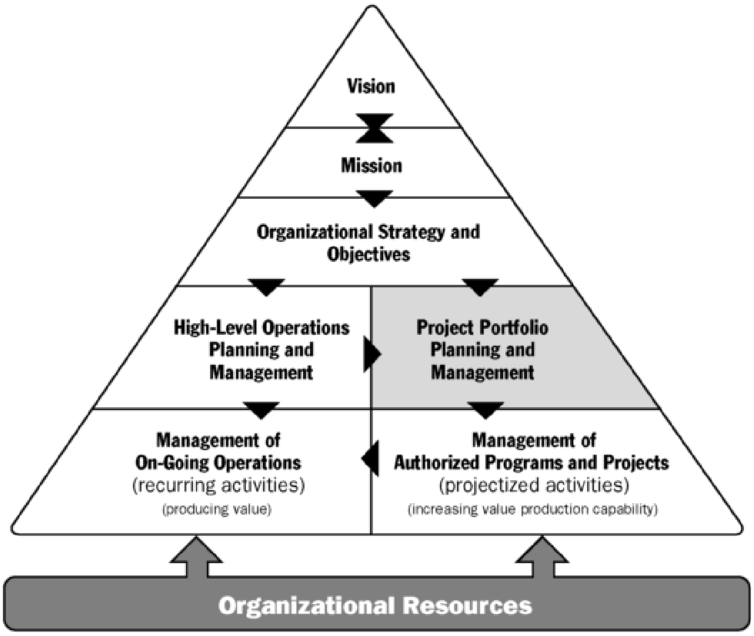

Figure 5. Organizational context of the Projects Portfolio Management (PMI, 2013a, p.7)

The top of the triangle (‘‘Vision,’’ ‘‘Mission,’’ and ‘‘Organizational Strategy and Objectives’’) illustrates the components used to set the targets or goals. These components direct all further organizational actions. The arrows in Figure 5 provide the general context of influencing relationships among the elements. The middle of the triangle (‘‘High-level Operations Planning and Management’’ and ‘‘Project Portfolio Planning and Management’’) represents the processes that establish appropriate actions required to meet the goals. These processes interact with the bottom of the triangle, in which the contribution of all operational activities must be compared to ongoing value creation, and the contribution of all project activities must be compared to the creation of new value. ‘‘Management of On-going Operations’’ and ‘‘Management of Authorized Programs and Projects,’’ which appear at the bottom of the triangle, correspond to those components that ensure the organization’s operations and portfolios are executed effectively and efficiently.

Indeed, many of the ailments that plague businesses’ new product efforts can be directly or indirectly traced to ineffective portfolio management, according to Cooper et al. (2001):

- *Strategic*: One negative side of poor portfolio management is that strategic criteria are missing in project selection. This translates into no strategic direction to projects selected; projects not strategically aligned with the business strategy;
- *Low-value projects*: Poor portfolio management means deficient Go/Kill and project selection decisions, which in turn leads to many mediocre projects in the pipeline – too many extensions, modifications, enhancements and short-term projects. Many of these are marginal value projects to the business. This translates into a lack of stellar, high reward projects, while the few really good projects are starved for resources – they take too long and may fail to achieve their full potential;
- *No focus*: Another outcome of poor portfolio management is a strong reluctance to kill projects: there are no consistent criteria for Go/Kill decisions, and projects just get added to an active list. The result is a lack of focus – too many projects, and resources thinly spread. This, in turn, leads to increased times to market, poor quality of execution and decreased success rates;
- *The wrong projects*: Poor portfolio management means that often the wrong projects are selected. With no formal selection method, decisions are not based on facts and objective criteria, but rather on politics, opinion and emotion, for example, "pet" projects of some senior executive. Many of these emotionally selected projects fail.

Blichfeldt and Eskerod (2008) developed a study with 30 companies where they show that while the companies have adopted portfolio management practices, they still struggle with completing projects within schedule and lack a broad overview of ongoing projects. The main reasons behind this are: (1) very different types of projects are included in the managed portfolio; and, (2) not all projects and smaller activities are managed as part of the portfolio.

Organizational Maturity in Project Portfolio Management

Typically, project management maturity models propose capacity levels in a sequence where each level is reached when the organization meets a list of criteria that are considered the best market practices. It is important to note these models include indicators and other elements such as organizational structure, training and communication (Killen & Hunt, 2009).

There are several models to assess the maturity of project and portfolio management, such as: (1) OPM3 – Organizational Project Management Maturity Model from PMI (PMI, 2013b); (2) P3M3 – Portfolio, Program and Project Management Maturity Model from Axelos (Axelos, 2013a); (3) OLMM – Outcomes and Learning-based Maturity Model from Catherine Killen and Robert Hunt (Killen & Hunt, 2009); and (4) Gartner PPM – Program and Portfolio Management Maturity Model from Mieritz and Fitzgerald of the Gartner Cooperate (Mieritz, Fitzgerald, Gomolski, & Light, 2007).

Table 2 presents a comparison between the referred maturity models taking into account fifteen criteria: publisher, scope, maturity level, discrete and continuous details, reference standard, creation, evaluation method, maturity level description, maturity dimensions, dependency of process areas, description of the reference model, data collection method, size of the questionnaire, support tools for the assessment and 'key process area (KPA)/ key performance indicator (KPI)'.

Table 2. Maturity Model Comparison: OPM3, P3M3, OLMM and Gartner PPM (Terlizzi, Moraes, Biancolino, & Garcez, 2014)

Criterion	OPM3	P3M3	OLMM	Gartner PPM
Publisher	PMI	OGC	Internationa Conference on Information Systems and Technology Management	Gartner
Scope	Portfolio, Program and Project	Portfolio, Program and Project	Portfolio	Program and Portfolio
Maturity level	Unidentified	1-5	Unidentified	1-5
Discrete and continues details	Continuous	Discrete	Discrete	Continuous
reference standard	PDCA	MSP/CMMI	CMMI	CMMI
Criation	2003	2006	2009	2008
Evaluation method	Self-assessment questionnaire, improvement planning list and list of best practices.	Self Assessment Questionnaire (9 issues), summary table and list of next steps	Evaluation sheet	Checklist Assessment
Maturity level Description	Does not exist	wide	restricted	wide
Maturity dimensions	Knowledge, evaluation, Improvement	persepctives: management control, benefits management, financial management, stakeholder management, risk management, organizational governance and resource management	process, structures and persons	persons, process, financial management, technology, relationship
Dependencies of process areas	interdependent	interdependent	not applicable	not applicable
description of the reference model	Yes	Yes	Unidentified	Unidentified
Data collection method	questionnaire	questionnaire	spreadsheet	checklist
Size of the questionnaire	600 best practices	9 issues	77 Capabilities	not applicable
support tools for the assessment	self-assessment training certification	self-assessment	Criteria sheet	Unidentified
KPA/KPI	not applicable	42	Unidentified	Unidentified

These challenges raise some research issues that the scientific community in the field should address to contribute to a more natural adoption of portfolio management techniques by the organizations:

(1) develop methods to support the adaptation, adoption, and evolution of project portfolios as a strategy for increasing the maturity of portfolio management;

(2) adopt portfolio management software to promote higher levels of portfolio performance, in addition to dealing with the complexity of the project portfolio and resource management, as well as providing greater satisfaction with project management practices (Coopers, 2012);

(3) study the factors that condition the maturity of project and portfolio management in the contexts of the (Silveira, Sbragia, & Kruglianskas, 2013): processes and tools; people and team; quality of project managers; guidance on business; guidance to customers; organizational support;

(4) formalize portfolio performance indicators to drive the performance assessment of the portfolio management implemented practices, namely based on the quality of execution, the success of the project portfolio, and the business success (Meskendahl, Jonas, Kock, & Gemünden, 2013). High maturity in portfolio management is directly related to its sustainability of project portfolios in organizations that adopt projects as changing management mechanisms;

3.3 Synopsis of PMI Portfolio Framework

The PfM process defined by PMI (PMI, 2013c) assumes that the company has a strategic plan, knows its mission, and has established its vision and goals.

An efficient portfolio management depends on the degree of maturity of a company and its processes. Thus, the knowledge of the maturity of a company is critical to determine its abilities and to select the correct methods to evaluate, select, prioritize and balance the projects, which is part of its portfolio, preferring the achievement of its objectives and defined goals in the strategic planning.

The PMI PfM framework is composed of a set of sixteen portfolio processes divided into five knowledge areas and three process groups.

The PMI PfM framework proposes three process groups for PfM: the *defining* process group, the *aligning* process group, and the *authorizing and controlling* process group.

The objective of the *defining* process group is to establish the strategy and the company's objectives that will be implemented in a portfolio. The objective of the *alignment* process group is to manage and optimize the portfolio. And, finally, the objective of the *authorizing and controlling* process group is to determine who authorizes the portfolio, as well as the ongoing oversight of the portfolio.

The knowledge areas identified in the PMI PfM framework are: strategic management, governance management, performance management, communication management and risk management (PMI, 2013c).

Table 3 presents the sixteen PfM processes from the PMI PfM framework, organized by knowledge areas and by process groups. Each portfolio, independently of the application area of the company, executes these sixteen processes sequentially.

A process group includes a set of PfM processes, each one demanding inputs and providing outputs, where the outcome of one process becomes the input to another (PMI, 2013c).

Table 3. Portfolio management processes organized by groups and knowledge areas (PMI, 2013c)

Portfolio Management Knowledge Areas (PMKA)	**Portfolio Management Process Groups (PMPG)**		
	Defining Process Group	***Aligning Process Group***	***Authorizing and Controlling Process Group***
Portfolio Strategic Management (PSM)	Develop Portfolio Strategic Plan Develop Portfolio Charter Define Portfolio Roadmap	Manage Strategic Change	
Portfolio Governance Management (PGM)	Develop Portfolio Management Plan Define Portfolio	Optimize Portfolio	Authorize Portfolio Provide Portfolio Oversight
Portfolio Performance Management (PPM)	Develop Portfolio Performance Management Plan	Manage Supply and Demand Manage Portfolio Value	
Portfolio Communication Management (PCM)	Develop Portfolio Communication Management Plan	Manage Portfolio Information	
Portfolio Risk Management (PRM)	Develop Portfolio Risk Management Plan	Manage Portfolio Risks	

Table 4 depicts the mapping between each process groups and the knowledge areas and process improvement stage from OPM3 (PMI, 2013b, 2013c). The last column of Table 4 is the mapping between the PMI PfM framework and the maturity model for PfM from OPM3.

The OPM3 is organized in three areas related to three elements for application in companies: knowledge, assessment and improvement. Combining these three elements in a continuous cycle of five steps: (1) prepare for assessment; (2) perform assessment; (3) plan improvements; (4) implement improvements; and (5) repeating the process. In OPM3, companies can then be classified into four stages of development in each portfolio process (Pinto & Williams, 2013): (1) standardize (S) - structured processes are adopted; (2) measure (M) - data is used to evaluate process performance; (3) control (C) - control plan developed for measures; and (4) continuously improve (I) - processes are optimized.

Table 4. The Mapping between process groups, knowledge areas and process improvement stages from OPM3

Portfolio Management Process Groups (PMPG)	Portfolio Management Knowledge Areas (PMKA)	Portfolio Processes (PP)	Acronym	OPM3 Process Improvement Stage (PIS)
Defining Process Group	Portfolio Strategic Management (PSM)	Develop Portfolio Strategic Plan	{PP 1} DPSP	S,M,C,I
	Portfolio Strategic Management (PSM)	Develop Portfolio Charter	{PP 2} DPC	S,M,C,I
	Portfolio Strategic Management (PSM)	Define Portfolio Roadmap	{PP 3} DPR	S,M,C,I
	Portfolio Governance Management (PGM)	Develop Portfolio Management Plan	{PP 4} DPMP	S,M,C,I
	Portfolio Governance Management (PGM)	Define Portfolio	{PP 5} DP	S,M,C,I
	Portfolio Performance Management (PPM)	Develop Portfolio Performance Management Plan	{PP 6} DPPMP	S,M,C,I
	Portfolio Communication Management (PCM)	Develop Portfolio Communication Management Plan	{PP 7} DPCMP	S,M,C,I
	Portfolio Risk Management (PRM)	Develop Portfolio Risk Management Plan	{PP 8} DPRMP	S,M,C,I
Aligning Process Group	Portfolio Strategic Management (PSM)	Manage Strategic Change	{PP 9} MSC	S,M,C,I
	Portfolio Governance Management (PGM)	Optimize Portfolio	{PP 10} OP	S,M,C,I
	Portfolio Performance Management (PPM)	Manage Supply and Demand	{PP 11} MSD	S,M,C,I
	Portfolio Performance Management (PPM)	Manage Portfolio Value	{PP 12} MPV	S,M,C,I
	Portfolio Communication Management (PCM)	Manage Portfolio Information	{PP 13} MPI	S,M,C,I
	Portfolio Risk Management (PRM)	Manage Portfolio Risks	{PP 14} MPR	S,M,C,I
Authorizing and Controlling Process Group	Portfolio Governance Management (PGM)	Authorize Portfolio	{PP 15} AP	S,M,C,I
	Portfolio Governance Management (PGM)	Provide Portfolio Oversight	{PP 16} PPO	S,M,C,I

PfM processes occur as a series of interrelated processes or bridges between the organizational strategy and the implemented programs/projects. These are part of the tactical work of the organization to meet the goals, objectives, and strategies of the organization (PMI, 2013c).

The generic data flow diagram about the process, depicted in Figure 6, shows the basic flow and interactions between the three process groups by identifying the artefacts that are created or necessary for the implementation of PfM processes.

The PMI PfM framework categorizes all the artefacts in the following content types: enterprise documents, portfolio documents, and portfolio reports (PMI, 2013c). For example, the enterprise documents artefacts are: (1) organizational strategy and objectives; (2) organizational communication strategy; (3) organizational risk tolerance; (4) organizational performance strategy; (5) enterprise environmental factors; (6) organizational process assets; and (7) inventory of work.

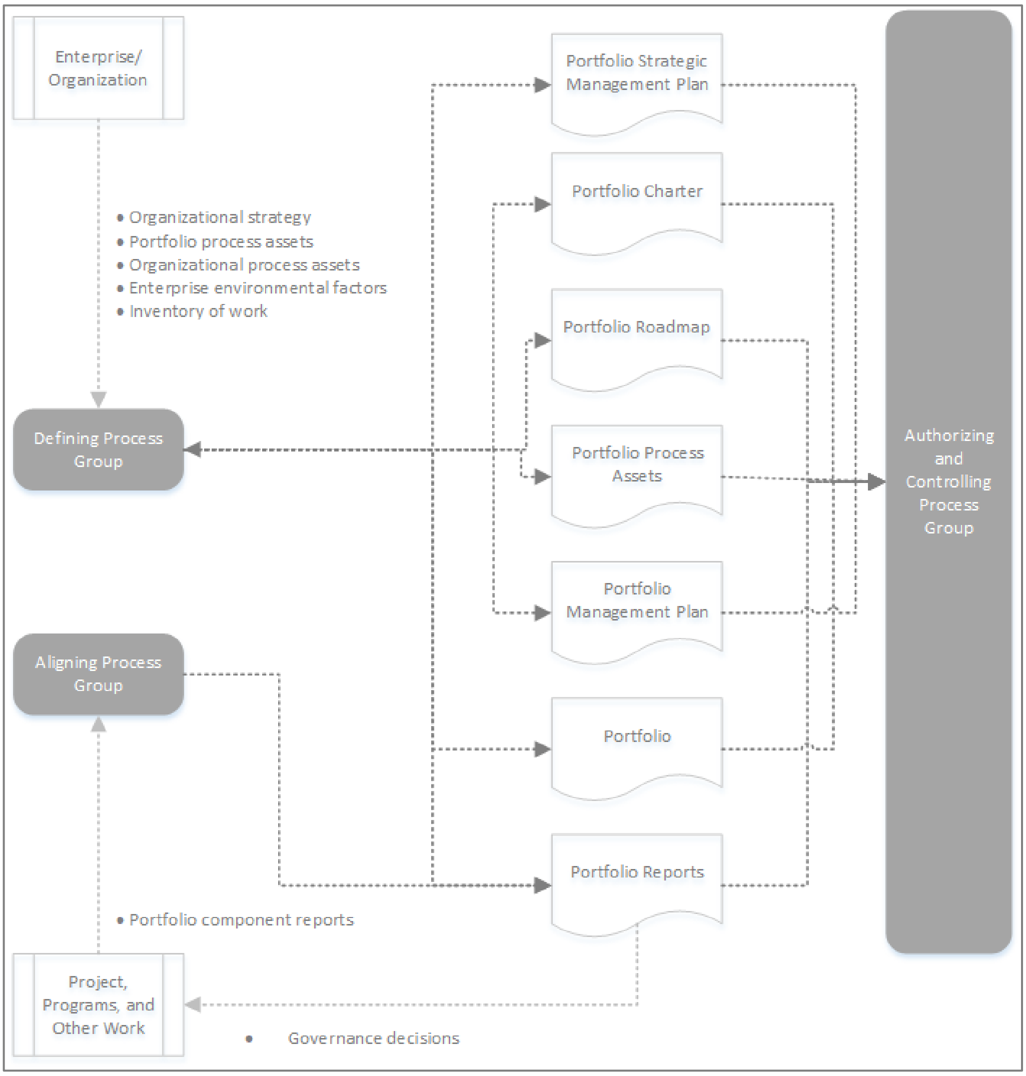

Figure 6. PMI PfM process group interactions by artefacts (PMI, 2013c)

3.4 Synopsis of OGC Portfolio Framework

The Management of Portfolios (MoP) of the UK Government Office of Government Commerce (Axelos, 2011) provides practices, which allow individuals and organizations to introduce portfolio management processes successfully. Since 2013, Axelos, a UK-based joint venture, has purchased OGC's best practices, including MoP.

Specifically, MoP provides general descriptions of principles and practices, as well as artefacts and examples to build approaches for management of project portfolios.

The Axelos defines project portfolio management (PfM) as a set of structured and coordinated strategic processes and decisions, which allows allowed the effective balance of organizational change and organizational business.

According to MoP, organizations must evolve to be successful, improving the management of their day-to-day business, adapting demands and expectations. The PfM responds to some fundamental questions, such as: (1) Are we doing the right things? (2) Are we doing these programs and projects in the right way? (3) As a result of the implemented changes in terms of effective services, are we realizing the benefits? MoP answers these questions ensuring that: (1) programs and projects to be implemented should be prioritized aligned with the organization's strategic objectives and the overall level of risk; (2) programs and projects must be to ensure effective and efficient delivery; and, (3) the realization of benefits is maximized to provide the highest return (in terms of strategic contribution and efficiency savings of the investment made) (Al Freidi, 2014).

Regardless of sector, size, market or geographic location, the principles, cycles and practices defined in the MoP can be applied to any organization. The use of PfM helps to assess the performance of the practices/processes and the portfolio as a whole in relation to the key performance indicators and the strategic plan of an organization (McHugh & Hogan, 2011).

The MoP provides five principles for the organizational environment, where the definition of portfolio and delivery practice should operate effectively: (1) senior management commitment; (2) alignment with the organization's governance structure; (3) alignment with the organization's strategic objectives; (4) the use of a portfolio office (real or virtual); and, (5) an energized change culture.

The MoP practices consider two cycles: (1) Portfolio Definition Cycle, that is divided into five practices, normally executed sequentially: (i) understand; (ii) categorize; (iii) prioritize; (iv) balance; and, (v) plan; (2) Portfolio Delivery Cycle, that is divided into seven practices: (i) management control; (ii) benefits management; (iii) financial management; (iv) risk management; (v) stakeholders engagement; (vi) organizational governance; and, (vii) resource management.

Table 5 depicts the internal alignment of the MoP practices regarding portfolio management cycles and portfolio management cycles practices (PMCP). In Table 5, for each practice of portfolio management cycles {PMCP n}, a column to define an acronym is included, where PMCP stands for portfolio management cycles practices, and n corresponds to the number of the practice.

Table 5. Internal alignment between MoP practices in terms of portfolio management cycles and portfolio management cycles practices (PMCP)

Portfolio management cycles	**Portfolio Management Cycles Practices (PMCP)**	**Acronym**
PDFC Portfolio Definition Cycle	Understand	{PMCP 1} PDFU
	Categorize	{PMCP 2} PDFC
	Prioritize	{PMCP 3} PDFP
	Balance	{PMCP 4} PDFB
	Plan	{PMCP 5} PDFP
PDLC Portfolio Delivery Cycle	Management Control	{PMCP 6} PDLMC
	Benefits Management	{PMCP 7} PDLBM
	Financial Management	{PMCP 8} PDLFM
	Risk Management	{PMCP 9} PDLRM
	Stakeholder Engagement	{PMCP 10} PDLSE
	Organizational Governance	{PMCP 11} PDLOG
	Resource Management	{PMCP 12} PDLREM

Figure 7 highlights the context in which each of the Portfolio Delivery and Portfolio Definition Cycles is executed, pointing out the PfM principles and how they interoperate.

The Portfolio Definition Cycle includes a series of sequential practices, but frequently some overlapping will occur. For instance, understanding generally comes before categorizing, which usually happens before prioritizing.

In the Portfolio Delivery Cycle, the practices are undertaken simultaneously, because in project and program life cycle several individual initiatives are executed in different moments. The definition and delivery practices occur continuously, but the implementation of the practices has a different pertinence and incidence in time (Axelos, 2011).

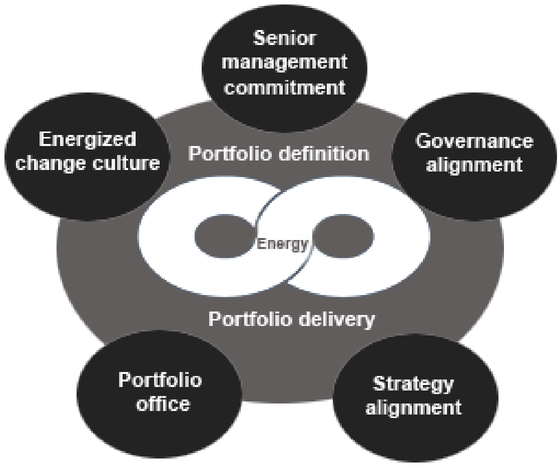

Figure 7. The portfolio management model from MoP (Axelos, 2011, p.10)

3.5 Conclusions

A project is a value-creating activity to meet a specific objective. When a project is successfully completed, it delivers novelty, differentiation and innovation on its product, either in a physical or service form. A project has a temporary nature having its defined start and end times**,** and has inevitable uncertainly factors due to its nature***.***

A program consists of undertakings in which multiple projects for achieving a holistic mission are organically combined and it has a multiplicity that includes significance or context that suggests solutions. The program is applied in politics, economy and society, and has scalability in size, dimensions and structures. It has complexity arising from interfaces between projects as well as combination and overlapping of project life cycles, and confronts uncertainty due to environmental changes since periods until completion are usually longer than with ordinary projects.

A portfolio is a group of projects and/or programs carried out under the sponsorship of an organization. The portfolios can be managed at an organizational, programmatic or functional level.

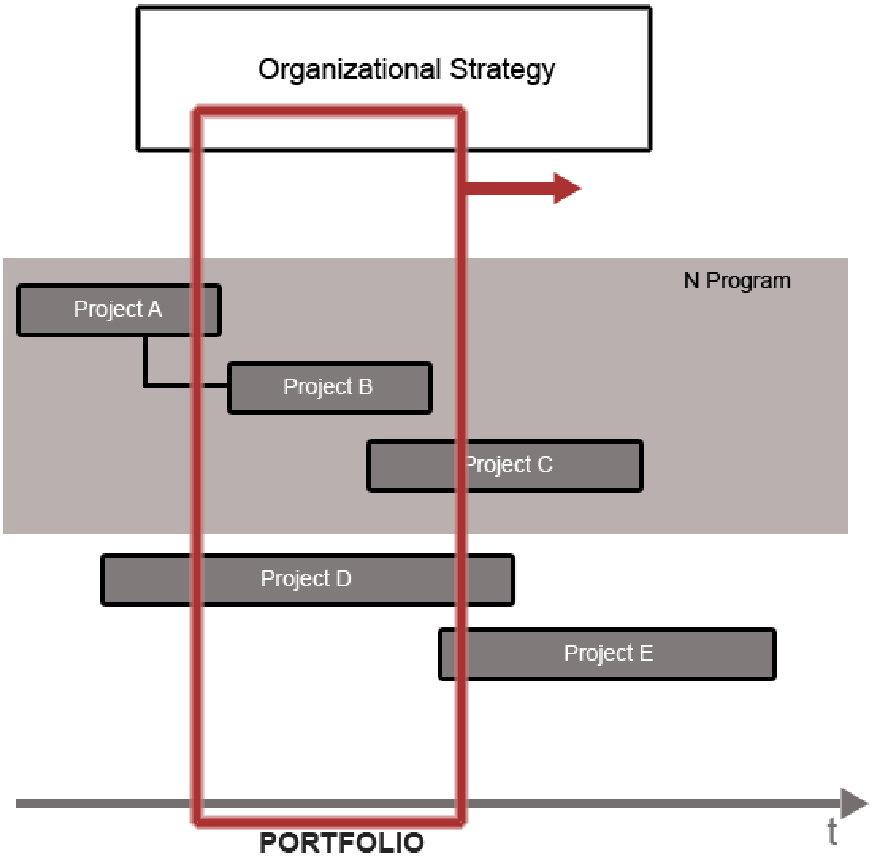

Figure 8. Portfolio Concept

In Figure 8, the red square represents the portfolio view at a given time. Portfolio management is different, depending on when it occurs. If in the current situation (the red square), we need to guard against the problems of dependence between ‘Project A’ and ‘Project B’ of the ‘N Program’, as well as other projects that are underway or that will start up another time,, namely, ‘Project E’. Portfolio management will address other challenges, which may not match the current portfolio.

From the literature review, it is verified that the PMI PfM framework is the most complete in the detail of the processes to manage project portfolios. On the other hand, through the literature review, it is confirmed that the OGC PfM framework was created to manage portfolios of information technology projects. Therefore, the next steps will be to know deeply the two PfM frameworks, PMI and OGC, in order to begin the development of an IT PfM framework adapted to the contexts of the project portfolios of the information technology in CIT organizations.

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CHAPTER 4

ALIGNMENT STUDIES WITH PMI AND OGC PORTFOLIO FRAMEWORKS

Summary: In this chapter, the deepening of knowledge about the PMI PfM framework and OGC PfM framework are verified. In order to prepare the creation of an IT PfM framework, this chapter starts by mapping dependencies between the PMI PfM framework processes. Subsequently, the mapping between processes and artefacts of the PMI PfM framework is created. Finally, for the OGC PfM framework, the mapping between artefacts and practices of the OGC PfM framework is developed.

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CHAPTER 4: ALIGNMENT STUDIES WITH PMI AND OGC PORTFOLIO FRAMEWORKS

"The popularity of portfolio methods that industry uses provides insights and guides to others. But words of caution: just because a method is popular, don't assume it gives the best results".

– Cooper et al. (2001, p.13)

4.1 Introduction

The use of PfM processes allows the establishment of a formal communication and decision structure (Coldrick, Longhurst, Ivey, & Hannis, 2005). In the improvement of PfM practices, the organizations should be guided through appropriate tools and techniques, having as guidance the different existent bodies of knowledge. In the late 1990s, the bodies of knowledge were published by the professional associations of project managers.

PfM practices are simply seen as those tools and techniques that practitioners use to "execute a PfM process", such as work breakdown structure or a project charter. Tools and techniques are closer to day-to-day practice, closer to things people do, closer to their tacit knowledge (Besner & Hobbs, 2008).

These bodies of knowledge are clearly important for both practitioners and academics. The bodies of knowledge are used as guides of "best practices" by the practitioners, but they also provide 'standards', against which the associations' certification programs run (Morris, Crawford, Hodgson, Shepherd, & Thomas, 2006; Smyth & Morris, 2007). The attempt to define the "discrete body of knowledge and related skills" is also in the interest of academics, because there are some difficulties in answering questions about the validity of the body of knowledge in the subject that is being discussed, in epistemological terms and in what is considered for the subject area. Thus, the repositioning of the body of knowledge is an important topic to be considered in research (Morris et al., 2006).

The use of internationally recognized bodies of knowledge brings several benefits to organizations, in the development of a methodology for PfM, such as: (1) recognition by external customers of the use of a renowned methodology; (2) ensuring the use of what is considered "best practice" by the organization; (3) the possibility of recruitment the organization may be assisted; (4) training and support on the methodology may be performed by specialized suppliers (McHugh & Hogan, 2011); and, finally, (5) recognition of the bodies of knowledge, as "best practices", and therefore the design and development barriers are minimized (Haji-Kazemi & Bakhshehsi, 2009).

4.2 Dependencies between PMI Processes

A first glance at the “Standard for Portfolio Management” from PMI, it is not easy to perceive the existing dependencies. Based on the detailed information about the processes inputs and the outputs, our efforts to highlight the existing dependencies intend to explain both the implementation order of the processes and the input-output interrelation they establish.

Elementary Dependency Analysis

In this section, the researcher describe how is characterized the elementary dependency of a particular PMI PfM framework process; what the researcher call the PP*n*-centric dependency analysis (*n* is the number of the process portfolio; see Table 5).

Because exemplifying all cases in the thesis does not become feasible, when the researcher refers *"…as an example*", it is one of the concrete cases of analysis.

As an example, it is analysed the {PP4} DPMP ‘Develop Portfolio Management Plan’, depicted in Figure 9. The {PP4} DPMP ‘Develop Portfolio Management Plan’ process receives information of the {PP1} DPSP ‘Develop Portfolio Strategic Plan’ process and sends information to the {PP14} MPR ‘Manage Portfolio Risks’ process and to the {PP16} PPO ‘Provide Portfolio Oversight process. All processes in the depicted graph are positioned in the respective process group lane (as an example, the {PP4} DPMP is located in the lane of the *Defining* process group).

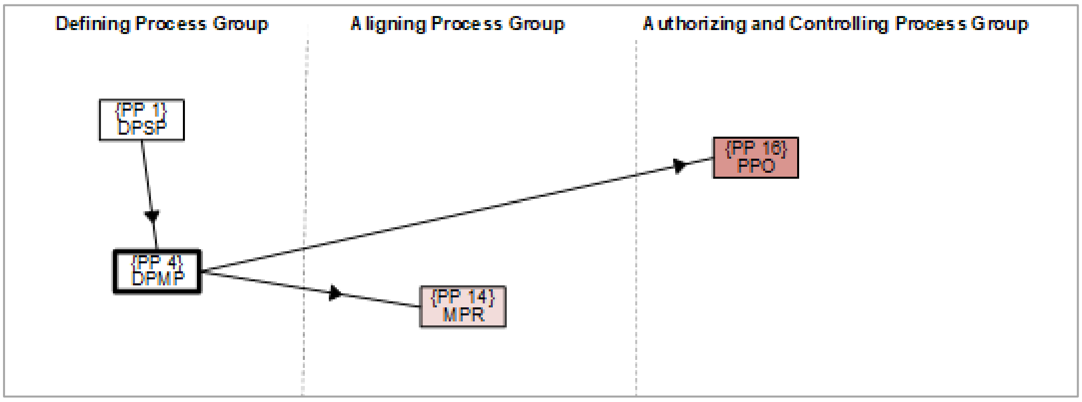

Figure 9. Elementary Dependency Analysis Graph

Elementary dependencies between processes are perfectly identified in the PMI PfM framework. However, the overview of all PfM processes organized by process groups or knowledge areas is not easily perceived. This is why our systematic analysis is applied to highlight all the detailed overall dependencies between the complete set of portfolio processes.

Portfolio Processes Dependencies

In order to obtain the complete set of all the dependencies between all portfolio processes, the researcher start to analyse the processes' inputs and outputs (see Figure 10).

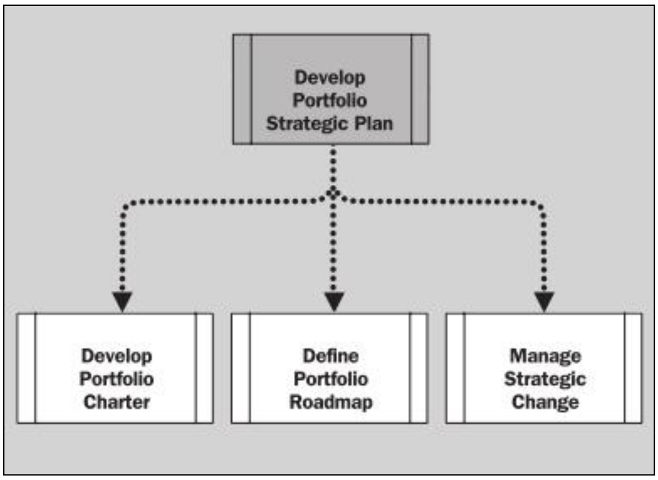

Figure 10. Example of dependency between portfolio processes (PMI, 2013c, p.43)

For the {PP4} DPMP ‘Develop Portfolio Management Plan’ process, the corresponding PP4-centric dependency analysis is explained below. In the ‘input and output processes’ section of the PMI PfM framework, the researcher can read: (1) {PP1} DPSP is an input process of the {PP4} DPMP; (2) {PP3} DPR is an input and output process of the {PP4} DPMP; and, (3) {PP7} DPCMP is an output process of the {PP4} DPMP. This means that the input processes of {PP4} DPMP are the {PP1} DPMP, {PP2} DPC and {PP3} DPR; the output processes are the {PP3} DPR, {PP5} DP, {PP6} DPPMP, {PP7} DPCMP, {PP10} OP, {PP15} AP, and {PP16} PPO. All these relations are described in the matrix of Table 6, where an “IN” stands for input process, “OUT” for output process, and “I/O” for input and output process. The matrix contains the information of all the perceived dependencies. Each matrix row represents the portfolio process source under analysis, and the columns represent the depended portfolio processes, both in the input and output perspectives.

Table 6. {PP4} DPMP matrix line

	Defining Process Group								Aligning Process Group						Authorizing and Controlling Process Group			
depended PP / PP depends	PSM {PP 1} DPSP S,M,C,I	PSM {PP 2} DPC S,M,C,I	PSM {PP 3} DPR S,M,C,I	PGM {PP 4} DPMP S,M,C,I	PGM {PP 5} DP S,M,C,I	PPM {PP 6} DPPMP S,M,C,I	PCM {PP 7} DPCMP M,C,I	PRM {PP 8} DPRMP S,M,C,I	PSM {PP 9} MSC M,C,I	PGM {PP 10} OP S,M,C,I	PPM {PP 11} MSD S,M,C,I	PPM {PP 12} MPV S,M,C,I	PCM {PP 13} MPI M,C,I	PRM {PP 14} MPR M,C,I	PGM {PP 15} AP S,M,C,I	PGM {PP 16} PPO S,M,C,I	Input Number of dependency	Output Number of dependency
PGM {PP 4} DPMP S,M,C,I	IN	IN	I/O		OUT	OUT	OUT			OUT					OUT	OUT	3	7

Portfolio Processes Centric Dependency Analysis

To create the complete matrix of the PfM processes the elementary dependency analysis must be performed for all the PfM processes. The resulting matrix of this overall analysis is described in Table 7. In order to easily understand, the effective impact of the dependencies between all the portfolio processes. The matrix is sorted by process groups, in Table 7 (note the red gradient).

Table 7. Dependencies between all the PfM Processes

		Defining Process Group								Aligning Process Group						Authorizing and Controlling Process Group			
	depended PP / PP depends	PSM {PP 1} DPSP S,M,C,I	PSM {PP 2} DPC S,M,C,I	PSM {PP 3} DPR S,M,C,I	PGM {PP 4} DPMP S,M,C,I	PGM {PP 5} DP S,M,C,I	PPM {PP 6} DPPMP S,M,C,I	PCM {PP 7} DPCMP M,C,I	PRM {PP 8} DPRMP S,M,C,I	PSM {PP 9} MSC M,C,I	PGM {PP 10} OP S,M,C,I	PPM {PP 11} MSD S,M,C,I	PPM {PP 12} MPV S,M,C,I	PCM {PP 13} MPI M,C,I	PRM {PP 14} MPR M,C,I	PGM {PP 15} AP S,M,C,I	PGM {PP 16} PPO S,M,C,I	Input Number of dependency	Output Number of dependency
Defining Process Group	PSM {PP 1} DPSP S,M,C,I		OUT	OUT						OUT								0	3
	PSM {PP 2} DPC S,M,C,I	IN		OUT						OUT								1	2
	PSM {PP 3} DPR S,M,C,I	I/O	IN							OUT								2	2
	PGM {PP 4} DPMP S,M,C,I	IN	IN	I/O		OUT	OUT	OUT			OUT					OUT	OUT	3	7
	PGM {PP 5} DP S,M,C,I	IN	IN	IN	IN						OUT					OUT	OUT	4	3
	PPM {PP 6} DPPMP S,M,C,I				IN							OUT	OUT					1	2
	PCM {PP 7} DPCMP M,C,I			IN	IN	IN								OUT				3	1
	PRM {PP 8} DPRMP S,M,C,I				IN										OUT			1	1
Aligning Process Group	PSM {PP 9} MSC M,C,I	OUT	OUT	OUT														0	3
	PGM {PP 10} OP S,M,C,I	IN	IN	IN	IN	IN										OUT	OUT	5	2
	PPM {PP 11} MSD S,M,C,I				IN	IN	IN											3	0
	PPM {PP 12} MPV S,M,C,I	IN		IN	IN		IN											4	0
	PCM {PP 13} MPI M,C,I				IN	IN		I/O										3	1
	PRM {PP 14} MPR M,C,I				IN	IN			I/O									3	1
Authorizing and Controlling Process Group	PGM {PP 15} AP S,M,C,I				IN	IN					IN						I/O	4	1
	PGM {PP 16} PPO S,M,C,I	IN	IN	IN	IN	IN					IN					I/O		7	1
	Input Number of dependency	7	5	6	11	7	2	1	1	0	2	0	0	0	0	1	1		
	Output Number of dependency	2	1	2	0	0	0	1	1	0	1	1	1	1	1	3	3		

In Figure 11, the researcher depicts the corresponding graph representation of the global matrix of Table 7. This global graph (also called *Global Portfolio Process Dependency Analysis Graph*) shows the global view of the dependencies between the portfolio processes. Bi-directional dependencies between the PfM processes of different process groups are described, through lines with left and right arrows.

Process Groups Centric Dependency Analysis

Process groups have clear dependencies and are typically performed in the same sequence for each portfolio (PMI, 2013c), so the analysis of the processes is done by process group.

To study, discover and analyse in detail the specific dependencies of the PfM process of one defining process group, based on the information in the global matrix, three additional graphs have been created. The researcher call them *PG-n Centric Dependency Analysis Graph* (where *n* corresponds to the process group under study: 1 – defining, 2 – aligning and 3 – authorizing and controlling). The main idea behind the creation of these PG-n centric graphs is to focus only on the dependencies that are concerned to the process group under study, by eliminating from the global graph a huge number of dependencies that the researcher do not want to take into account when the researcher is studying a particular process group.

Figure 12, Figure 13 and Figure 14 present, respectively, the PG-1, PG-2 and PG-3 Centric Dependency Analysis Graphs. As an example, the construction of the PG-1 uses the information in the first eight rows of the global matrix that correspond to the *defining* process group.

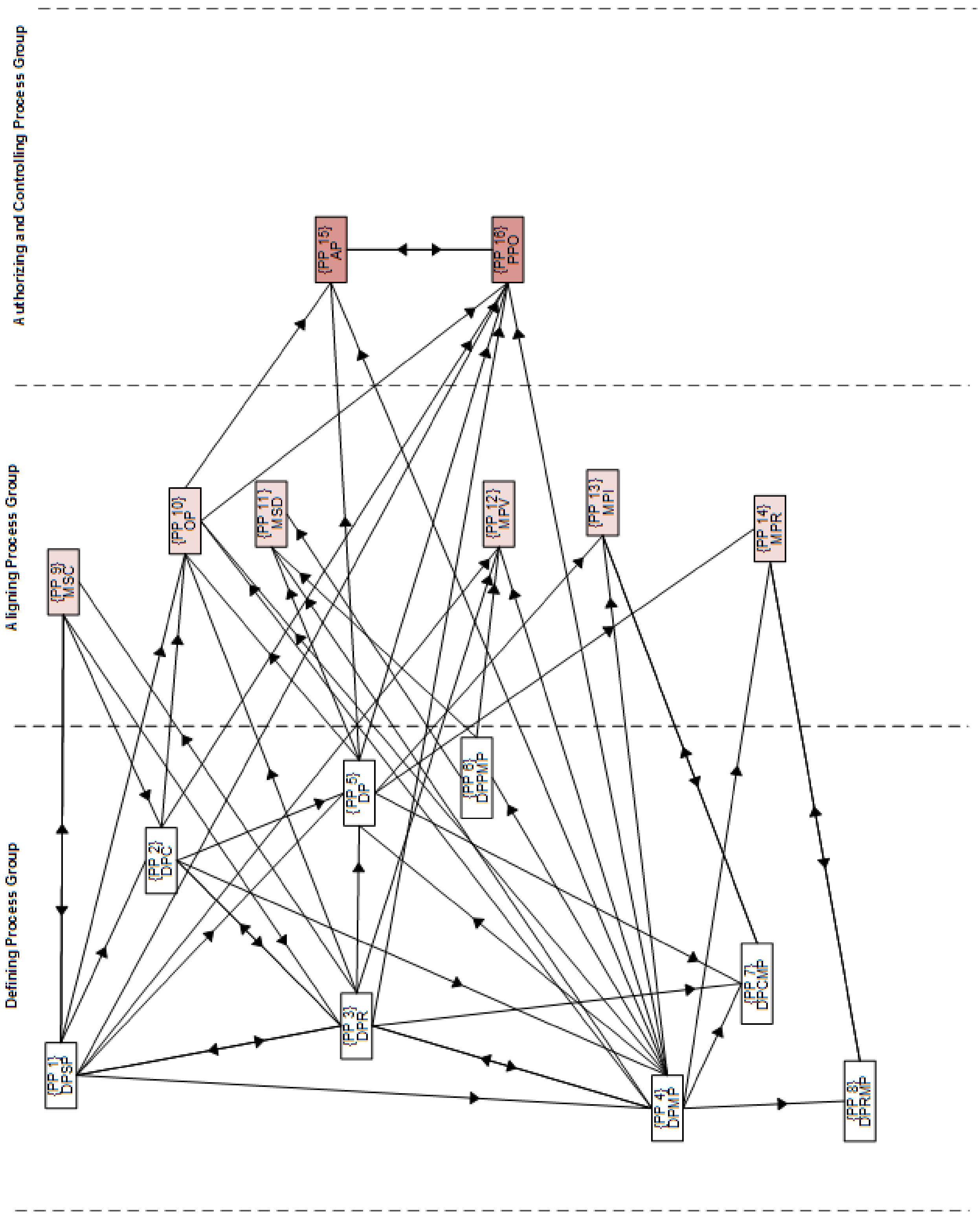

Figure 11. Global Portfolio Process Dependency Analysis Graph

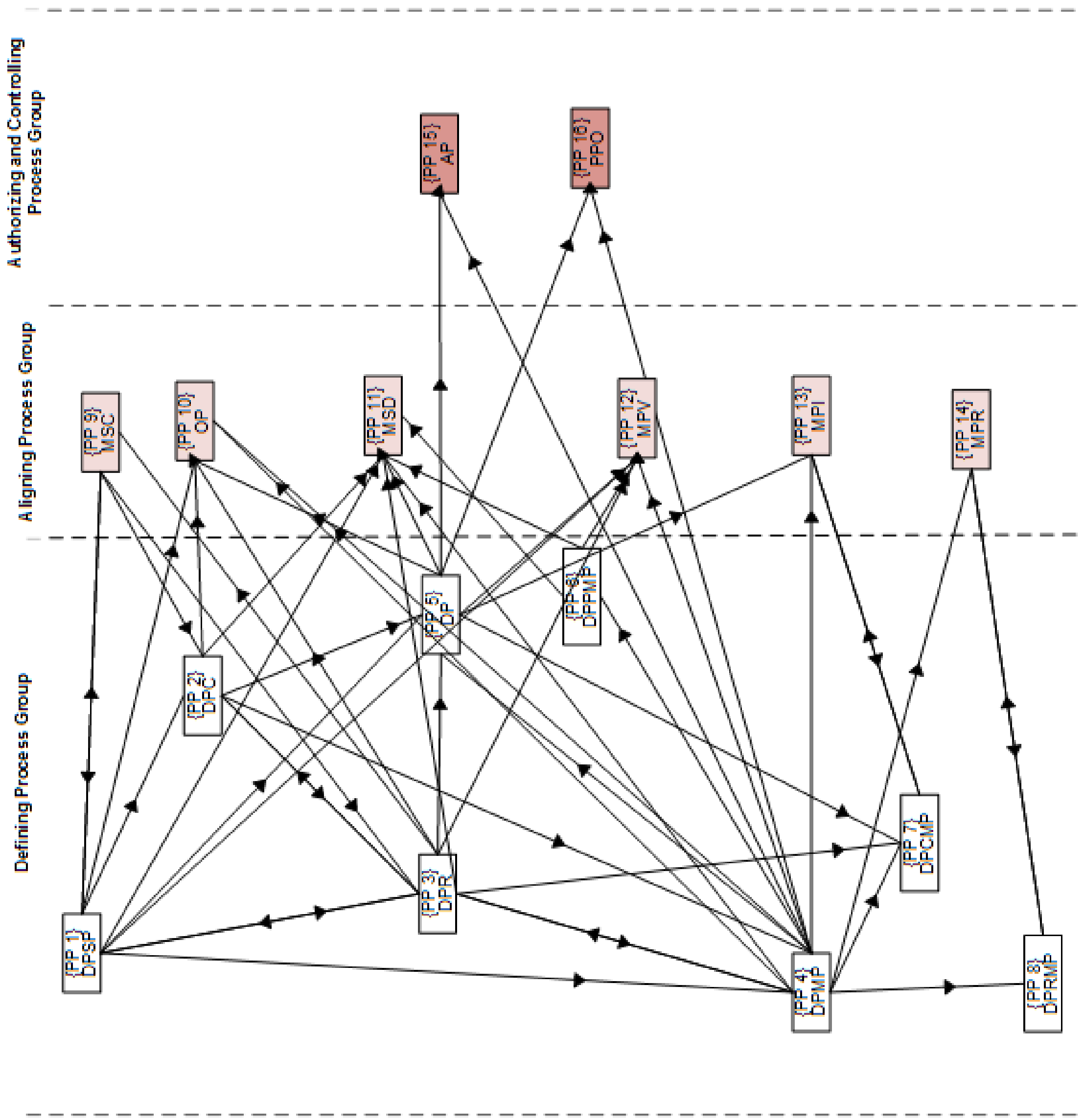

Figure 12. PG-1 (Defining Process Group) Centric Dependency Analysis Graph

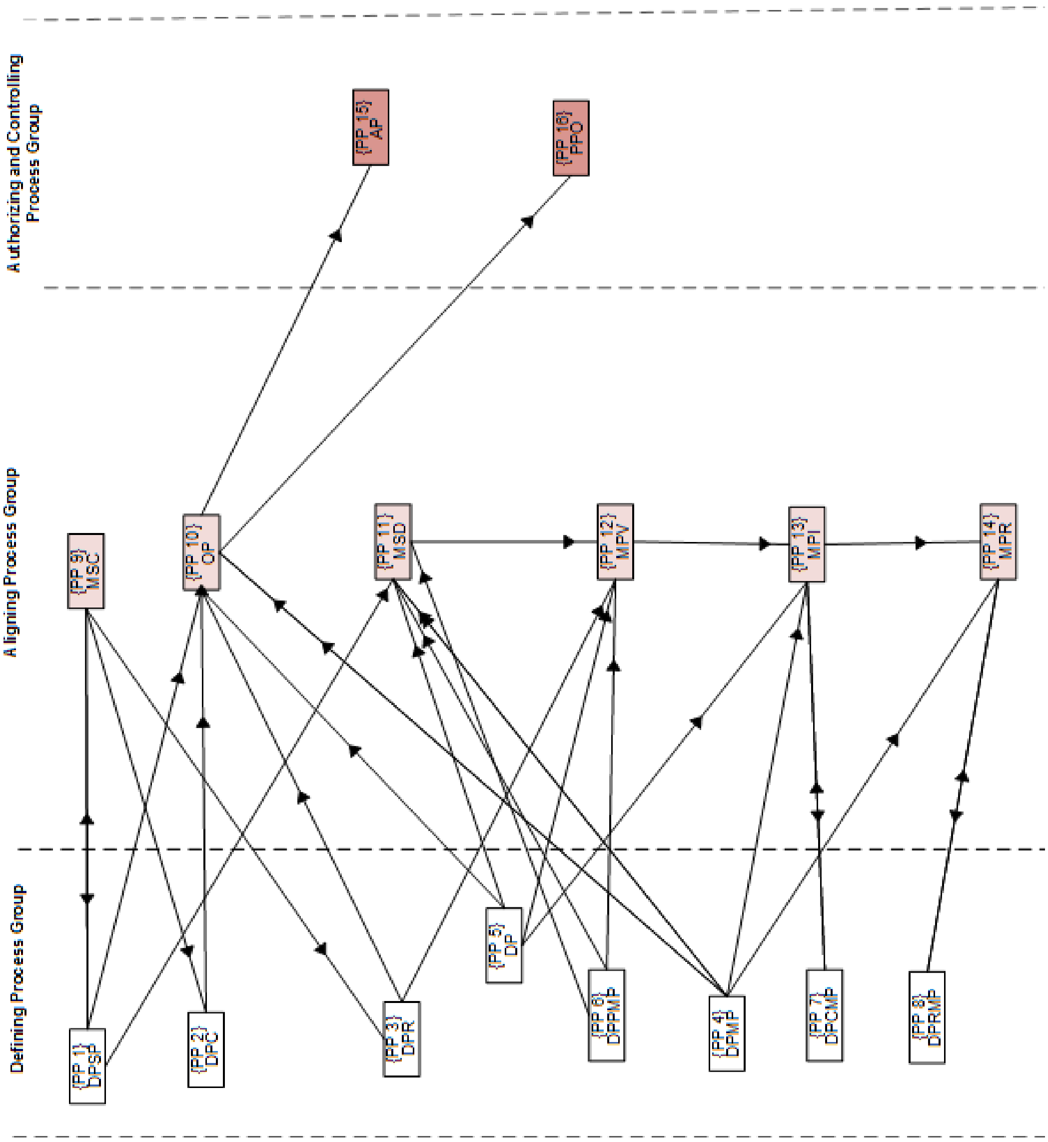

Figure 13. PG-2 (Aligning Process Group) Centric Dependency Analysis Graph

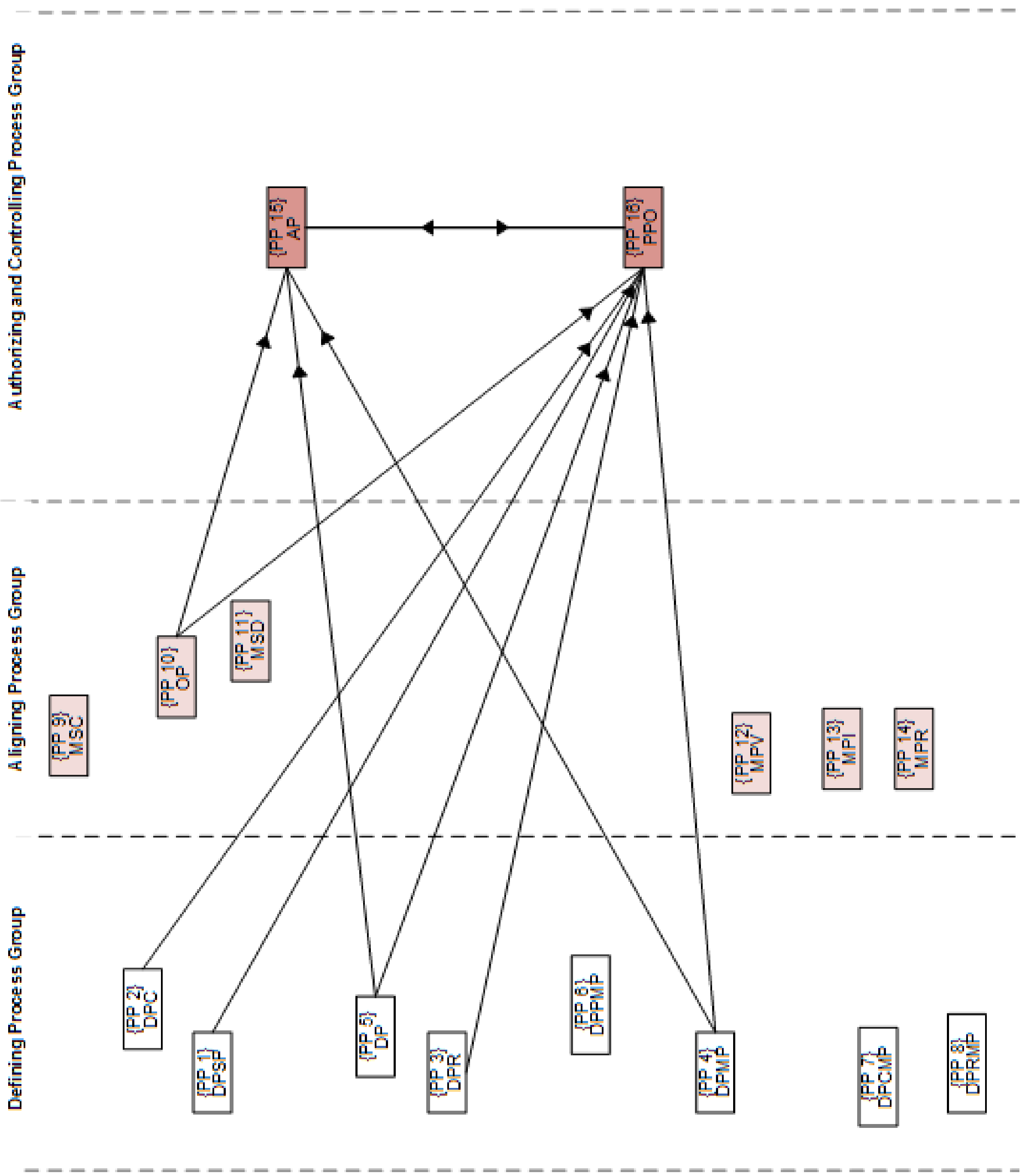

Figure 14. PG-3 (Authorizing and Controlling Process Group) Centric Dependency Analysis Graph

For a better understanding of the PG-1 graph, as an example, the researcher analysed the process {PP4} 'DPMP' Develop Portfolio Management Plan '. The graph shows the dependencies between {PP4} DPMP and PfM processes. Table 8 shows the matrix line corresponding to the process {PP4} DPMP and dependencies, "IN", "I/O" and "OUT" with other PfM processes. Two views on the same data. It is possible to see that the {PP4} DPMP presents dependencies from other nine PfM processes: {PP1} DPSP, {PP2} DPC, {PP3} DPR, {PP5} DP, {PP6} DPPMP, {PP7} DPCMP, {PP10} OP, {PP15} AP, and {PP16} PPO. The {PP4} DPMP process performs a key role in the PMI PfM standard, since, it is the process that sends more information to the other processes, so, it shows more ‘OUT’ and ‘I/O’-type dependencies.

Table 8. PG-1 centric dependency analysis for {PP4} DPMP

depended PP / PP depends	PSM **{PP 1}** **DPSP** S,M,C,I	PSM **{PP 2}** **DPC** S,M,C,I	PSM **{PP 3}** **DPR** S,M,C,I	PGM **{PP 4}** **DPMP** S,M,C,I	PGM **{PP 5}** **DP** S,M,C,I	PPM **{PP 6}** **DPPMP** S,M,C,I	PCM **{PP 7}** **DPCMP** M,C,I	PRM **{PP 8}** **DPRMP** S,M,C,I	PSM **{PP 9}** **MSC** M,C,I	PGM **{PP 10}** **OP** S,M,C,I	PPM **{PP 11}** **MSD** S,M,C,I	PPM **{PP 12}** **MPV** S,M,C,I	PCM **{PP 13}** **MPI** M,C,I	PRM **{PP 14}** **MPR** M,C,I	PGM **{PP 15}** **AP** S,M,C,I	PGM **{PP 16}** **PPO** S,M,C,I	**Input Number of dependency**	**Output Number of dependency**
PSM **{PP 3}** **DPR** S,M,C,I																		
PGM **{PP 4}** **DPMP** S,M,C,I	IN	IN	I/O		OUT	OUT	OUT			OUT					OUT	OUT	2	6
PGM **{PP 5}** **DP** S,M,C,I																		

Within the context of the *aligning* process group (Figure 13), the graph emphasizes the fact that the *aligning* process group receives information from the *defining* process group and produces outputs for the *authorizing and controlling* and the *defining* process groups. It is also possible to perceive that some threads of processes of the *aligning* process group conclude their activities inside the group itself; see, for example, {PP11} MSD and {PP12} MPV.

Figure 14 shows the PG-3 centric dependency analysis graph that supports the dependency analysis of the only two existing processes within the *authorizing and controlling* process group: the {PP15} AP and the {PP16} PPO. These two processes are mainly recipients of information from the other two process groups and do not produce information back. By analysing the graph, it is possible to perceive that the two processes of the *authorizing and controlling* process group are relevant closing processes of the project PfM life cycle.

Knowledge areas and Processes Groups Centric Dependency Analysis

The PMI PfM framework classifies each PfM process by one of the following five knowledge areas: portfolio strategic management, portfolio governance management, portfolio performance management, portfolio communication management, and portfolio risk management. The genuine nature of the existing dependencies between the PfM processes is better understood based on the information made available by the PMI PfM framework, the reason why the researcher have constructed the graph depicted in Figure 15. This graph results from the annotation of the *Global Portfolio Process Dependency Analysis Graph* presented in Figure 11 with reference to the knowledge areas.

The analysis of the graph in Figure 15 allows to conclude that: (1) the processes under the *portfolio strategic management* knowledge area are the first processes to be executed; (2) the *portfolio governance management* is the only knowledge area that comprises PfM processes from all the three process groups; (3) the PfM processes classified by the *portfolio governance management* knowledge area are the ones that present a higher number of dependencies among all the portfolio processes; and, (4) the *performance management*, *risk management*, and *communication management* knowledge areas present a limited number of PfM process dependencies.

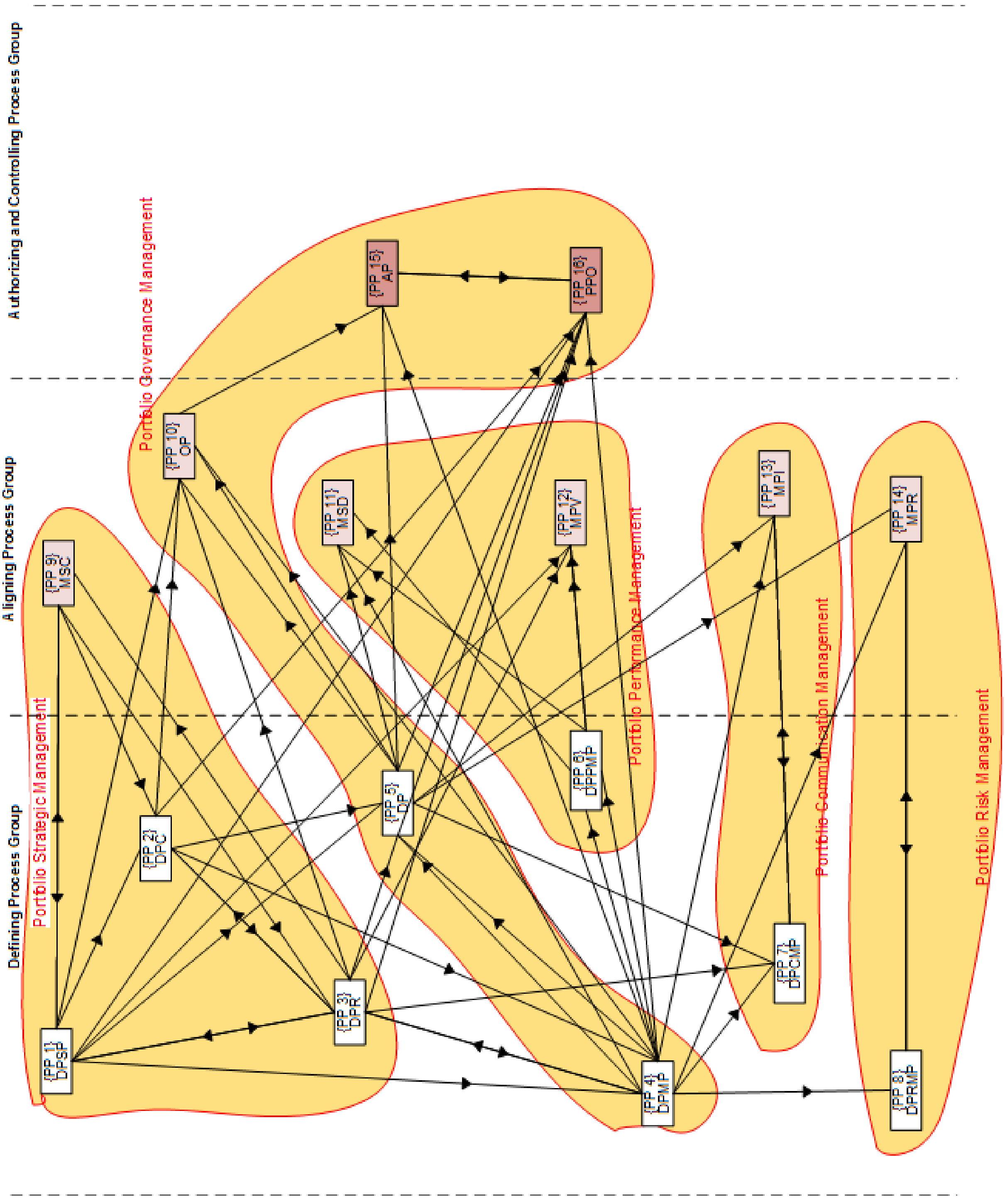

Figure 15. Global Portfolio Process Dependency Analysis Graph with annotated Knowledge Areas

4.3 Mapping between PMI Artefacts and Processes

Understanding the mapping between processes and artefacts presented in the PMI PfM framework appears to be limited. The researcher, based on the detailed information of input and output artefacts, aimed to highlight the existing mapping and made more explicitly the implementation order of the processes and the input-output interrelation established by these processes.

Artefacts are here defined as: approaches (e.g., SWOT analysis), criteria (e.g., Net Present Value - NPV, Internal Rate of Return - IRR and Payback), documents, legal requirements, processes, practices, guidance and templates (e.g., business case preparation), tactical information (strategy, portfolio delivery plan) and models.

In order to obtain the full mapping between artefacts and PfM processes, the researcher started to analyse the inputs and outputs artefacts. As an example, for the {PP7} DPCMP 'Develop Portfolio Communication Management Plan' process, the corresponding PP7-centric mapping analysis is briefly explained below. Analysing the input and output artefacts section of the PMI PfM framework shows (see Table 9) that the 'Organizational Process Assets' are an input artefact of the {PP7} DPCMP and the 'Portfolio Management Plan' is an input and an output artefact of the {PP7} DPCMP. The input artefacts of {PP7} DPMP are the 'Organizational Process Assets', 'Portfolio Process Assets', 'Portfolio', 'Portfolio Roadmap', 'Portfolio Management Plan', 'Risks and Issues Report', 'Governance Decisions Report' and 'Performance Report'. The output artefacts of {PP7} DPMP are 'Portfolio Process Assets' and 'Portfolio Management Plan'.

Table 9. {PP7} DPCMP matrix line

Portfolio Process / Artefacts	Enterprise Documents Artefacts							Portfolio Documents Artefacts							Portfolio Reports Artefacts										
	Organizational Strategy and Objectives	Organizational Communication Strategy	Organizational Risk tolerance	Organizational Performance Strategy	Enterprise Environmental Factors	Organizational Process Assets	Inventory of Work	Portfolio Process Assets	Portfolio Strategic Plan	Portfolio	Portfolio Roadmap	Portfolio charter	Portfolio Risk Management Plan	Portfolio Management Plan	Resources	Risks and Issues	Value and Benefits	Governance Decisions	Performance	Financial	Number of Artefacts	INPUT Number of Artefacts - Internal Process	INPUT Number of Artefacts - External Process	OUTPUT Number of Artefacts - Internal Process	OUTPUT Number of Artefacts - External Process
PCM {PP 7} DPCMP M,C,I						IN-E-A		I/O-A		IN-A	IN-A			I/O-A		IN-A		IN-A	IN-A		10	7	1	2	0

All these relations are described in Table 9 matrix, where an "IN" stands for input artefact (variant "IN-A" corresponds to internal artefacts of the PfM processes, and "IN-E-A" corresponds to external artefacts of PfM processes), "OUT-A" for output artefact, and "I/O-A" for input and output artefact (variant "I/O-A" corresponds to internal artefact of the PfM processes and "I/O-E-A" corresponds to external artefact of the PfM processes). Each matrix row indicates the PfM process source under analysis, and the columns constitute the mapped artefacts.

The elementary dependency analysis is performed for all the PfM processes, in order to create the complete matrix between artefacts and PfM processes (see Table 10). For a better understanding of the effective impact of the dependencies between all artefacts and all the PfM processes, the matrix is sorted by process groups (note the red gradient) and artefacts categories ('Enterprise Documents', 'Portfolio Documents' and 'Portfolio Reports').

Elementary Dependency Analysis with SPEM

In this section, the researcher describe how is characterized the elementary dependency between artefacts of a particular PfM process - what the researcher call the PP*n*-centric dependency analysis (*n* is the number of the PfM process; see Chapter 3, Table 3).

As an example, the researcher analyse the {PP4} DPMP 'Develop Portfolio Management Plan' again through its interaction with artefacts depicted in Figure 16.

The {PP4} DPMP process receives information through the artefacts 'organizational communication strategy', 'organizational risk tolerance', 'organizational performance strategy', 'enterprise environmental factors', 'organizational process assets', 'portfolio charter', 'portfolio roadmap', and sends information to the 'portfolio management plan'. The following artefacts are input and output of {PP4} DPMP: 'portfolio process assets' and 'portfolio strategic plan', as during this process ({PP4} DPMP) sometimes is necessary to conduct updates in these particular artefacts. All PfM processes in the depicted graph are positioned in the respective process group lane (as an example, the PP4 {DPMP} is located in the lane of the *Defining* process group).

Table 10. Mapping between all the PMI PfM processes and all artefacts

	Portfolio Process / Artefacts	Enterprise Documents Artefacts							Portfolio Documents Artefacts							Portfolio Reports Artefacts										
		Organizational Strategy and Objectives	Organizational Communication Strategy	Organizational Risk tolerance	Organizational Performance Strategy	Enterprise Environmental Factors	Organizational Process Assets	Inventory of Work	Portfolio Process Assets	Portfolio Strategic Plan	Portfolio	Portfolio Roadmap	Portfolio charter	Portfolio risk management plan	Portfolio management plan	Resources	Risks and Issues	Value and Benefits	Governance Decisions	Performance	Financial	Number of Artefacts	INPUT Number of Internal Artefacts	INPUT Number of External Artefacts	OUTPUT Number of Internal Artefacts	OUTPUT Number of External Artefacts
Defining Process Group	PSM {PP 1} DPSP S,M,C,I	IN-E-A	IN-E-A	IN-E-A	IN-E-A	IN-E-A	IN-E-A	IN-A	IN-A	OUT-A	OUT-A											10	2	6	2	0
	PSM {PP 2} DPC S,M,C,I					IN-E-A			I/O-A	I/O-A			OUT-A									6	2	1	3	0
	PSM {PP 3} DPR S,M,C,I									IN-A	IN-A	OUT-A	OUT-A									4	2	0	2	0
	PGM {PP 4} DPMP S,M,C,I		IN-E-A	IN-E-A	IN-E-A	IN-E-A	IN-E-A		I/O-A	I/O-A		IN-A	IN-A		OUT-A							12	4	5	3	0
	PGM {PP 5} DP S,M,C,I								IN-A	IN-A	I/O-A	I/O-A	IN-A		I/O-A							9	6	0	3	0
	PPM {PP 6} DPPMP S,M,C,I					IN-E-A	IN-E-A		I/O-A						I/O-A							6	2	2	2	0
	PCM {PP 7} DPCMP M,C,I						IN-E-A		I/O-A		IN-A	IN-A			I/O-A		IN-A		IN-A	IN-A		10	7	1	2	0
	PRM {PP 8} DPRMP S,M,C,I					IN-E-A	I/O-E-A		I/O-A					OUT-A	I/O-A							8	2	2	3	1
Aligning Process Group	PSM {PP 9} MSC M,C,I								I/O-A			OUT-A	OUT-A		OUT-A							5	1	0	4	0
	PGM {PP 10} OP S,M,C,I								I/O-A	IN-A	I/O-A	I/O-A	IN-A		I/O-A	I/O-A	I/O-A	I/O-A		I/O-A	I/O-A	20	11	0	9	0
	PPM {PP 11} MSD S,M,C,I										I/O-A				I/O-A	OUT-A	IN-A		OUT-A	OUT-A		8	3	0	5	0
	PPM {PP 12} MPV S,M,C,I								OUT-A	IN-A	OUT-A	IN-A			I/O-A	IN-A	IN-A		OUT-A	I/O-A		11	6	0	5	0
	PCM {PP 13} MPI M,C,I								I/O-A		IN-A				I/O-A	IN-A	I/O - A	IN-A	I/O - A	IN-A	IN-A	13	9	0	4	0
	PRM {PP 14} MPR M,C,I	IN-E-A				IN-E-A	OUT-A		I/O-A		IN-A			OUT-A	I/O-A	IN-A	OUT-A	IN-A			IN-A	13	6	2	5	0
Authorizing and Controlling Process Group	PGM {PP 15} AP S,M,C,I								OUT-A		I/O-A				I/O-A	I/O-A			OUT-A		I/O-A	10	4	0	6	0
	PGM {PP 16} PPO S,M,C,I								I/O-A	IN-A	I/O-A	IN-A	IN-A		I/O-A	I/O-A	I/O-A		OUT-A	I/O-A	I/O-A	18	10	0	8	0
	Number of processes	2	2	2	2	6	6	1	14	8	11	8	7	2	13	7	7	3	6	6	5					
	INPUT Number of Internal Processes	0	0	0	0	0	0	1	12	7	9	6	4	0	11	6	5	3	1	5	5					
	INPUT Number of External Process	2	2	2	2	6	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
	OUTPUT Number of Internal Process	0	0	0	0	0	1	0	12	3	7	4	3	2	13	4	3	1	4	4	3					
	OUTPUT Number of External Process	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0					

Elementary dependencies between artefacts are correctly identified in the PMI PfM framework. However, the overview of all PfM artefacts organized by process groups is not easily perceived. A Process Group includes the constituent PfM processes that are linked to the respective inputs and outputs (artefacts and PfM processes), where the result or outcome of one process becomes the input to another.

The Process Groups should not be thought as PfM phases (PMI, 2013c). This is why our systematic analysis is applied to highlight all the detailed overall dependencies between the complete set of portfolio artefacts.

For the mapping of dependencies between PfM processes and artefacts is used Software Process Engineering Metamodel (SPEM) version 2.0, which is an Object Management Group (OMG) Standard, and is based on a metamodel containing three main elements: activity, work product and process role. SPEM2.0 is the standard dedicated to software process modelling. It aims to provide organizations with means to define a conceptual framework, offering the necessary concepts for modelling, interchanging, documenting, managing and presenting their development methods and processes (OMG, 2008).

Process modelling allows human understanding, process communication, its automation and its improvement, where SPEM 2.0 supports process modelling, and business Process Modelling notation, which supports the modelling of business processes (Garcia, Vizcaino, & Ebert, 2011).

Process Group Centric Dependency Analysis with SPEM

The objective of centric dependency analysis is to focus on the dependencies between artefacts and portfolio processes related to a specific process group. For this purpose, three additional models have been created. They are called *PG-n Centric Dependency Analysis Model* (where *n* corresponds to the process group under study: 1 – *defining*, 2 – *aligning* and 3- *authorizing and controlling*).

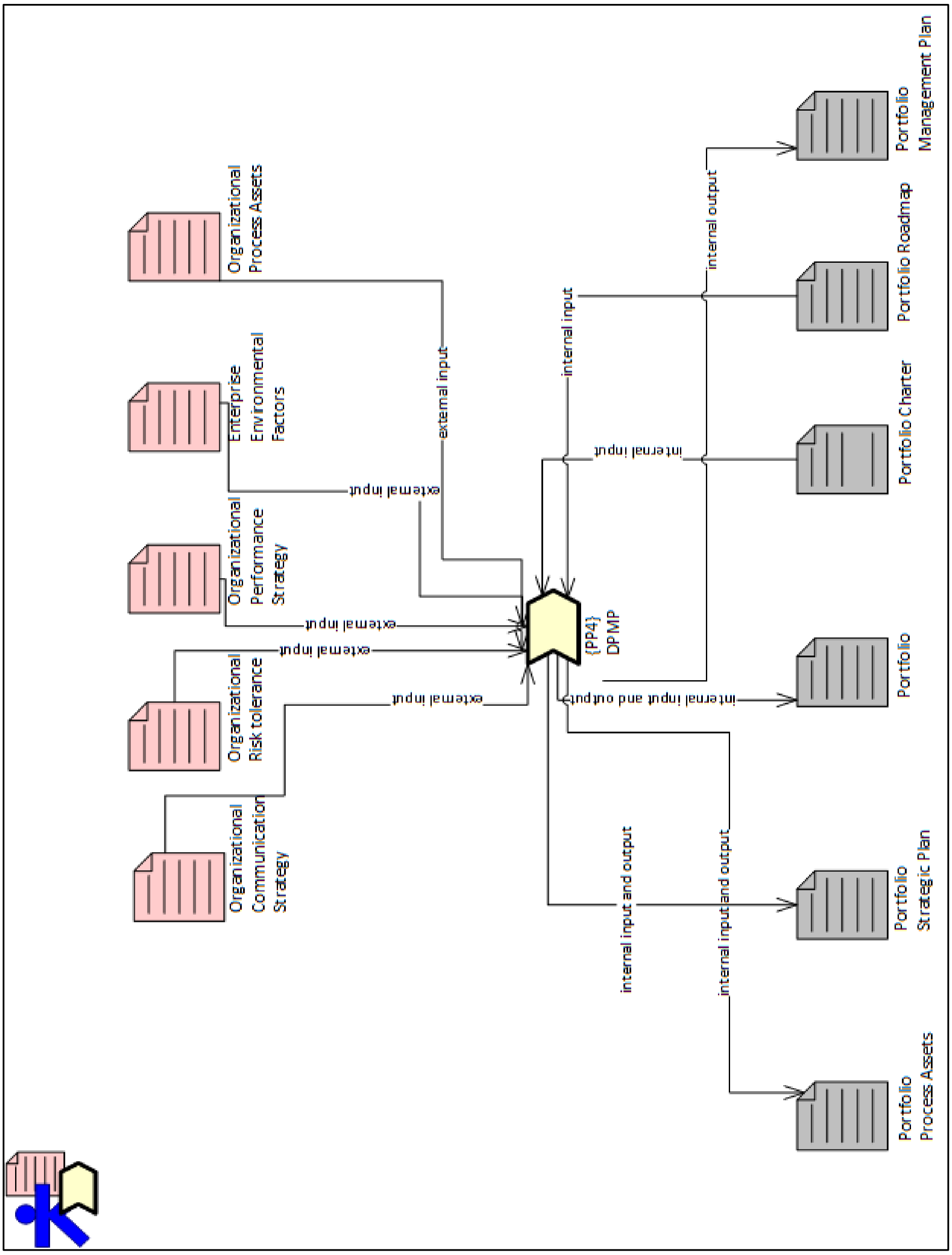

Figure 16. PP4-Centric Dependency Analysis

Figure 17, Figure 18 and Figure 19 present, respectively, the *PG-1, PG-2* and *PG-3 Centric Dependency Analysis Model*. As an example, the construction of the *PG-1 Centric Dependency Analysis Model* uses the information of the first eight rows of the global matrix (see Table 10) that correspond to the *defining* process group.

The artefacts in red tone are related to the category ‘Enterprise Documents’, those in light grey tone belong to the category ‘Portfolio Documents’, and those in dark grey tone are connected to the category ‘Portfolio Reports’.

To a better understanding of the creation of the PG-1 model, the {PP1} DPSP ‘Develop Portfolio Strategic Plan’, {PP2} DPC ‘Develop Portfolio Charter’ and {PP7} DPCMP ‘Develop Portfolio Communication Management Plan’ are analysed as an example. To show in the model the dependencies faced by the {PP1} DPSP process with the artefacts, the researcher must parse the matrix row that corresponds to {PP1} DPSP as described in Table 10. This process presents a considerable number of dependencies from organizational artefacts: ‘organizational strategy and objectives’, ‘organizational communication strategy’, ‘organizational risk tolerance’, ‘organizational performance strategy’, ‘enterprise environmental factors’, ‘organizational process assets’, ‘inventory of work’, ‘portfolio process assets’, ‘portfolio strategic plan’ and ‘portfolio’.

The {PP1} DPSP has a high dependency on external artefacts (‘Enterprise Documents’ category), artefacts which are developed out of the PfM process. The dependency on external artefacts (‘Enterprise Documents’ category) for the execution of {PP1} DPSP may create risks for the execution of this process.

The {PP2} DPC is only dependent on the external artefact ‘enterprise environmental factors’, and receives information already created by {PP1} DPSP, the ‘portfolio strategic plan’, and ‘process portfolio assets’ artefacts. The artefact generated for {PP2} DPC is ‘portfolio charter’.

The {PP7} DPCMP is the only process, for *defining* process group, which has as input artefact the ‘portfolio reports’ category, namely, ‘risks and issues’, ‘governance decisions’ and ‘performance’ reports.

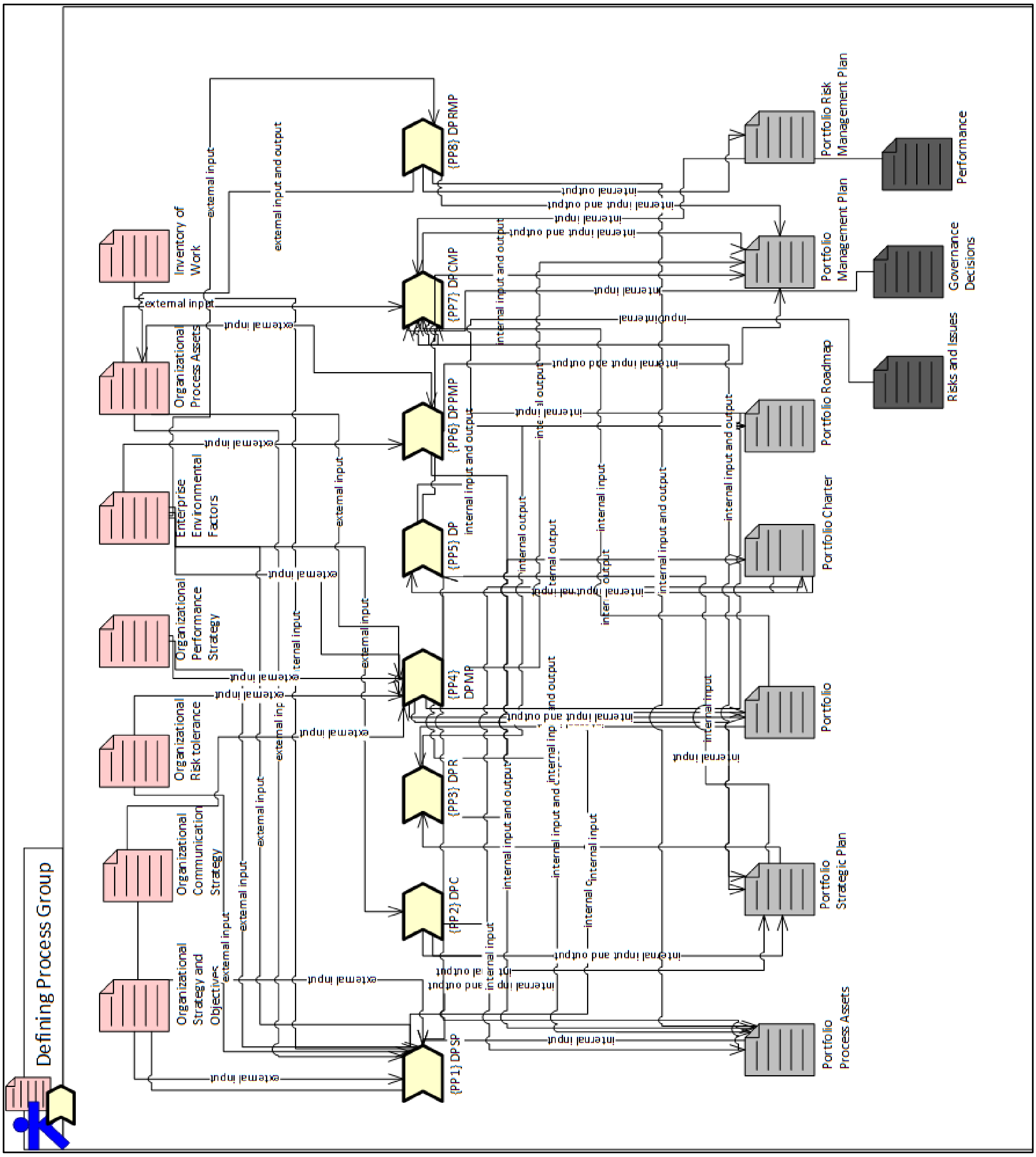

Figure 17. PG-1 Centric Dependency Analysis Model

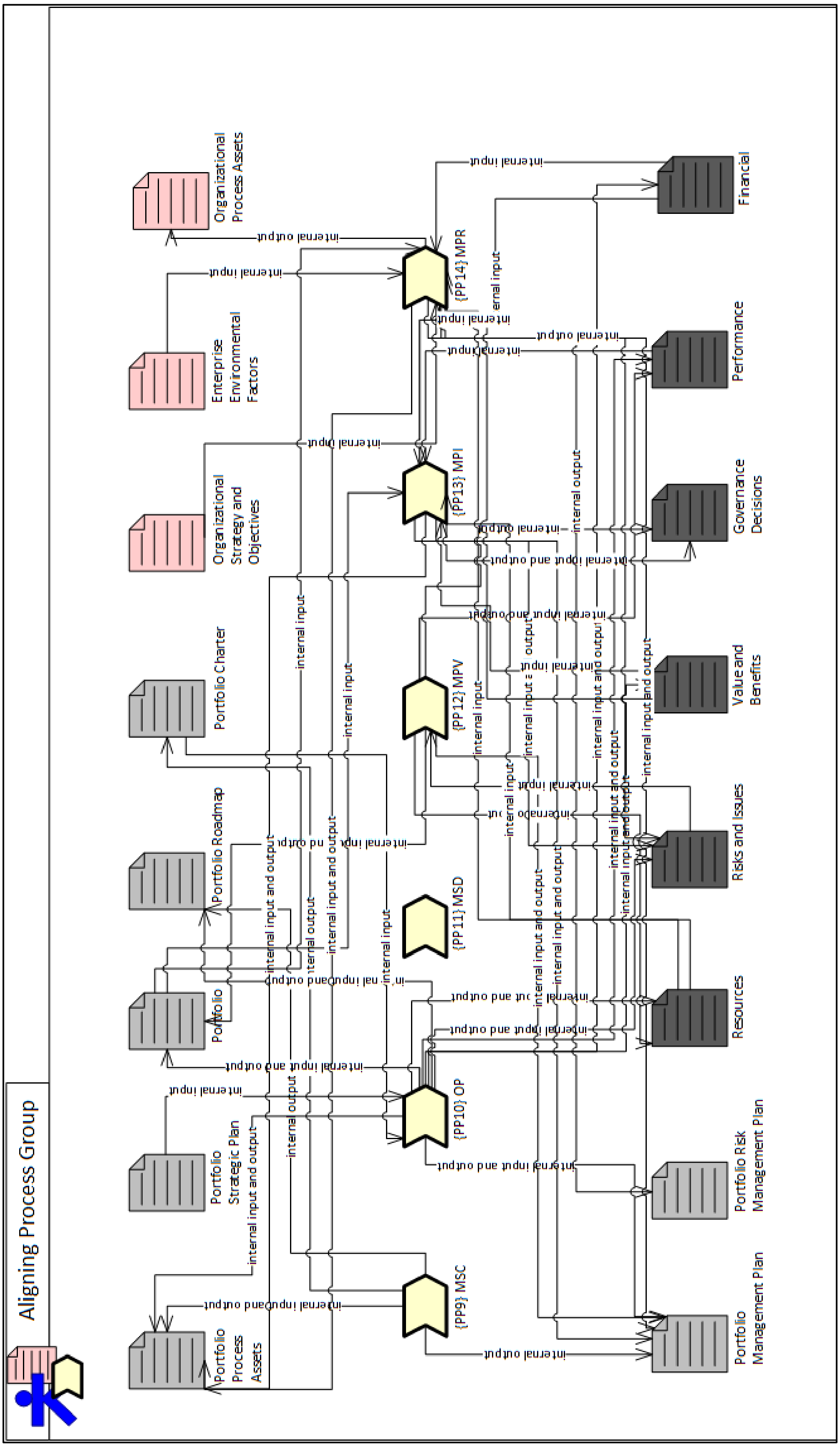

Figure 18. PG-2 Centric Dependency Analysis Model

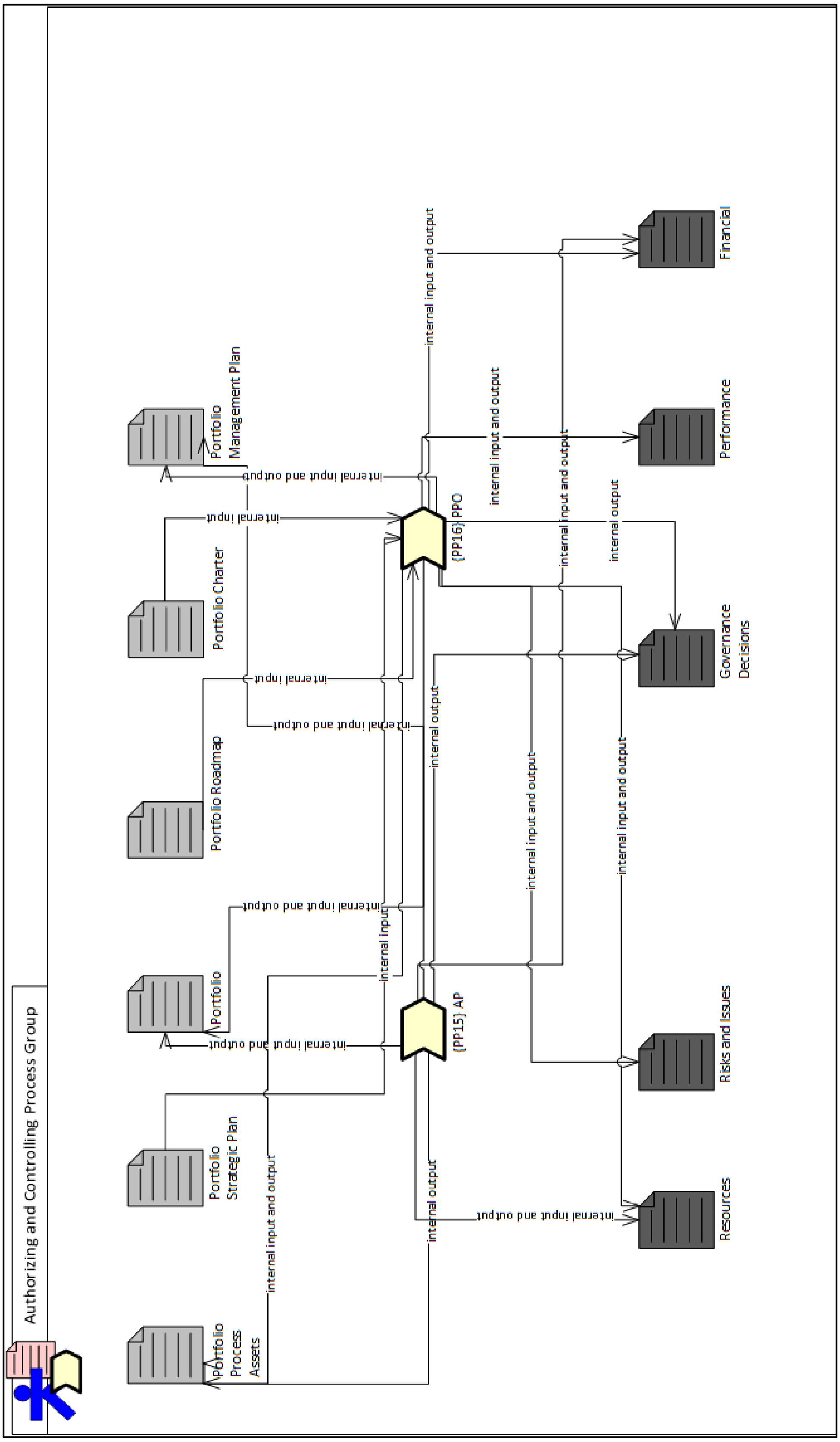

Figure 19. PG-3 Centric Dependency Analysis Model

Figure 18 emphasizes that the *aligning* process group receives more information from the ‘Portfolio Documents’ category and produces more outputs for the ‘Portfolio Reports’ category. The *aligning* process group is the process group that is already implemented when monitoring the portfolio, with few dependencies from organizational artefacts, using more PfM documents and creating PfM control reports for the organization.

From the {PP 10} OP process until the {P13} MPI process there are many inputs from artefacts of the ‘Portfolio Report’ category and also outputs from the ‘Portfolio Documents’ and ‘Portfolio Report’ categories.

Figure 19 shows the PG-3 centric dependency analysis model that supports the dependency analysis of the only two existing processes within the *authorizing and controlling* process group: the {PP15} AP and the {PP16} PPO. These two processes are mainly recipients of information of the ‘Portfolio Documents’ and ‘Portfolio Reports’ artefacts category. By analysing the model, it is possible to perceive that the two processes of the *authorizing and* contr*olling* process group are relevant closing processes of the PfM life cycle, through the output artefact ‘Portfolio Report’ category.

Summarizing, the researcher can conclude that: (1) the {PP1} DPSP generates information for execution of the {PP2} DPC and the {PP3} DPR; (2) the {PP3} DPR is the first process of the *defining* group to use only artefacts of the ‘Portfolio Documents’ category, showing that organizational information is already included in the ‘portfolio strategic plan’ and ‘portfolio’ artefacts; (3) the {PP4} DPMP is the process with strong dependence of organizational artefacts of the ‘Enterprise Documents’ category, and together with {PP5} DP are the processes with more outputs to the ‘Portfolio Documents’ category; therefore they are the processes with greater importance and stronger impact on the *defining* process group; (4) the {PP5} DP and the {PP6} DPPMP receive many inputs from {PP4} DPMP through artefacts of the ‘Portfolio Documents’ category that, in turn, are refined by introducing new information to the same artefacts and contributing to new artefacts of PfM; (5) the {PP8} DPRMP, as the last process to be executed on the *defining* process group, practically receives as input artefacts the ‘Enterprise Documents’ and ‘Portfolio Documents’ categories, and as output artefacts the ‘Portfolio Documents’ category; (6) the *aligning* process group is characterized by default to use the ‘Enterprise Documents’ artefacts, except the {PP14} MPR, which as well as receiving as input artefact an ‘Enterprise Documents’ artefact, also contributes to an ‘Enterprise Documents’ artefact; (7) the {PP10} OP is the process with the most interactions (input and output) between artefacts; (8) the ‘portfolio process assets’ is the most used artefact as input in the processes; and, (9) the ‘portfolio management plan’ is the most updated artefact from the PfM processes (the artefact that more interaction receives from processes, both at the input and output level), by referring in jointly with the ‘portfolio process assets’ as fundamental artefacts for PfM.

4.4 Mapping between OGC Artefacts and Practices

The mapping between practices of OGC PfM framework is not performed, because the main objective is to understand which artefacts exist in each of the practices.

For the effective PfM in organizations, managers must have artefacts that allow them to execute the practices defined by the standards. In the OGC PfM framework, there is no effective mapping between practices and artefacts.

As an example, for the *balance* practice, {PMCP 4} PDFB, the ‘strategic objectives’ artefact is an input and the ‘portfolio’ artefact is both an input and an output. In Table 11, there are described all the relations, where an “IN” stands for input artefact, “OUT” for output artefact, and “I/O” for input and output artefact. In fact, Table 11 is the result of the cut on Table 12, corresponding to the PMCP4 - centric mapping analysis. In the matrix depicted in Table 11, each column represents one portfolio practice and each line represents one artefact.

For each practice, the artefacts are analysed, as input and output, of the OGC PfM framework. The result of this analysis is presented in Table 12.

As referred before, the complete matrix (see Table 12) is created with elementary dependency analysis for all the PfM practices. The matrix is sorted by Portfolio Management Cycles Practices-PMCP (note the white and red colour), and PMCP artefacts.

Table 11. {PMCP4} PDFB column

PMCP ARTEFACTS	Artefacts/ Portfolio Management Cycles (practices)	Portfolio Definition Cycle {PMCP 4} PDFB
Strategic Objectives	Market Stading	IN
Strategic Objectives	Innovation	IN
Strategic Objectives	Human Resources	IN
Strategic Objectives	Financial Resources	IN
Strategic Objectives	Physical Resources	IN
Strategic Objectives	Productivity	IN
Strategic Objectives	Social Responsability	IN
Strategic Objectives	Profit Requirements	IN
Organizational Environmental Analysis	SWOT analysis	
Organizational Environmental Analysis	PESTLE analysis	
Organizational Environmental Analysis	Porter's five forces analysis	
	Individual Stakeholder Engagement and Communication Plans	
	Organizational Management Strategy and Risk	
	Governance Structures	
	Portfolio Risk Management Strategy	
	Financial Metrics and Investment Criteria	OUT
	Portfolio	I/O
	Portfolio Maps	OUT
	Portfolio reports	
	Portfolio Scope	
	Portfolio's Categorization	
	Portfolio's Governance	OUT
	Portfolio Strategy	OUT
	Benefits Forecast	OUT
	Portfolio-level Benefits Realization Plan	
	Portfolio's Business Case	
	Financial Plan	
	Portfolio's Performance	OUT
	Portfolio-level Performance Metrics	
	Portfolio Stakeholder Engagement and Communication Plan	
	Portfolio Resource Schedule	
	Resource Forecast	
	Portfolio Skills Register	
	Standards and Templates to guide programme and project Planners	
	Lessons Learned	
Portfolio Delivery Plan	Schedule	
Portfolio Delivery Plan	Resources	
Portfolio Delivery Plan	Cost	
Portfolio Delivery Plan	Risk	I/O
	Portfolio-level financial plan	

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Table 12. Mapping all artefacts and all Portfolio Practices for PfM

Artefacts/ Portfolio Management Cycles (practices)		Portfolio Definition Cycle					Portfolio Delivery Cycle							Number of Artefacts	INPUT Number of Artefacts	OUTPUT Number of Artefacts
		(PMCP 1) PDFU	(PMCP 2) PDFC	(PMCP 3) PDFP	(PMCP 4) PDFB	(PMCP 5) PDFP	(PMCP 6) PDLMC	(PMCP 7) PDLBM	(PMCP 8) PDLFM	(PMCP 9) PDLRM	(PMCP 10) PDLSE	(PMCP 11) PDLOG	(PMCP 12) PDLREM			
PMCP ARTEFACTS — Strategic Objectives	Market Stading	IN	IN	IN	IN		IN	I/O				I/O		9	7	2
Strategic Objectives	Innovation	IN	IN	IN	IN		IN	I/O				I/O		9	7	2
Strategic Objectives	Human Resources	IN	IN	IN	IN		IN	I/O				I/O	I/O	11	8	3
Strategic Objectives	Financial Resources	IN	IN	IN	IN		IN	I/O	IN			I/O	I/O	12	9	3
Strategic Objectives	Physical Resources	IN	IN	IN	IN		IN	I/O				I/O	I/O	11	8	3
Strategic Objectives	Productivity	IN	IN	IN	IN		IN	I/O				I/O		9	7	2
Strategic Objectives	Social Responsability	IN	IN	IN	IN		IN	I/O				I/O		9	7	2
Strategic Objectives	Profit Requirements	IN	IN	IN	IN		IN	I/O				I/O		9	7	2
Organizational Environmental Analysis	SWOT analysis	IN												1	1	0
Organizational Environmental Analysis	PESTLE analysis	IN												1	1	0
Organizational Environmental Analysis	Porter's five forces analysis	IN												1	1	0
Individual Stakeholder Engagement and Communication Plans											IN			1	1	0
Organizational Management Strategy and Risk				IN						I/O				3	2	1
Governance Structures												IN		1	1	0
Portfolio Risk Management Strategy										OUT		OUT		2	0	2
Financial Metrics and Investment Criteria				IN	OUT		OUT		IN					4	2	2
Portfolio		OUT	OUT	I/O	I/O	OUT	I/O	I/O	IN	OUT		OUT		14	5	9
Portfolio Maps				OUT	OUT	OUT	OUT	OUT	OUT	OUT				7	0	7
Portfolio reports							OUT	OUT	OUT	OUT				4	0	4
Portfolio Scope		OUT	OUT			OUT				IN				4	1	3
Portfolio's Categorization			OUT							OUT			OUT	3	0	3
Portfolio's Governance			OUT		OUT		I/O	I/O		I/O		OUT		9	3	6
Portfolio Strategy		OUT	OUT	I/O	OUT	I/O	IN		I/O			OUT		11	4	7
Benefits Forecast		OUT		OUT	OUT	OUT	OUT	I/O						7	1	6
Portfolio-level Benefits Realization Plan								OUT		OUT				2	0	2
Portfolio's Business Case							I/O	IN	IN	IN	OUT	I/O		8	5	3
Financial Plan									IN					1	1	0
Portfolio's Performance					OUT		OUT	IN						3	1	2
Portfolio-level Performance Metrics							OUT							1	0	1
Portfolio Stakeholder Engagement and Communication Plan											OUT			1	0	1
Portfolio Resource Schedule													OUT	1	0	1
Resource Forecast													OUT	1	0	1
Portfolio Skills Register													OUT	1	0	1
Standards and Templates to guide programme and project Planners													OUT	1	0	1
Lessons Learned							OUT	OUT						2	0	2
Portfolio Delivery Plan	Schedule					OUT	I/O	I/O	OUT	OUT			OUT	8	2	6
Portfolio Delivery Plan	Resources	OUT	OUT			OUT	I/O	I/O	OUT	OUT			OUT	10	2	8
Portfolio Delivery Plan	Cost	OUT	OUT			OUT	I/O	I/O	I/O	OUT				10	3	7
Portfolio Delivery Plan	Risk			OUT	I/O	OUT	I/O	I/O	OUT	I/O		OUT		12	4	8
Portfolio-level financial plan		OUT							OUT					2	0	2
Number of Artefacts		18	15	17	18	10	30	36	15	17	3	24	13			
INPUT Number of Artefacts		11	8	12	10	1	16	17	7	5	1	10	3			
OUTPUT Number of Artefacts		7	7	5	8	9	14	19	8	12	2	14	10			

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Elementary Dependency Analysis

The researcher present the characterization of the elementary dependency that exists in the artefacts of a concrete PfM practice; the researcher denominate this the *PMCP n-centric dependency analysis* (where n corresponds to the number of the PfM practice; see Chapter 3, Table 5).

As an example, depicted in Figure 20, the researcher analyse the interaction between practices with artefacts, through {PMCP 3} PDFP 'Prioritize' practice.

The {PMCP 3} PDFP practice receives information of the following artefacts: 'strategic objectives', 'organizational management strategy and risk', 'financial metrics and investment criteria', 'portfolio', and 'portfolio strategy'. Taking into account that during this practice sometimes it is necessary to conduct updates in some particular artefacts, 'portfolio' and 'portfolio strategy' are simultaneously input and output artefacts of {PMCP 3} PDFP. As output artefact, only 'benefits forecast' is referable.

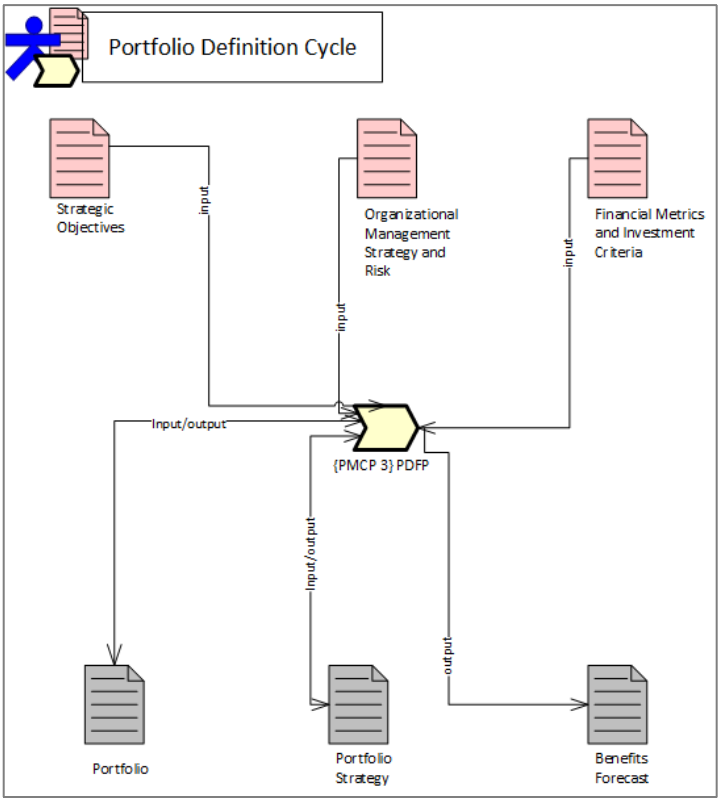

Figure 20. {PMCP 3} PDFP - Centric Dependency Analysis

Portfolio Management Cycles Centric Dependency Analysis

In the OGC PfM framework, the overview of the input and output artefacts of the practices in the PfM cycles, as well as their dependencies, is not perceived. So, the researcher apply a systematic analysis with the objective of highlighting these same dependencies for all the practices and the set of all the artefacts.

The purpose of the centric dependency analysis is to highlight the relations that exist between the artefacts and the MoP practices in the cycles of the specific portfolio management. The researcher denominate this the *PMC-n Centric Dependency Analysis Model* (where, n corresponds to the cycle of the portfolio management: 1 – Definition, 2 – Delivery).

Figure 21 and Figure 22 present, respectively, the PMC-1 and PMC-2 Centric Dependency Analysis Model. As an example, the PMC-1 Centric Dependency Analysis Model uses the information of the first five columns of the global matrix (see Table 12), corresponding to the 'Portfolio Definition Cycle'. All practices are positioned in the respective Portfolio management cycles lane. For a better understanding of the types of artefacts, the researcher represent the 'Enterprise Artefacts' category in red tone and the 'Portfolio Artefacts' category in grey tone.

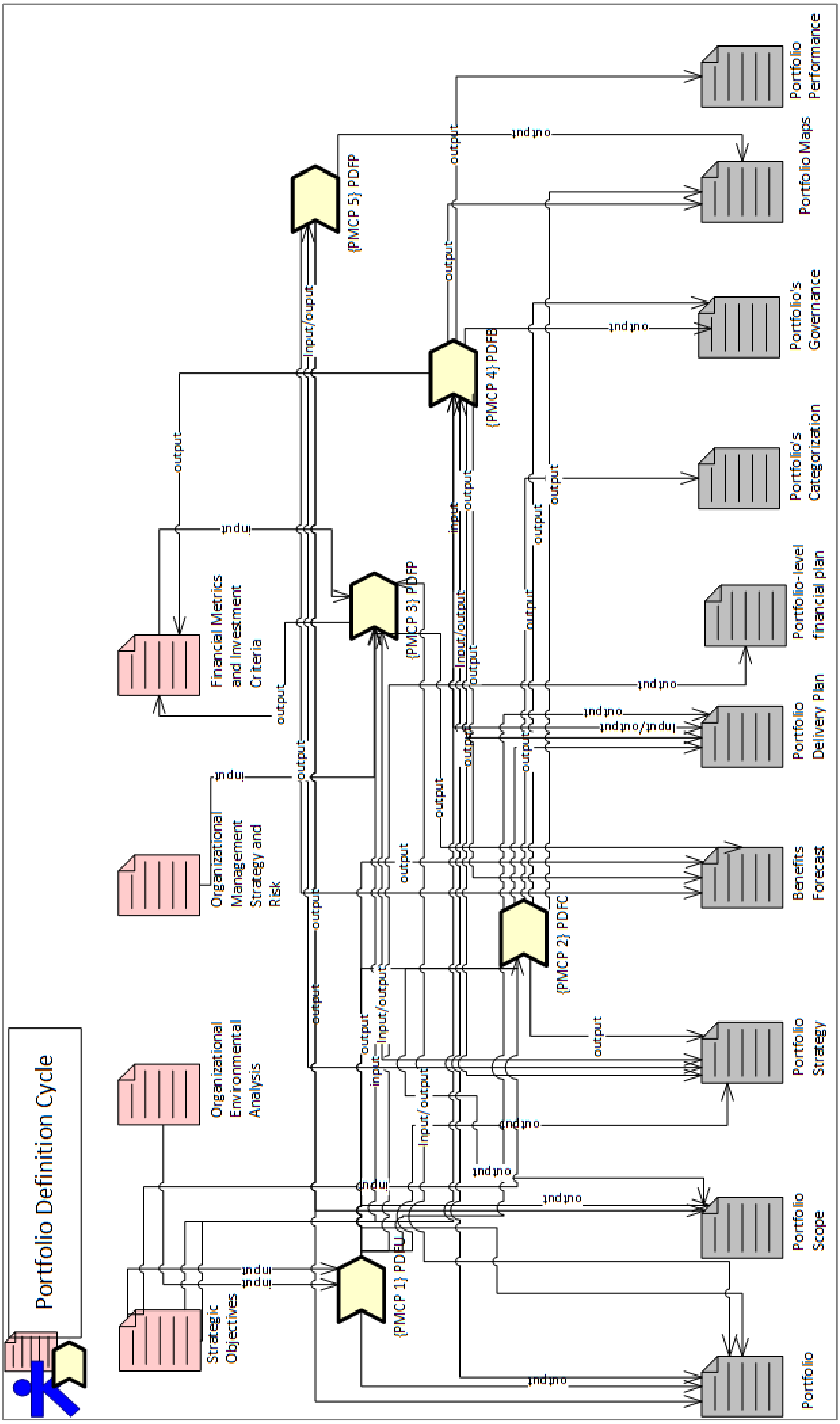

Figure 21. PMC-1 Centric Dependency Analysis Model

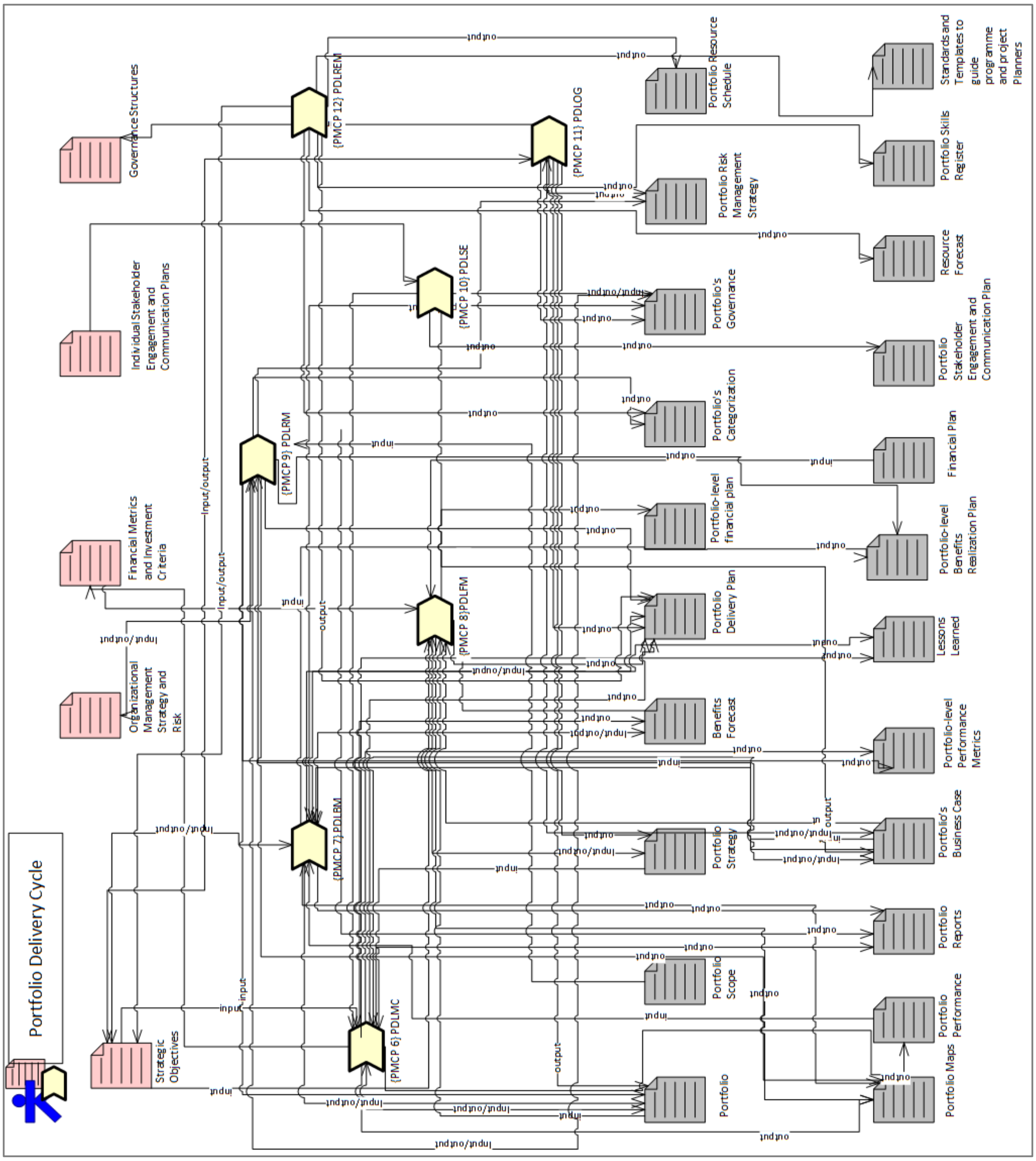

Figure 22. PMC-2 Centric Dependency Analysis Model

As an example, for the creation of the PMC-1 model, the {PMCP 1} PDFU ‘understand’ practice, the {PMCP 2} PDFC ‘categorize’ practice, and the {PMCP 3} PDFP ‘prioritize’ practice are analysed. To represent in the model the dependencies faced by the {PMCP 1} PDFU practice with the artefacts, the researcher must parse the matrix column that corresponds to the {PMCP 1} PDFU practice, as shown in Table 12. This {PMCP 1} PDFU practice presents a considerable number of artefacts: ‘strategic objectives’, ‘organizational environmental analysis’, ‘portfolio’, ‘portfolio scope’, ‘portfolio strategy’, ‘benefits forecast’, ‘portfolio delivery plan’ (resources and cost), and ‘portfolio-level financial plan’. The {PMCP 1} PDFU practice presents a high dependency from ‘Enterprise Artefacts’, which are developed outside the scope of the PfM process. Therefore, this dependency from external artefacts may create serious risks for the execution of this practice.

The {PMCP 2} PDFC practice is only dependent on the external artefact strategic objectives and generates, as output, several artefacts: ‘portfolio’, ‘portfolio scope’, ‘portfolio categorization’, ‘portfolio governance’, ‘portfolio strategy’, and ‘portfolio delivery plan’ (resources and cost). These three last artefacts are simultaneously output artefacts from the {PMCP 2} PDFC practice.

The {PMCP 3} PDFP practice depends on two of the artefacts produced by {PMCP 1} PDFU practice and {PMCP 3} PDFC practice: the ‘portfolio’ and the ‘portfolio strategy’. It produces several artefacts as outputs: ‘portfolio maps’, ‘benefits forecast’, and ‘portfolio delivery plan’ (risk).

Figure 22 emphasizes the fact that the set of practices within the ‘Portfolio Delivery Cycle’ receives more information from the ‘Portfolio Artefacts’ and presents few dependencies from the ‘Enterprise Artefacts’. This confirms the ‘Portfolio Delivery Cycle’ as the set of practices intended to monitor the portfolio and, thus, more focused on the development of documents and control reports for feeding back the organization in what concerns the way the portfolio is being managed.

Based on the analysis of Figure 21 and Figure 22, several main findings can be drawn:

(1) {PMCP 1} PDFU is the practice with the strongest dependence from 'Enterprise Artefacts', and that generates the first PfM artefacts: 'portfolio', 'portfolio scope', 'portfolio strategy', 'benefits forecast', 'portfolio-level financial plan' and 'Portfolio Delivery Plan (cost and resources)';

(2) Mainly based on the strategic objectives artefact, the {PMCP 2} PDFC practice generates several 'Portfolio Artefacts', namely the 'portfolio categorization' artefact, which supports the decision to categorize the projects in the portfolio;

(3) {PMCP 4} PDF is the first practice in the 'Portfolio Definition Cycle' to generate information (artefacts) for the 'financial metrics and investment criteria';

(4) {PMCP 5} PDFP practice does not need any 'Enterprise Artefact' to be performed;

(5) {PMCP 6} PDLMC practice stands out for the generation of control artefacts, such as: 'portfolio', 'portfolio maps', 'portfolio reports', 'portfolio governance', 'portfolio business case', 'portfolio-level performance metrics', 'lessons learned' and 'portfolio delivery Plan';

(6) {PMCP 7} PDLBM practice is the practice that demands more inputs and generates more artefacts in the entire OGC PfM framework. In opposition, {PMCP 10} PDLSE is the practice that demands fewer inputs and generates less artefacts;

(7) {PMCP 8} PDLFM practice uses, as input artefacts of the 'Enterprise Artefacts' category, the 'strategic objectives (financial resources)' and 'financial metrics and investment criteria', and in the 'portfolio artefacts' category, it uses the 'portfolio business case', 'financial plan' (only used in this practice), and 'portfolio delivery plan (cost)'. This practice is concerned with input and output artefacts regarding financial component of the PfM;

(8) {PMCP 9} PDLRM uses artefacts of the 'Enterprise Artefacts' category, such as 'organizational management strategy and risk' and 'portfolio delivery plan

(risk)', and contributes to several artefacts, namely the 'portfolio risk management strategy';

(9) The {PMCP 11} PDLOG practice uses the 'strategic objectives' artefact, and it is also an explicit contribution (output artefact) to this same artefact;

(10) The {PMCP 12} PDLREM practice is concerned with the necessary resources, and generates the following artefacts: 'portfolio resource schedule', 'resource forecast', 'portfolio skills register', and 'standards and templates to guide program and project planners';

(11) The PfM practices that need more input information are: {PMCP 7} PDLBM, followed by {PMCP 6} PDLMC;

(12) The practice that generates more information is {PMCP 7} PDLBM, evidencing the concern of the OGC PfM framework for portfolio benefits realization;

(13) 'Strategic objectives' artefact is the most commonly used 'Enterprise Artefact' category; finally;

(14) 'Portfolio maps' and 'portfolio strategy' artefacts are the most updated artefacts.

4.5 Conclusions

The theoretical contribution of this research work is the knowledge building in the PfM area, whose current level still shows gaps concerning the practices and processes, which must be performed in an organization, and how professionals must perform them using the available artefacts, processes and practices. Therefore, the first step was to analyse and map the dependencies between the PMI PfM Framework processes. The second step was to analyse the input and output artefacts into portfolio practices from the OGC PfM framework. The next step will be to analyse the mapping between artefacts and portfolio processes of the PMI PfM framework.

In the particular context of this study, IT development organizations, the {PP4} DPMP process, with a strong dependency on organizational artefacts, is particularly important to establish the project requirements boundaries. Defining requirements in IT development projects is often very complex, namely because of the high number of stakeholders involved and the complexity of the scope definition. The implementation of the {PP16} PPO process, which receives inputs mainly through internal artefacts, needs to take into account the different approaches to managing software projects. In software development companies it is common to coexist more traditional approaches and more agile approaches for managing different types of software projects, which brings many implications on how to monitor the portfolio to ensure alignment with the organization's strategy and objectives.

Moreover, through the 'process portfolio assets', 'portfolio management plan' and 'portfolio' artefacts, it is verified the need for inputs of the artefacts generated from the management of IT development projects, because of the particularity of the development process (agile or waterfall) and outputs generated by the IT development project, whose goal is to enrich the 'Portfolio' artefact with characteristics and criteria of IT development projects.

The strong dependency of the {PMCP 1} PDFU on the 'Enterprise Artefacts' category is important to establish the project requirements boundaries in IT development organizations. As referred above, the complexity of requirements definition in IT development projects may be high, namely when there is a high number of stakeholders and/or when there is, indeed, a complex scope. Therefore, the {PMCP 10} PDLSE is also extremely relevant to address this issue.

The next Chapter compares these two PfM frameworks from PMI and OGC, in order to better understand PfM processes, practices and artefacts, and to propose a tailored PfM framework for IT development projects, with customized PfM practices/processes and artefacts for this particular organizational context, based on these authoritative PMI and OGC frameworks, as PfM is context dependent.

CHAPTER 5
TAILORING PMI AND OGC PORTFOLIO FRAMEWORKS

Summary: This chapter presents the mapping between artefacts form OGC PfM framework and PMI PfM framework. After, the researcher describes the mapping between PMI PfM framework processes and OGC PfM framework artefacts, with the objective of presenting a tailored IT PfM framework based on the two frameworks, PMI and OGC. Section 5.3 presents the specification of the dependency analysis between OGC PfM artefact and PMI PfM processes using BPMN model, and shows the traceability map of the artefact OGC.A [27.1] Portfolio Delivery Plan - Schedule using Unified Modelling Language (UML) State Machine Model.

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CHAPTER 5: TAILORING PMI AND OGC PORTFOLIO FRAMEWORKS

"Project Portfolio Management is needed today as never before, as Project Portfolio Management leaders help their organizations through the challenges of digitalization, combined with an ongoing need to keep costs under control…"

– Gartner (2017, p.4)

5.1 Introduction

The strategy definition in organizations and its implementation by projects has been difficult to achieve (Abdollahyan, 2011; Charan, Ram; Colvin, 1999; Moore, 2010). PfM processes provide the linkage between the organization's strategic objectives and their programs and projects (PMI, 2013c). It is worthless to have the latest technology and resources to develop projects, if there are no organized processes and focus on strategic interests (Dickinson, Thornton, & Graves, 2001). Therefore, PfM is crucial for organizations in general and in particular to IT organizations.

IT governance is defined as a set of structures and processes in order to ensure IT support, to adequately maximize the organization's business objectives and strategies by adding value to the services provided, weighing the risks and obtaining a return on IT investment (Youssfi, Boutahar, & Elghazi, 2014). In an IT organization, the portfolio includes all operations, and IT projects already underway. For all these operations and projects to be successful, PfM practices, processes or methods must be used (Castillo, 2016; Teller, Kock, & Gemünden, 2014).

Organizations need to develop processes, tools, and techniques that support their business, to act at the required level, but keeping in mind that these processes and tools need to evolve over time (McCarthy, Tsinopoulos, Allen, & Rose-Anderssen, 2006). There are different tools and techniques that can be used in estimating, evaluating, and choosing projects for a portfolio. However, many of these techniques are not widely applied, because of its complexity, requiring many input data, or simply because of their high degree of difficulty in understanding and use by decision makers (Archer & Ghasemzadeh, 1999).

Some PfM frameworks have been developed, with the premise of providing practices able to guide the process of selecting, prioritizing and monitoring projects (Archer & Ghasemzadeh, 1999; Bitman & Sharif, 2008; Blau, Pekny, Varma, & Bunch, 2004; Cooper et al., 1997; Cooper, Edgett, & Kleinschmidt, 1999; Mikkola, 2001). One of the risks identified in the successful implementation of PfM is the emergence of errors in implementation of PfM processes (Cagno, Caron, & Mancini, 2007; Costantino, Gravio, & Nonino, 2015), suggesting that PfM practices should be appropriately customised to individual situations, as different practices are required in different contexts (Martinsuo, 2013).

The PMI PfM framework presents the knowledge of PfM through a set of processes (PMI, 2013c), and OGC PfM framework as a set of practices (Axelos, 2011). These processes and practices have emerged as an approach to support decision making in organizations. The methods, techniques, and tools contribute to the minimization of uncertainties and systematization of the decision. Thus, PfM ensures that the set of projects in the portfolio meets the business' objectives.

Therefore, for a better understanding and deepening of processes and artefacts for PfM, this chapter, in the first phase, aims to map the artefacts between the two PfM frameworks, PMI and OGC. In the second phase, the proposed framework is based on PMI PfM processes and OGC PfM artefacts. For a better understanding of the process, inputs and outputs artefacts, the IT PfM framework is modelled using the BPMN-*Business Process Modelling Notation* (OMG, 2013).

5.2 Mapping between PMI PfM Artefacts and OGC PfM Artefacts

PfM practices are merely seen as those tools and techniques that practitioners use to "execute a PfM process", such as work breakdown structure or a project charter. Tools and techniques are closer to the day-to-day practice, closer to the things people do, closer to their tacit knowledge (Besner & Hobbs, 2008).

PMI PfM framework is considered to be the most complete for PfM (McDonald & Sarbazhosseini, 2013; Young & Conboy, 2013), but by the analysis done, OGC PfM framework has a greater wealth of how to execute processes, through numerous artefacts.

Therefore, for a better understanding and deepening of PfM, the full mapping between PMI PfM artefacts and OGC PfM artefacts is developed. Based on her extensive professional experience in PfM, the researcher starts to analyse deeply if a given OGC PfM artefact "do not fully represent", "represent approximately", "have more information" or "simply are different" from a PMI PfM artefact.

The artefacts definitions in both frameworks (Axelos, 2011; PMI, 2013c) are carefully considered for the mapping between PMI PfM artefacts and OGC PfM artefacts; as well as for the PMI PfM artefact concepts is also used the Framework for Project Management, the PMBoK (PMI, 2013a).

Table 13 presents definitions of all artefacts used in PMI PfM processes. Whereas artefacts are documents, but also, procedures, definitions of processes, among others.

Table 14 presents definitions of all artefacts used in OGC PfM practices. Whereas artefacts are documents, but also, procedures, definitions of practices, among others.

Table 13. PMI PfM Artefacts Definitions (PMI, 2013a, 2013c)

PMI Artefacts	Artefacts Definitions
PMI.A[1] Organizational Strategy and Objectives	An organizational document that contains the mission and vision statements as well as goals, objectives, and strategies intended to achieve the vision.
PMI.A[2] Organizational Communication Strategy	Organizational Communication Strategy focused on satisfying the most important information needs of stakeholders so that effective portfolio decisions are made and organizational objectives are met.
PMI.A[3] Organizational Risk tolerance	Organizational Risk tolerance is the degree, volume or amount of risk that an organization can withstand. It indicates how sensitive organizations, stakeholders, and people are towards risks. High tolerance often means that organizations welcome high risks while tolerance tells otherwise.
PMI.A[4] Organizational Performance Strategy	Organizational Performance Strategy describes performance measures, reporting (on scope, cost, schedule, and resources), resource optimization, and benefits realization for organization.
PMI.A[5] Enterprise Environmental Factors	Conditions, not under the immediate control of the team, that influence, constrain, or direct the project, program, or portfolio. Organizational governance processes, culture, and detailed hierarchy structure; legal constraints; governmental or industry standards (e.g., regulatory agency regulations, codes of conduct, product standards, quality standards, and workmanship stand-ards); infrastructure (e.g., existing facilities and capital equipment); Existing a human resources (e.g., skills, disciplines, and knowledge, such as design, development, law, contracting, and purchasing, personnel administration (e.g., hiring and firing guide-lines, employee performance reviews, and training records), marketplace condition".
PMI.A[6] Organizational Process Assets	Plans, processes, policies, procedures, and knowledge bases specific to and used by the performing organization.
PMI.A[7] Inventory of Work	A list of active work that may be potential portfolio components and a starting point to develop a portfolio.
PMI.A[8] Portfolio Process Assets	Portfolio plans, processes, policies, procedures, and knowledge bases. (1) Processes, guidelines, policies, and procedures; (2) Specifications, work instructions, proposal evaluation criteria, and performance measurement criteria; (3) Templates (e.g., component proposals, lessons learned, and performance and risk management); (4) Portfolio communication requirements; (5) Procedures for portfolio component work authorizations; (6) Performance measurement databases used to collect and make available measurement data on portfolio components and track cash flow, including actual resources used and forecast of resources required; (7) Portfolio component files; and (8)Historical information and lessons learned knowledge bases"
PMI.A[9] Portfolio Strategic Plan	A formal, approved document that describes the portfolio vision, objectives, and goals to achieve organizational strategy and objectives.
PMI.A[10] Portfolio	Projects, programs, subportfolios, and operations managed as a group to achieve strategic objectives. Portfolio is the updated list of components resulting from developing a strategic plan and aligning identified work or components to the defined organizational strategy and objectives
PMI.A[11] Portfolio Roadmap	A document that provides the high-level strategic direction and portfolio information in a chronological fashion for portfolio management and ensures dependencies within the portfolio are established and evaluated.
PMI.A[12] Portfolio charter	The document issued by the portfolio sponsor that formally authorizes the existence of a portfolio and provides the portfolio manager with the authority to apply portfolio resources to portfolio activities.
PMI.A[13] Portfolio risk management plan	A subsidiary plan or component of the portfolio management plan that describes how risk management activities will be structured and performed.
PMI.A[14] Portfolio management plan	A formal, approved document that defines how the portfolio will be executed, monitored, and controlled to meet organizational strategy and objectives.
PMI.A[15] Resources Report	Reports that provide information on resources.
PMI.A[16] Risks and Issues Report	Reports that provide information on risks and issues.
PMI.A[17] Value and Benefits Report	Reports that provide information on value and benefits (financial or non-financial).
PMI.A[18] Governance Decisions Report	Portfolio governing body decisions based on portfolio performance, component proposals, and risks as well as capability and capacity of resources, funding allocations, and future investment requirements.
PMI.A[19] Performance Report	Reports that provide information on performance.
PMI.A[20] Financial Report	Reports that provide information on financial.

Table 14. OGC PfM Artefacts Definitions (Axelos, 2011)

OGC Artefacts		Artefacts Definitions
OGC.A[1] Strategic Objectives	OGC.A[1.1] Market Stading	desired share of the present and new markets
	OGC.A[1.2] Innovation	development of new goods and services, and of skills and methods required to supply them
	OGC.A[1.3] Human Resources	selection and development of employees
	OGC.A[1.4] Financial Resources	identification of the sources of capital and their use
	OGC.A[1.5] Physical Resources	equipment and facilities and their use
	OGC.A[1.6] Productivity	use of the resources relative to the output
	OGC.A[1.7] Social Responsability	awareness and responsiveness to the effects on the wider community of the stakeholders
	OGC.A[1.8] Profit Requirements	achievement of the measurables financial well-being and growth
OGC.A[2] Organizational Environmental Analysis	OGC.A[2.1] SWOT analysis	Acronym for strengths, weaknesses, opportunities and threats. A technique to determine favourable and unfavourable factors in relation to business change or current state
	OGC.A[2.2] PESTLE analysis	Acronym for political, economic, social, technological, legal and environmental. A techinique used generally in organizational change management to undertake an environmental scan at a strategic level.
	OGC.A[2.3] Porter's five forces analysis	rivalry, threat of substitutes, buyer power, supplier power and barriers to entry
OGC.A[3] Individual Stakeholder Engagement and Communication Plans		Improved engagement and communication between relevant stakeholders, including senior managers, in understanding and meeting organizational needs and expectations and in communicating strategic objectives (and the means by which they will be achieved) to all those involved.
OGC.A[4] Organizational Management Strategy and Risk		Risk management at a portfolio level encompasses the following main elements: Implementing standards which apply to all change initiatives within the portfolio and which align to the organizational risk management policy. A risk management strategy should be agreed at portfolio level and should be included in the portfolio management
OGC.A[5] Governance Structures		Encompasses the structures, accountabilities and policies, standards and processes for decision-making within an organization in order to answer the key strategic questions 'Are we doing the right things?', 'Are we doing them the right way?' and 'Are we realizing the benefits?'
OGC.A[6] Portfolio Risk Management Strategy		Standard roles and processes for portfolio risk management should be incorporated into the portfolio management framework. These processes should be consistent with any existing organizational risk management policy.
OGC.A[7] Financial Metrics and Investment Criteria		Investment criteria that are used to prioritize initiatives should be tailored to suit each portfolio category or segment. For example, financial metrics are often used for revenue generation and cost-saving categories. In contrast, service/product enhancement categories may use criteria based on scale of enhancement per £/$/€ m invested. Many organizations employ financial metrics to prioritize initiatives such as 'net present value' (NPV), 'internal rate of return' (IRR) or 'payback'.
OGC.A[8] Portfolio		The totality of an organization's investment (or segment thereof) in the changes required to achieve its strategic objectives.
OGC.A[9] Portfolio Maps		Collate all prioritization information and analyse
OGC.A[10] Portfolio reports		Ensure that the status of each of the top portfolio-level is incorporated into the portfolio dashboard and that actions are reviewed regularly and updated.
OGC.A[11] Portfolio Scope		Collecting consistent data on the scope of the current portfolio is greatly aided where clear guidance exists about what constitutes a project or programme and what type of initiatives are to be included in the portfolio.
OGC.A[12] Portfolio's Categorization		Splitting a portfolio into organizationally appropriate categories or segments -for examples, by initiative type or investment objective. The organization's investment criteria can be tailored to suit each category of investment
OGC.A[13] Portfolio's Governance		Encompasses the structures, accountabilities and policies, standards and processes for decision-making within an organization in order to answer the key strategic questions 'Are we doing the right things?', 'Are we doing them the right way?' and 'Are we realizing the benefits?'
OGC.A[14] Portfolio Strategy		A collection of top-level strategic information that provides total clarity to all stakeholders regarding the content and long-term objectives of the portfolio. The portfolio strategy is and important communication tool.
OGC.A[15] Benefits Forecast		Benefits forecast are realized in practice and value created is optimized from our accumulated investment in change
OGC.A[16] Portfolio-level Benefits Realization Plan		To summarize the benefits forecast to be realized in the year ahead and so provide a clear view of the planned returns from the organization's accumulated investment in change. To provide a baseline against which to assess the benefits actually realized
OGC.A[17] Portfolio's Business Case		Portfolio's Business cases should only include tangible financial benefits (commonly referred to as 'hard benefits'), separated into three categories: (1) Incremental revenue – all types of additional revenue, including where increased volumes and fee margins result in an increased revenue budget or forecast. (2) Cost saves – all types of cost savings, resulting in a reduction in budgeted and forecast costs as part of the performance management process. (3) Other – all additional tangible financial benefits resulting in a positive impact to the business's profit and loss accounts, such as balance sheet improvement leading to a proven 'profit and loss' impact.
OGC.A[18] Financial Plan		This will include the required capital and operating expenditure to complete the initiative and the consequent financial requirements post implementation – i.e. the financial impact on BAU including depreciation and cost of capital charges where applicable.
OGC.A[19] Portfolio's Performance		Portfolio management should align with the organization's performance management system: (1) Utilizing the expertise of the organization's performance management function in designing and implementing new portfolio performance metrics and driver-based models linking change initiatives, and their benefits, to the organization's strategic objectives; (2)Ensuring that the performance management function is engaged at an early point in the development of business cases and that it validates claimed impacts on organizational performance in the context of the planned impact of the existing portfolio; (3) Incorporating the anticipated impact of the portfolio on strategic objectives in the organization's performance targets; (4) Making appropriate use of the existing management information system in designing the content and format of portfolio reporting; (5) Aligning performance and portfolio reporting, in terms of both timing and content, to ensure consistent messages and effective decision-making.
OGC.A[20] Portfolio-level Performance Metrics		Outline of the high-level benefits the portfolio is designed to achieve and the metrics to be used to assess their realization.Benefits eligibility guidance – the detailed rules on the identification, classification, quantification, valuation and validation of benefits.
OGC.A[21] Portfolio Stakeholder Engagement and Communication Plan		Statement of the objectives of portfolio stakeholder engagement and communications. Description of the key stakeholder groups analysed by interest and influence. Media to be used for each group.
OGC.A[22] Portfolio Resource Schedule		Profiled comparison of demand and supply for constrained resources throughout the planning period, highlighting periods of slack and under-capacity.
OGC.A[23] Resource Forecast		Understand the demand – this requires that consideration be given to the resource requirements including staff and skills (types and timing) of not only the current live programmes and projects, but also those in the development pipeline. This in turn requires that initiatives forecast resource demands accurately and consistently. The portfolio office will therefore need to develop standards for consistent resource forecasting and compile a portfolio resource schedule from the plans of individual initiatives.
OGC.A[24] Portfolio Skills Register		Understand the supply – for example, complete a simple portfolio skills register recording key staff skills, experience and current availability.
OGC.A[25] Standards and Templates to guide programme and project Planners		Set portfolio-wide standards for resource forecasting: Consistent forecasting is essential, so define standards and templates to guide programme and project planners
OGC.A[26] Lessons Learned		A commitment to continuous improvement, including identifying improvements to the portfolio management practices via membership of appropriate professional groups, capturing lessons learned from robust post-implementation reviews, submissions under the champion–challenger model and periodic portfolio effectiveness reviews
OGC.A[27] Portfolio Delivery Plan	OGC.A[27.1] Schedule	A collection of tactical regarding the planned delivery of the portfolio based on the overarching portfolio strategy. The portfolio delivery plan usually focuses on the forthcoming year in detail in terms of schedule to be realized
	OGC.A[27.2] Resources	A collection of tactical regarding the planned delivery of the portfolio based on the overarching portfolio strategy. The portfolio delivery plan usually focuses on the forthcoming year in detail in terms of resource plans to be realized
	OGC.A[27.3] Cost	A collection of tactical regarding the planned delivery of the portfolio based on the overarching portfolio strategy. The portfolio delivery plan usually focuses on the forthcoming year in detail in terms of costs to be realized
	OGC.A[27.4] Risk	A collection of tactical regarding the planned delivery of the portfolio based on the overarching portfolio strategy. The portfolio delivery plan usually focuses on the forthcoming year in detail in terms of risks and benefits to be realized
OGC.A[28] Portfolio-level financial plan		To summarize the financial commitments inherent in the approved portfolio for the year ahead as a basis for formal senior management budgetary approval. To provide a baseline against which to track and compare actual spend.

Table 15, the 'Organizational Strategy and Objectives' artefact, identified with the prefix PMI.A[1] (all other PMI PfM artefacts always have a prefix PMI.A[n], where n is a sequential number, from 1 to n).

Table 15. PMI.A[1] Organizational Strategy and Objectives Matrix Column

			PMI ARTEFACT'S
			Enterprise Documents Artefacts
			PMI.A[1] Organizational Strategy and Objectives
OGC ARTEFACT'S	OGC.A[1] Strategic Objectives	OGC.A[1.1] Market Stading	–
		OGC.A[1.2] Innovation	–
		OGC.A[1.3] Human Resources	–
		OGC.A[1.4] Financial Resources	–
		OGC.A[1.5] Physical Resources	–
		OGC.A[1.6] Productivity	–
		OGC.A[1.7] Social Responsability	–
		OGC.A[1.8] Profit Requirements	–
	OGC.A[2] Organizational Environmental Analysis	OGC.A[2.1] SWOT analysis	
		OGC.A[2.2] PESTLE analysis	
		OGC.A[2.3] Porter's five forces analysis	
	Number of relationships		8

Analysing whether the OGC PfM artefacts "do not fully represent", "represent approximately", "have more information" or "simply are different" from a PMI PfM artefact, the researcher finds the following examples: artefacts OGC.A[1.1] 'Market Stading', OGC.A[1.2] 'Innovation', OGC.A[1.3] 'Human Resources', OGC.A[1.4] 'Financial Resources', OGC.A[1.5] 'Physical Resources', OGC.A[1.6] 'Productivity', OGC.A[1.7] 'Social Responsibility' and OGC.A[1.8] 'Profit Requirements'. These OGC PfM artefacts do not individually represent the full PMI PfM artefact, PMI.A[1] 'Organizational Strategy and Objectives'; but all together, OGC.A[1.1], OGC.A[1.2], OGC.A[1.3], OGC.A[1.4], OGC.A[1.5], OGC.A[1.6], OGC.A[1.7], and OGC.A[1.8], represent approximately the artefact PMI.A[1].

All these relations are represented in Table 16 matrix, where an "**-**" represents that the OGC PfM artefact does not fully represent the PMI PfM artefact, the "+" represents that the OGC PfM artefact has more information than the PMI PfM artefact, "**≈**" represents that the OGC PfM artefact is approximately the PMI PfM artefact, and the "[blank]" represents that the OGC PfM artefact is simply different than PMI PfM artefact. Each matrix row represents an artefact from the OGC PfM framework under analysis, and the columns represent an artefact from the PMI PfM framework.

Table 16 shows all the artefacts, for a better understanding of how the mapping is done. The researcher uses, as an example, the following artefacts from the PMI PfM framework: PMI.A [5] 'Enterprise Environmental Factors' (because it has many symbols "-"), and PMI.A [8] 'Portfolio Process Assets' (because it represents n OGC PfM artefacts).

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Table 16. The mapping between the OGC PfM artefacts with the PMI PfM artefacts

OGC ARTEFACT'S		PMI ARTEFACT'S: Enterprise Documents Artefacts							Portfolio Documents Artefacts							Portfolio Reports Artefacts						Number of relationships
		PMI.A[1] Organizational Strategy and Objectives	PMI.A[2] Organizational Communication Strategy	PMI.A[3] Organizational Risk tolerance	PMI.A[4] Organizational Performance Strategy	PMI.A[5] Enterprise Environmental Factors	PMI.A[6] Organizational Process Assets	PMI.A[7] Inventory of Work	PMI.A[8] Portfolio Process Assets	PMI.A[9] Portfolio Strategic Plan	PMI.A[10] Portfolio	PMI.A[11] Portfolio Roadmap	PMI.A[12] Portfolio charter	PMI.A[13] Portfolio risk management plan	PMI.A[14] Portfolio management plan	PMI.A[15] Resources	PMI.A[16] Risks and Issues	PMI.A[17] Value and Benefits	PMI.A[18] Governance Decisions	PMI.A[19] Performance	PMI.A[20] Financial	
OGC.A[1] Strategic Objectives	OGC.A[1.1] Market Stading	–																				1
	OGC.A[1.2] Innovation	–																				1
	OGC.A[1.3] Human Resources	–																				1
	OGC.A[1.4] Financial Resources	–																				1
	OGC.A[1.5] Physical Resources	–																				1
	OGC.A[1.6] Productivity	–																				1
	OGC.A[1.7] Social Responsability	–																				1
	OGC.A[1.8] Profit Requirements	–																				1
OGC.A[2] Organizational Environmental Analysis	OGC.A[2.1] SWOT analysis					–																1
	OGC.A[2.2] PESTLE analysis					–																1
	OGC.A[2.3] Porter's five forces analysis					–																1
OGC.A[3] Individual Stakeholder Engagement and Communication Plans			–				–															2
OGC.A[4] Organizational Management Strategy and Risk				+	–		+															3
OGC.A[5] Governance Structures						–	+															2
OGC.A[6] Portfolio Risk Management Strategy									–					≈								2
OGC.A[7] Financial Metrics and Investment Criteria									–												–	2
OGC.A[8] Portfolio											≈											1
OGC.A[9] Portfolio Maps												≈										1
OGC.A[10] Portfolio reports																–	–	–	–	–	–	6
OGC.A[11] Portfolio Scope													–									1
OGC.A[12] Portfolio's Categorization								–	–													2
OGC.A[13] Portfolio's Governance									–										–			2
OGC.A[14] Portfolio Strategy									–	–												2
OGC.A[15] Benefits Forecast																		–				1
OGC.A[16] Portfolio-level Benefits Realization Plan																		–				1
OGC.A[17] Portfolio's Business Case																						0
OGC.A[18] Financial Plan																					–	1
OGC.A[19] Portfolio's Performance																				≈		1
OGC.A[20] Portfolio-level Performance Metrics																				–		1
OGC.A[21] Portfolio Stakeholder Engagement and Communication Plan			+						–													2
OGC.A[22] Portfolio Resource Schedule									–							+						2
OGC.A[23] Resource Forecast									–							+						2
OGC.A[24] Portfolio Skills Register																						0
OGC.A[25] Standards and Templates to guide programme and project Planners									–													1
OGC.A[26] Lessons Learned									–													1
OGC.A[27] Portfolio Delivery Plan	OGC.A[27.1] Schedule								–	–				–	–							4
	OGC.A[27.2] Resources								–							≈						2
	OGC.A[27.3] Cost								–												–	2
	OGC.A[27.4] Risk								–								–					2
OGC.A[28] Portfolio-level financial plan																					+	1
Number of relationships		8	2	1	1	4	3	1	14	2	1	1	1	2	1	4	2	3	2	3	5	

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The PMI.A[5] 'Enterprise Environmental Factors' from PMI PfM framework refers to an artefact, that includes: (1) organizational governance processes, culture, and detailed hierarchy structure; (2) legal constraints; (3) governmental or industry standards (e.g., regulatory agency regulations, codes of conduct, product standards, quality standards, and workmanship standards); (4) infrastructure (e.g., existing facilities and capital equipment); (5) existing human resources (e.g., skills, disciplines, and knowledge, such as design, development, law, contracting, and purchasing); (6) personnel administration (e.g., hiring and firing guidelines, employee performance reviews, and training records); and, (7) Marketplace condition*".*

Table 17 refers the PMI.A[5] 'Enterprise Environmental Factors' is related with the OGC.A[2] 'Organizational Environmental Analysis' from OGC PfM framework, through the use of the same terms or identical (it is in bold in the previous sentences), and by the definition in both references made a similarity approximation between artefacts, thus, the artefact PMI.A[5] 'Enterprise Environmental Factors' alone does not fully represent the artefacts OGC.A[2.1] 'SWOT analysis', OGC.A[2.2] 'PESTLE analysis', OGC.A[2.3] 'Porter's five forces analysis' and OGC.A[5] 'Governance Structures'. However, all these four artefacts from OGC PfM framework, together, represent approximately the artefact PMI.A[5] 'Enterprise Environmental Factors', providing more detailed information on how to develop this same artefact.

Table 17. The mapping between PMI.A[5] 'Enterprise Environmental Factors' and OGC PfM Artefact's

			PMI ARTEFACT'S
			Enterprise Documents Artefacts
			PMI.A[5] Enterprise Environmental Factors
OGC ARTEFACT'S	**OGC.A[2] Organizational Environmental Analysis**	OGC.A[2.1] SWOT analysis	–
		OGC.A[2.2] PESTLE analysis	–
		OGC.A[2.3] Porter's five forces analysis	–
	OGC.A[3] Individual Stakeholder Engagement and Communication Plans		
	OGC.A[4] Organizational Management Strategy and Risk		
	OGC.A[5] Governance Structures		–
	Number of relationships		4

PMI.A[8] 'Portfolio Process Assets' in the PMI PfM framework refers to "…portfolio process assets as necessary, as follows: (1) processes, guidelines, policies, and procedures; (2) specifications, work instructions, proposal evaluation criteria, and performance measurement criteria; (3) templates (e.g., component proposals, lessons learned, and performance and risk management); (4) portfolio communication requirements; (5) procedures for portfolio component work authorizations; (6) performance measurement databases used to collect and make available measurement data on portfolio components and track cash flow, including actual resources used and forecast of resources required; (7) portfolio component files; and, (8) historical information and lessons learned knowledge bases*"*.

Through the definition presented above, the artefacts that could represent part of this definition have been identified in the OGC PfM framework, and it is reached 14 artefacts that together represent the PMI.A [8] 'Portfolio Process Assets', among them: OGC.A [6] 'Portfolio Risk Management Strategy', OGC.A [7] 'Financial Metrics and Investment Criteria', among others as it is characterized in Table 18.

Table 18. The mapping between PMI.A[8] 'Portfolio Process Assets' and OGC PfM Artefact's

			PMI ARTEFACT'S
			Portfolio Documents Artefacts
			PMI.A[8] Portfolio Process Assets
OGC ARTEFACT'S	OGC.A[6] Portfolio Risk Management Strategy		–
	OGC.A[7] Financial Metrics and Investment Criteria		–
	OGC.A[12] Portfolio's Categorization		–
	OGC.A[13] Portfolio's Governance		–
	OGC.A[14] Portfolio Strategy		–
	OGC.A[21] Portfolio Stakeholder Engagement and Communication Plan		–
	OGC.A[22] Portfolio Resource Schedule		–
	OGC.A[23] Resource Forecast		–
	OGC.A[25] Standards and Templates to guide programme and project Planners		–
	OGC.A[26] Lessons Learned		–
	OGC.A[27] Portfolio Delivery Plan	OGC.A[27.1] Schedule	–
		OGC.A[27.2] Resources	–
		OGC.A[27.3] Cost	–
		OGC.A[27.4] Risk	–
	Number of relationships		14

To exemplify the "+" type mapping shown in Table 19, and globally in Table 16, the researcher presents the example of the PMI.A [3] 'Organizational Risk tolerance' of the PMI PfM framework. The "+" relationship means that the OGC PfM framework artefact has more information than the PMI PfM framework artefact. Therefore, the artefact OGC.A [4] 'Organizational Management Strategy and Risk' has more information than the 'Organizational Risk Tolerance' artefact PMI.A [3], which means that the 'Organizational Risk Tolerance' is only part of the information contained in the artefact 'Organizational Management Strategy and Risk' (see Table 19)

Table 19. The mapping between PMI.A[3] 'Organizational Risk tolerance' and OGC PfM Artefact's

	PMI ARTEFACT'S	
	Enterprise Documents Artefacts	**Number of relationships**
	PMI.A[3] Organizational Risk tolerance	
OGC.A[4] Organizational Management Strategy and Risk	**+**	1
Number of relationships	1	

From the overall mapping between PMI and OGC PfM artefacts, only two artefacts are approximately the same in the PMI PfM framework: PMI.A [10] 'Portfolio' is approximately the same than the OGC.A [8] 'Portfolio', and PMI.A [11] 'Portfolio Roadmap' is approximately the same than the OGC.A [9] 'Portfolio Maps'. The OGC.A [17] 'Portfolio Business Case' and OGC.A [24] 'Portfolio Skills Register' artefacts do not represent any PMI PfM artefact, where the researcher concludes both the artefacts, 'Portfolio's Business Case' and 'Portfolio Skills Register', are not concepts explored in PMI PfM processes.

In order to identify which OGC PfM artefacts approximately fulfil the PMI PfM artefact, Table 20 is developed, which represents the global mapping of all OGC PfM artefacts per PMI PfM artefact.

Table 20. Resume of the Mapping of each PMI PfM artefact with the various OGC PfM artefacts

PMI Artefact (PMI PfM framework)	**OGC Artefacts** (OGC PfM framework)
PMI.A[1] Organizational Strategy and Objectives	-OGC.A[1.1]; -OGC.A[1.2] ;-OGC.A[1.3]; -OGC.A[1.4]; -OGC.A[1.5]; -OGC.A[1.6]; -OGC.A[1.7]; -OGC.A[1.8]
PMI.A[2] Organizational Communication Strategy	-OGC.A[3];+OGC.A[21]
PMI.A[3] Organizational Risk tolerance	+OGC.A[4]
PMI.A[4] Organizational Performance Strategy	-OGC.A[4]
PMI.A[5] Enterprise Environmental Factors	-OGC.A[2.1];-OGC.A[2.2];-OGC.A[2.3]; -OGC.A[5]
PMI.A[6] Organizational Process Assets	-OGC.A[3];+OGC.A[4];+OGC.A[5]
PMI.A[7] Inventory of Work	-OGC.A[12]
PMI.A[8] Portfolio Process Assets	-OGC.A[6];-OGC.A[7];-OGC.A[12];-OGC.A[13];-OGC.A[14];-OGC.A[21];-OGC.A[22];-OGC.A[23];-OGC.A[25];-OGC.A[26];-OGC.A[27.1];-OGC.A[27.2];-OGC.A[27.3];-OGC.A[27.4]
PMI.A[9] Portfolio Strategic Plan	-OGC.A[14];-OGC.A[27.1]
PMI.A[10] Portfolio	≈OGC.A[8]
PMI.A[11] Portfolio Roadmap	≈OGC.A[9]
PMI.A[12] Portfolio charter	-OGC.A[11]
PMI.A[13] Portfolio risk management plan	≈OGC.A[6];-OGC.A[27.1]
PMI.A[14] Portfolio management plan	-OGC.A[27.1]
PMI.A[15] Resources Report	-OGC.A[10];+OGC.A[22];+OGC.A[23];≈OGC.A[27.1]
PMI.A[16] Risks and Issues Report	-OGC.A[10];-OGC.A[27.4]
PMI.A[17] Value and Benefits Report	-OGC.A[10];-OGC.A[15];-OGC.A[16]
PMI.A[18] Governance Decisions Report	-OGC.A[10];-OGC.A[13];
PMI.A[19] Performance Report	-OGC.A[10];≈OGC.A[19];-OGC.A[20]
PMI.A[20] Financial Report	-OGC.A[7];-OGC.A[10];-OGC.A[18];-OGC.A[27.3];+OGC.A[28]

5.3 Dependency between PMI PfM Processes and OGC PfM Artefacts

Elementary Dependency Analysis

In this section, the researcher describes how it is characterized the elementary dependency between artefacts from OGC PfM framework of a particular portfolio process from PMI PfM framework; what is called the PP*n*-centric dependency analysis (*n* is the number of the process portfolio).

As an example, the researcher analyses the PMI process {PP1} DPSP ‘Develop Portfolio Strategic Plan’, through their interaction with artefacts from the OGC PfM framework.

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Table 21. The mapping between all the PMI portfolio processes and OGC PfM artefacts

Portfolio Process (PMI) / Artefacts (OGC)	PMI-Defining Process Group								PMI-Aligning Process Group						PMI-Authorizing and Controlling Process Group				
OGC ARTEFACTS	PSM (PP 1) DPSP S,M,C,I	PSM (PP 2) DPC S,M,C,I	PSM (PP 3) DPR S,M,C,I	PGM (PP 4) DPMP S,M,C,I	PGM (PP 5) DP S,M,C,I	PPM (PP 6) DPPMP S,M,C,I	PCM (PP 7) DPCMP M,C,I	PRM (PP 8) DPRMP S,M,C,I	PSM (PP 9) MSC M,C,I	PGM (PP 10) OP S,M,C,I	PPM (PP 11) MSD S,M,C,I	PPM (PP 12) MPV S,M,C,I	PCM (PP 13) MPI M,C,I	PRM (PP 14) MPR M,C,I	PGM (PP 15) AP S,M,C,I	PGM (PP 16) PPO S,M,C,I	Number of Artefacts	INPUT Number of Artefacts	OUTPUT Number of Artefacts
OGC.A[1] Strategic Objectives – OGC.A[1.1] Market Stading	IN													IN			2	2	0
OGC.A[1] Strategic Objectives – OGC.A[1.2] Innovation	IN													IN			2	2	0
OGC.A[1] Strategic Objectives – OGC.A[1.3] Human Resources	IN													IN			2	2	0
OGC.A[1] Strategic Objectives – OGC.A[1.4] Financial Resources	IN													IN			2	2	0
OGC.A[1] Strategic Objectives – OGC.A[1.5] Physical Resources	IN													IN			2	2	0
OGC.A[1] Strategic Objectives – OGC.A[1.6] Productivity	IN													IN			2	2	0
OGC.A[1] Strategic Objectives – OGC.A[1.7] Social Responsability	IN													IN			2	2	0
OGC.A[1] Strategic Objectives – OGC.A[1.8] Profit Requirements	IN													IN			2	2	0
OGC.A[2] Organizational Environmental Analysis – OGC.A[2.1] SWOT analysis	IN	IN		IN		IN		IN						IN			6	6	0
OGC.A[2] Organizational Environmental Analysis – OGC.A[2.2] PESTLE analysis	IN	IN		IN		IN		IN						IN			6	6	0
OGC.A[2] Organizational Environmental Analysis – OGC.A[2.3] Porter's five forces analysis	IN	IN		IN		IN		IN						IN			6	6	0
OGC.A[3] Individual Stakeholder Engagement and Communication Plans	IN			IN		IN	IN	I/O						OUT			7	5	2
OGC.A[4] Organizational Management Strategy and Risk	IN			IN		IN	IN	I/O						OUT			7	5	2
OGC.A[5] Governance Structures	IN			IN		IN	IN	I/O						OUT			7	5	2
OGC.A[6] Portfolio Risk Management Strategy	IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O		OUT	I/O	I/O	OUT	I/O	24	12	12
OGC.A[7] Financial Metrics and Investment Criteria	IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O		OUT	I/O	I/O	I/O	I/O	25	13	12
OGC.A[8] Portfolio	OUT		IN		I/O		IN			I/O	I/O	OUT	IN	IN	I/O	I/O	16	9	7
OGC.A[9] Portfolio Maps			I/O	IN	I/O		IN		I/O	I/O		IN				IN	12	8	4
OGC.A[10] Portfolio reports							IN			I/O	I/O	I/O	I/O	I/O	I/O	I/O	15	8	7
OGC.A[11] Portfolio Scope		OUT	OUT	IN	IN				OUT	IN						IN	7	4	3
OGC.A[12] Portfolio's Categorization	IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O		OUT	I/O	I/O	OUT	I/O	24	12	12
OGC.A[13] Portfolio's Governance	IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O	OUT	OUT	I/O	I/O	OUT	I/O	25	12	13
OGC.A[14] Portfolio Strategy	I/O	I/O	IN	I/O	IN	I/O	I/O	I/O	I/O	I/O		I/O	I/O	I/O	OUT	I/O	27	14	13
OGC.A[15] Benefits Forecast										IN			IN	IN			3	3	0
OGC.A[16] Portfolio-level Benefits Realization Plan										IN			IN	IN			3	3	0
OGC.A[17] Portfolio's Business Case																	0	0	0
OGC.A[18] Financial Plan										IN			IN	IN	I/O	I/O	7	5	2
OGC.A[19] Portfolio's Performance							IN			IN	OUT	I/O	IN			I/O	8	5	3
OGC.A[20] Portfolio-level Performance Metrics							IN			IN	OUT	I/O	IN			I/O	8	5	3
OGC.A[21] Portfolio Stakeholder Engagement and Communication Plan	IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O		OUT	I/O	I/O	OUT	I/O	24	12	12
OGC.A[22] Portfolio Resource Schedule	IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	28	15	13
OGC.A[23] Resource Forecast	IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	28	15	13
OGC.A[24] Portfolio Skills Register																	0	0	0
OGC.A[25] Standards and Templates to guide programme and project Planners	IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O		OUT	I/O	I/O	OUT	I/O	24	12	12
OGC.A[26] Lessons Learned	IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O		OUT	I/O	I/O	OUT	I/O	24	12	12
OGC.A[27] Portfolio Delivery Plan – OGC.A[27.1] Schedule	OUT	I/O	IN	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	30	15	15
OGC.A[27] Portfolio Delivery Plan – OGC.A[27.2] Resources	IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O		OUT	I/O	I/O	OUT	I/O	24	12	12
OGC.A[27] Portfolio Delivery Plan – OGC.A[27.3] Cost	IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O		OUT	I/O	I/O	I/O	I/O	25	13	12
OGC.A[27] Portfolio Delivery Plan – OGC.A[27.4] Risk	IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O		OUT	I/O	I/O	OUT	I/O	24	12	12
OGC.A[28] Portfolio-level financial plan										IN			IN	IN	I/O	I/O	7	5	2
Number of Artefacts	29	18	5	22	17	20	22	20	16	24	8	19	22	34	18	22			
INPUT Number of Artefacts	27	17	4	22	17	20	22	20	15	24	5	8	22	31	9	22			
OUTPUT Number of Artefacts	3	15	2	14	3	14	14	17	16	17	8	18	15	16	18	20			

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In Table 21, {PP1} DPSP ‘Develop Portfolio Strategic Plan’ process from PMI PfM framework receives information through the OGC PfM artefacts (“+”, “-“ or “≈” represent): A[1] ‘Strategic Objectives’, A[2] ‘Organizational Environmental Analysis’, A[3] ‘Individual Stakeholder Engagement and Communication Plans’, A[4] ‘Organizational Management Strategy and Risk’, A[5] ‘Governance Structures’, A [6] ‘Portfolio Risk Management Strategy’, A[7] ‘Financial Metrics and Investment Criteria’, A[12] ‘Portfolio's Categorization’, A[13] ‘Portfolio's Governance’, A[14] ‘Portfolio Strategy’, A[21] ‘Portfolio Stakeholder Engagement and Communication Plan’, A[22] ‘Portfolio Resource Schedule’, A[23] ‘Resource Forecast’, A[25] ‘Standards and Templates to guide programme and project Planners’, A[26] ‘Lessons Learned’, A[27.2] ‘PDP.Resources’ (PDP represents ‘Portfolio Delivery Plan’, sub-group, Resources), A[27.3] ‘PDP.Cost’ (PDP represents ‘Portfolio Delivery Plan’, sub-group, Cost) and A[27.4] ‘PDP.Risk’ (PDP represents ‘Portfolio Delivery Plan’, sub-group, Risk).

The tailored IT PfM framework proposed adopts the processes from the PMI PfM framework and, through the mapping of artefacts from the PMI PfM framework to OGC PfM framework, a complete artefact’s structure from OGC PfM framework is used.

After {PP1} DPSP ‘Develop Portfolio Strategic Plan’ process is executed, it sends or generates information to the following OGC PfM artefacts: A[27.1] ‘PDP. Schedule’, A[8] ‘Portfolio’ and A[14] ‘Portfolio Strategy’. All PMI PfM processes in the depicted mapping, in Table 21, are positioned in the respective knowledge area from PMI PfM framework (as an example, the {PP1} DPSP ‘Develop Portfolio Strategic Plan’, is located in the lane of the ‘Portfolio Strategic Management’ knowledge area). All the PMI PfM processes are organized by five knowledge areas.

The tailored IT PfM framework proposed is developed under the knowledge areas from PMI PfM framework, with two objectives: (1) to clarify the sequence of processes to be executed for each area of knowledge; and, (2) to perceive if professionals can perform only a set of processes without any dependence on other processes, for example, the professional only perform the processes of the area of knowledge, portfolio risk management.

A knowledge area includes PMI PfM processes, which are linked to the respective inputs and outputs (artefacts and processes).

The tailored IT PfM framework, with processes from PMI PfM framework and OGC PfM artefacts, and a possible order of execution of the processes by area of knowledge is presented, in detail by using the Business Process Model and Notation (BPMN), as an example, Figure 23.

According to the Object Management Group (OMG), the BPMN notation is a process-modelling standard, which purpose is to facilitate the understanding of process diagrams by all stakeholders involved. This notation is used to draw the flowchart drawings that represent the activities or tasks belonging to a business process (OMG, 2013).

BPMN is a graphical notation explicitly created to represent business processes, identifying activities, dependency control, the tasks, and sub processes (Lübke & Schneider, 2008). Therefore, the BPMN notation is used for the representation of the Tailoring PMI PfM framework and the OGC PfM framework and their interaction with OGC PfM artefacts.

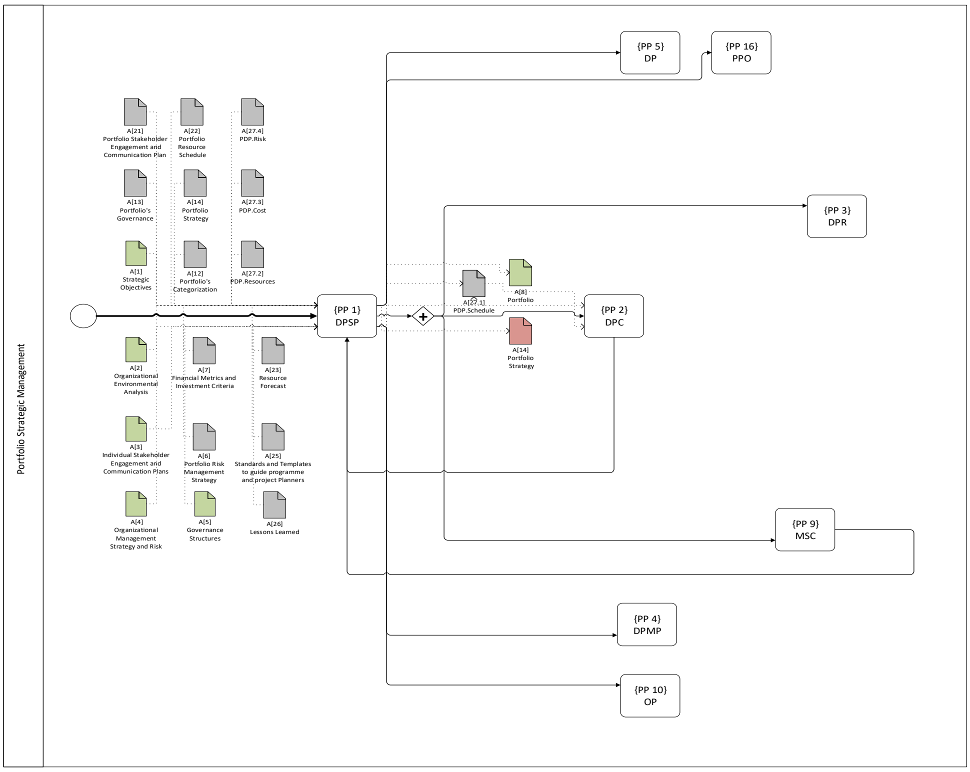

Figure 23. {PP1} DPSP 'Develop Portfolio Strategic Plan'- Centric Dependency Analysis

In Figure 23, green artefacts represent artefacts not yet used by the PMI PfM processes; grey artefacts represent artefacts created by PMI PfM processes; and red artefacts represent artefacts already created and generated by PMI PfM processes.

Knowledge Area Centric Dependency Analysis

The objective of using centric dependency analysis in this thesis is to show the dependencies between portfolio processes from the PMI PfM framework and artefacts from the OGC PfM framework related to a specific knowledge area from PMI PfM framework. Therefore, five models have been created. They are called *KA-n Centric Dependency Analysis Model* (where *n* corresponds to the knowledge area under study, 1 – *Portfolio Strategic Management*, 2 – *Portfolio Governance Management,* 3 – *Portfolio Performance Management, 4 – Portfolio Communication Management and 5 – Portfolio Risk Management)*. Figure 24 to Figure 28 present, respectively, the KA-1, KA-2, KA-3, KA-4 and KA-5 Centric Dependency Analysis Model. As an example, the construction of the KA-1 Centric Dependency Analysis Model uses the information of all columns with prefix PSM, Portfolio Strategic Management – Knowledge Area, of the global matrix (see Table 21).

For a better understanding of the creation of the KA-1 model, the PMI PfM processes; {PP1} DPSP 'Develop Portfolio Strategic Plan', {PP2} DPC 'Develop Portfolio Charter', {PP3} DPR 'Define Portfolio Roadmap', and {PP9} MSC 'Manage Strategic Change' are analysed as examples.

To represent in the model the dependencies faced by the {PP1} DPSP 'Develop Portfolio Strategic Plan' process with the artefacts, the researcher must parse the matrix column that corresponds to {PP1} DPSP 'Develop Portfolio Strategic Plan', as shown in Table 21.

{PP1} DPSP 'Develop Portfolio Strategic Plan' process, as the first PMI PfM process to be handled, needs several input OGC PfM artefacts, such as: A[1] 'Strategic Objectives', A[2] 'Organizational Environmental Analysis', A[3] 'Individual Stakeholder Engagement and Communication Plans', A[4] 'Organizational Management Strategy and Risk' and A[5] 'Governance

Structures'. All of them are organizational artefacts, which any organization might have for an efficient PfM.

Green tone artefacts are required to execute a given PMI PfM process, for example, {PP1} DPSP 'Develop Portfolio Strategic Plan' process, but after executing the same process, {PP1} DPSP process, does not occur the update of this same artefact in the process group of area of knowledge covered, for example, A[2] 'Organizational Environmental Analysis'.

Artefacts with grey tone are input or output of a process, but, after the execution of this process, artefact update occurs (red tone).

While A[6] 'Portfolio Risk Management Strategy', A[7] 'Financial Metrics and Investment Criteria', A[12] 'Portfolio's Categorization', A[13] 'Portfolio's Governance', A[14] 'Portfolio Strategy', A[21] 'Portfolio Stakeholder Engagement and Communication Plan', A[22] 'Portfolio Resource Schedule', A[23] 'Resource Forecast', A[25] 'Standards and Templates to guide program and project Planners', A[26] 'Lessons Learned', A[27.2] 'PDP.Resources', A[27.3] 'PDP.Cost', and A[27.4] 'PDP.Risk' are OGC PfM artefacts necessary for implementing {PP1} DPSP 'Develop Portfolio Strategic Plan' process. These artefacts are, also, portfolio artefacts, which are created in the following PMI PfM processes, and represent input artefacts at the second, third, and other iterations of the {PP1} DPSP 'Develop Portfolio Strategic Plan' process. Therefore, these artefacts are represented for the first time in a grey tone, and after being updated, these artefacts turn into a red tone.

When the artefacts have a grey tone, it allows the researcher to conclude that the artefacts are created in other PMI PfM processes during the first iteration of the processes, and are updated during the processes iteration cycles (i.e., performed, more than once, over the PfM).

The area defined at Figure 24 in yellow shadow tone represents the KA-1 Centric Dependency Analysis Model, i.e., processes executed in the *Portfolio Strategic Management* knowledge area; the processes and iterations outside the yellow tone represent iterations with other processes and artefacts in other knowledge management area.

With the BPMN representations and the necessary artefact updates, and despite the cyclic existence of the processes from PMI PfM framework, by the use of the artefacts themselves, some processes that would be executed in parallel, have a sequential order. The researcher proposes an order for the execution of some processes within a KA. In KA-1 is suggested the following order of the processes' execution: (1º) {PP 1} DPSP, (2º) {PP 2} DPC, (3º) {PP 3} DPR and (4º) {PP 9} MSC. {PP 3} DPR and {PP 9} MSC processes have a dependency between them. Therefore, PMI PfM processes can be executed in this way or vice versa. In PMI PfM framework, {PP2} DPC, {PP3} DPR and {PP9} MSC processes are executed in parallel after the {PP1} DPSP.

By the iterations between the KA-1 processes, the processes are revisited several times during the PfM lifecycle, as demonstrated in Figure 24.

Figure 25 shows the KA-2 Centric Dependency Analysis Model with the *Portfolio Governance Management* knowledge area, with the processes {PP 4} DPMP, {PP 5} DP, {PP 10} OP, {PP 15} AP and {PP 16} PPO.

{PP 4} DPMP 'Develop Portfolio Management Plan' process requires several artefacts to be executed, for a organizational artefact, A[2] 'Organizational Environmental Analysis', which is no longer used by any other process of this KA.

The researcher proposes an order for the execution of the processes from *Portfolio Governance Management* knowledge area: (1º) {PP 4} DPMP, (2º) {PP 5} DP, (3º) {PP 10} OP, (4º) {PP 15} AP, and (5º) {PP 16} PPO. {PP 15} AP and {PP 16} PPO processes, as artefacts have dependency between them, can be executed in this way or vice versa.

Figure 26 presents the processes flow of the *Portfolio Performance Management* knowledge area, KA-3 Centric Dependency Analysis Model.

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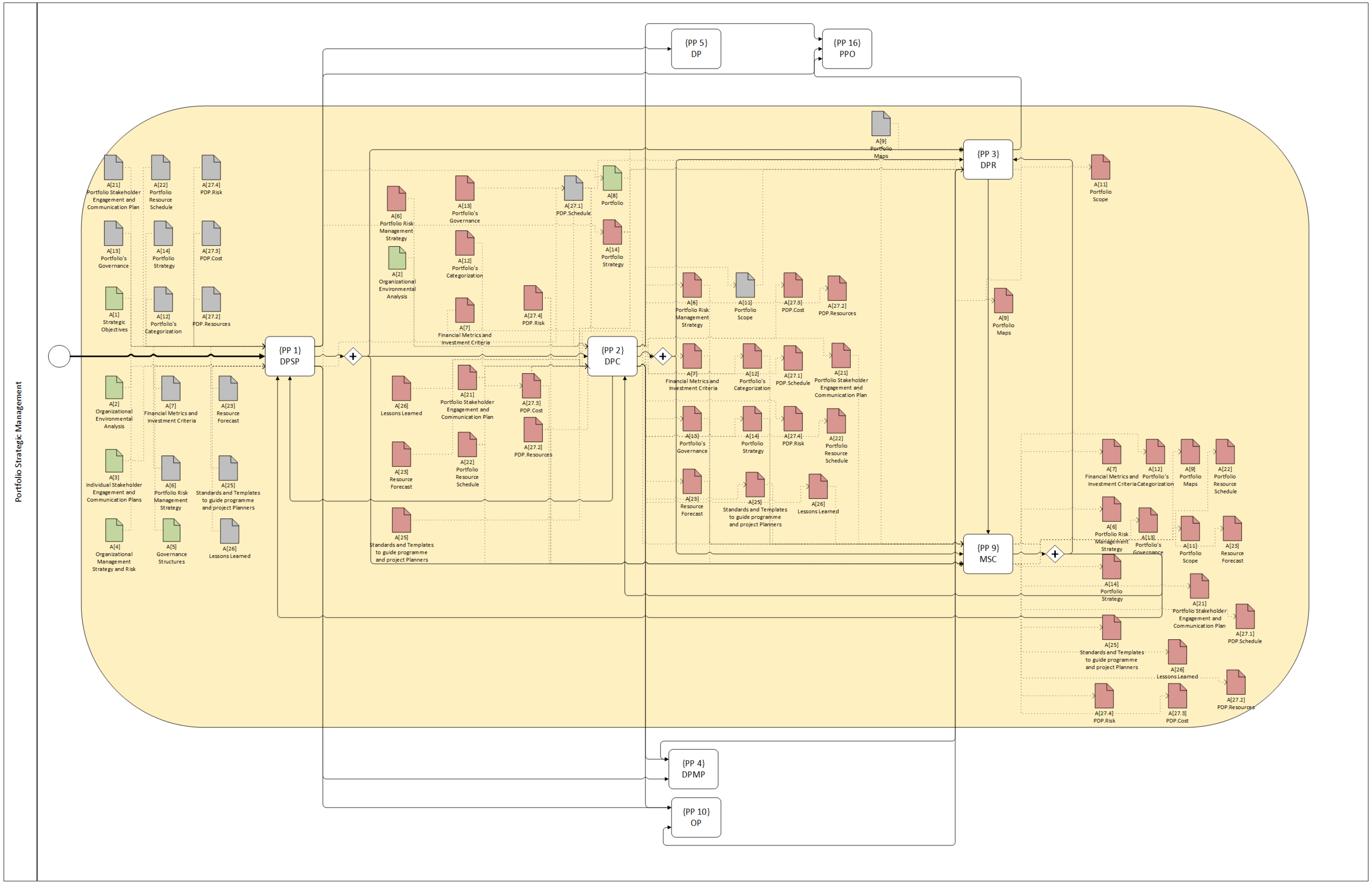

Figure 24. KA-1 Centric Dependency Analysis Model

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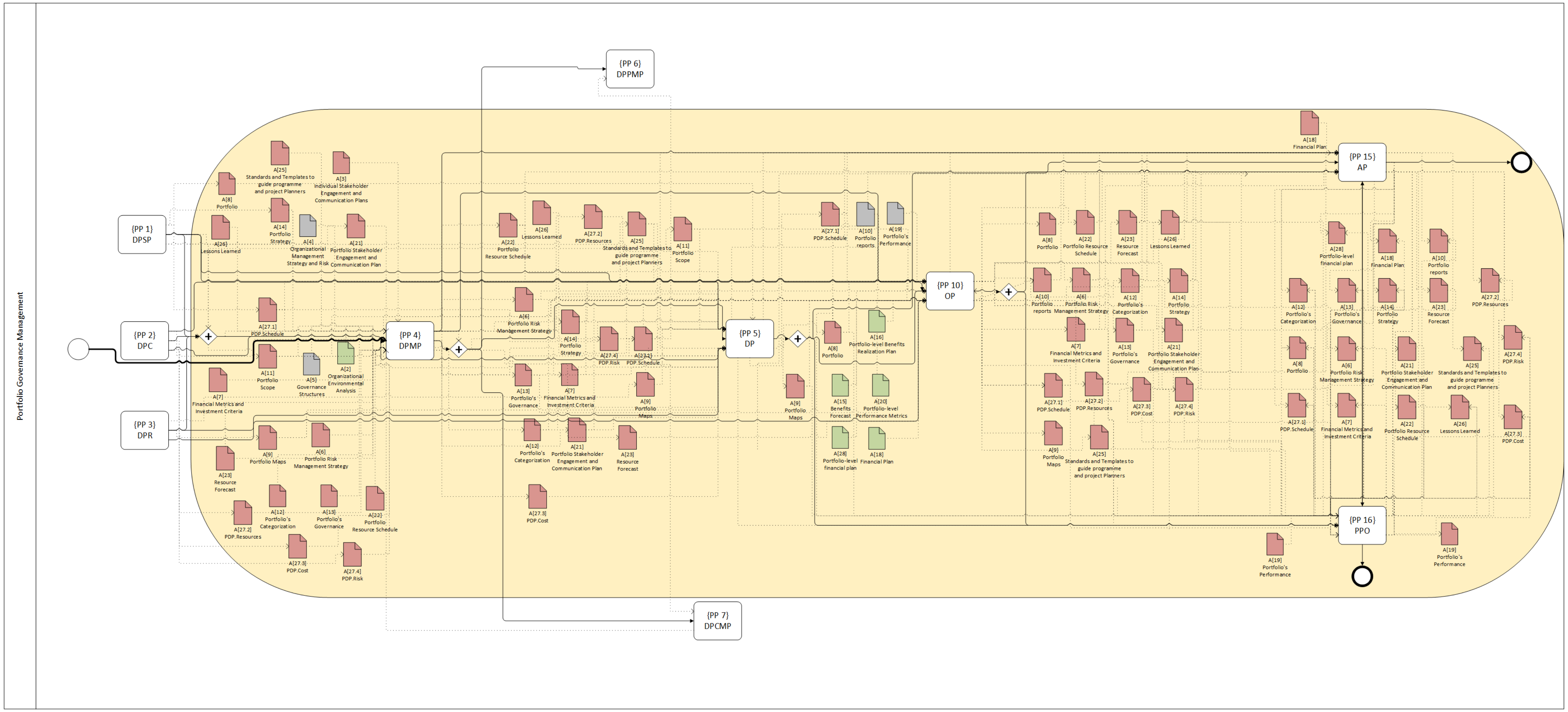

Figure 25. KA-2 Centric Dependency Analysis Model

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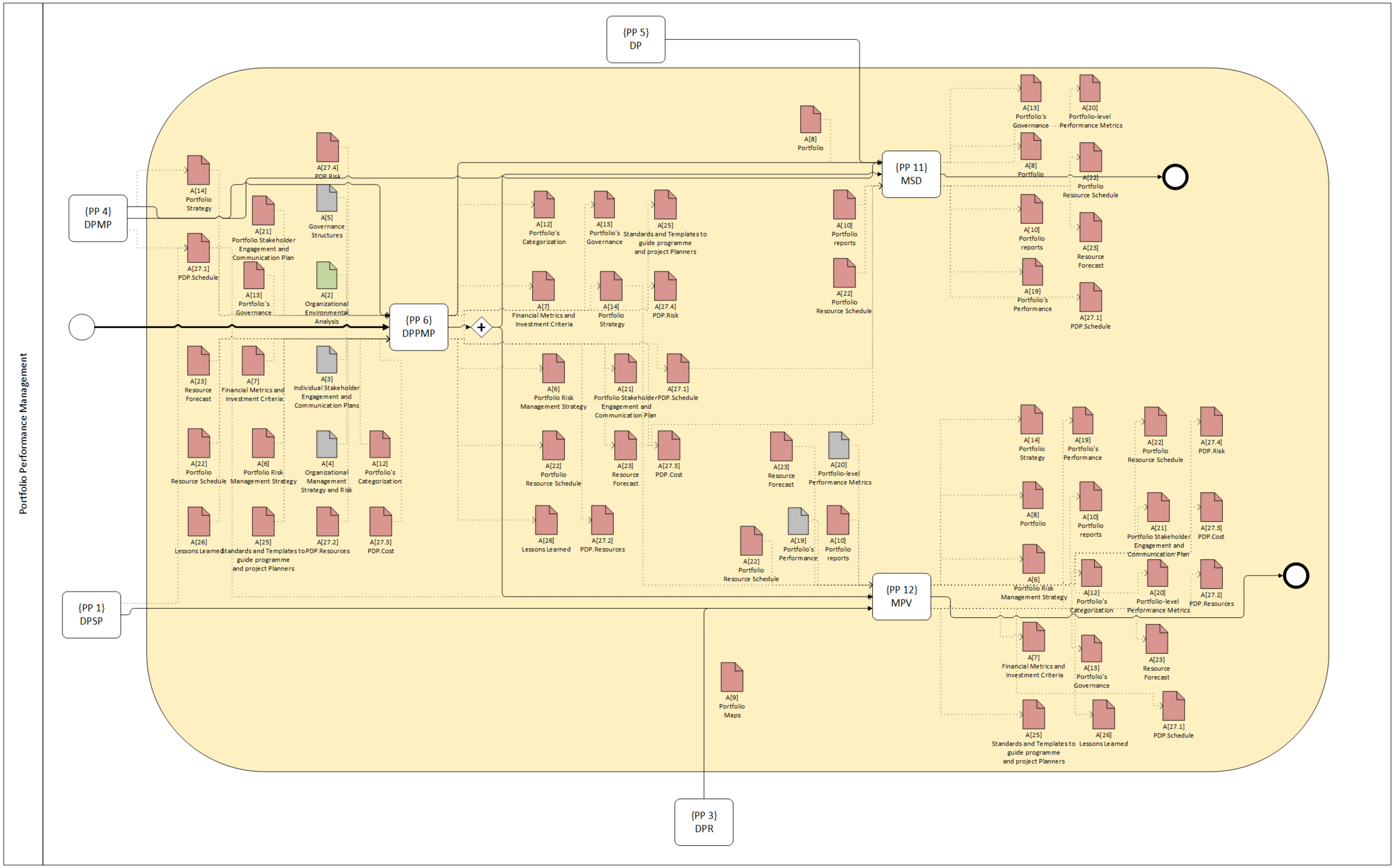

Figure 26. KA-3 Centric Dependency Analysis Mode

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Three processes are characterized in the KA-3 Centric Dependency Analysis Model: {PP 6} DPPMP, {PP 11} MSD and {PP 12} MPV, which are related through their artefacts. Most of the input and output artefacts represented in Figure 27 are created in processes of previous areas of knowledge (red tones), the reason why the researcher is able to conclude that this area of knowledge is only used after other areas of knowledge, which makes sense, because it is about portfolio performance management. In KA-3 Centric Dependency Analysis Model, for example, A[19] ‘Portfolio's Performance’ and A[20] ‘Portfolio-level Performance Metrics’ artefacts (grey tone) are updated (red tone), when executing {PP 12} MPV process.

The order proposed for execution of the KA-3 Centric Dependency Analysis Model processes is as follows: (1º) {PP 6} DPPMP, and then (2º) {PP 11} MSD or (3º) {PP 12} MPV. There is no cyclical interaction between {PP 11} MSD and {PP 12} MPV.

KA-4 Centric Dependency Analysis Model represents the *Portfolio Communication Management* knowledge area processes, {PP 7} DPCMP and {PP 13} MPI (see Figure 27).

For the KA-4 Centric Dependency Analysis Model, the processes’ order of execution proposed is as follows: (1º) {PP 7} DPCMP, and (2º) {PP 13} MPI, where outputs artefacts in the {PP 13} MPI process may be inputs in {PP 7} DPCMP process during the following iterations. This KA-4 Centric Dependency Analysis Model is characterized only by two processes, but with cyclic iterations, where artefacts are updated according to a new iteration.

Figure 28 presents the KA-5 Centric Dependency Analysis Model, with the two processes of the *Portfolio Risk Management* knowledge area, {PP 8} DPRMP and {PP 14} MPR. KA-5 Centric Dependency Analysis Model is characterized by the input artefacts of the ‘portfolio’ and ‘organizational’ among them, A[1] ‘Strategic Objectives’ and A[2] ‘Organizational Environmental Analysis’.

The order of execution of the KA-5 processes proposed is as follows: (1º) {PP 8} DPRMP, and (2º) {PP 14} MPR, being the iterations cycled between the two processes.

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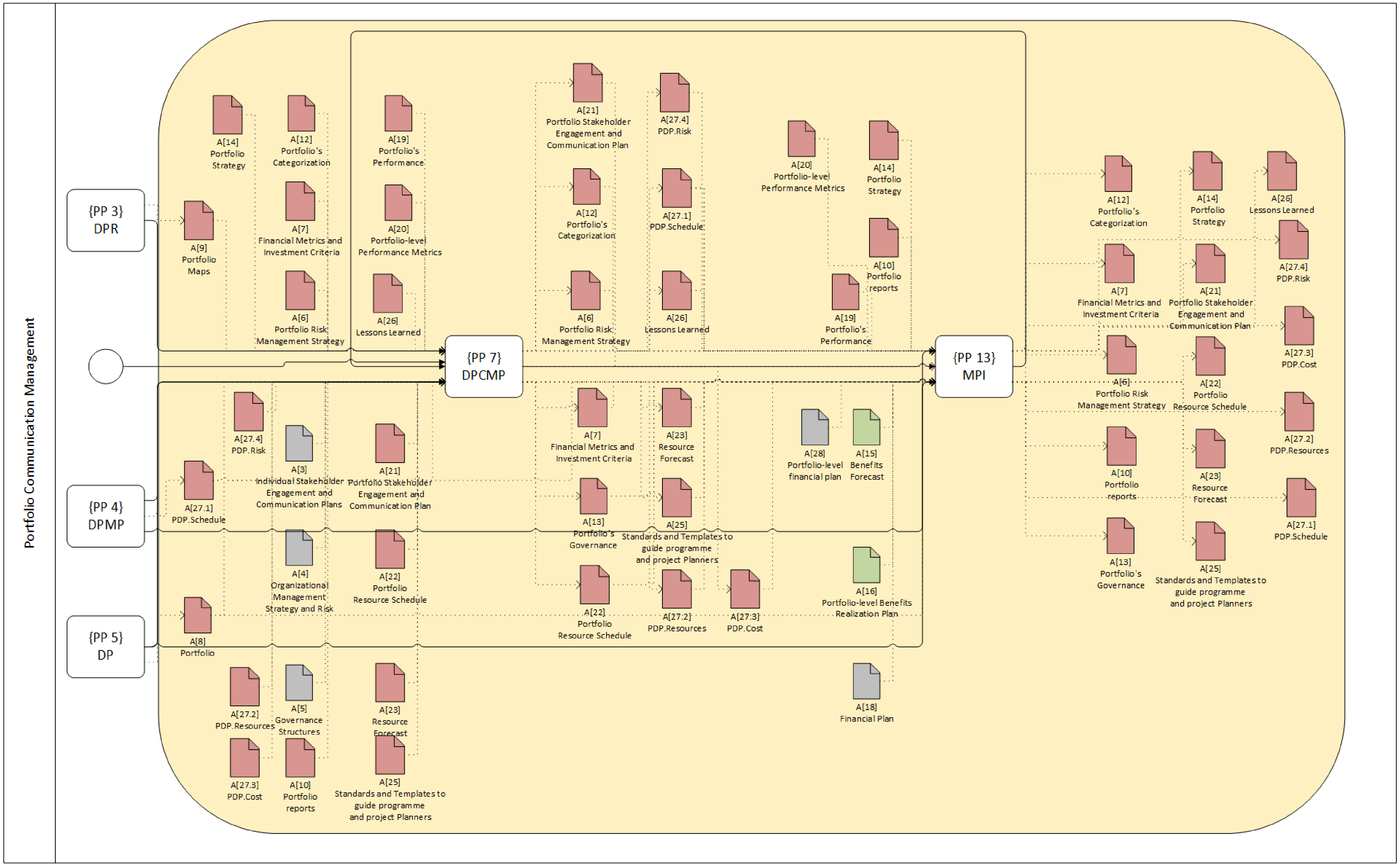

Figure 27. KA-4 Centric Dependency Analysis Model

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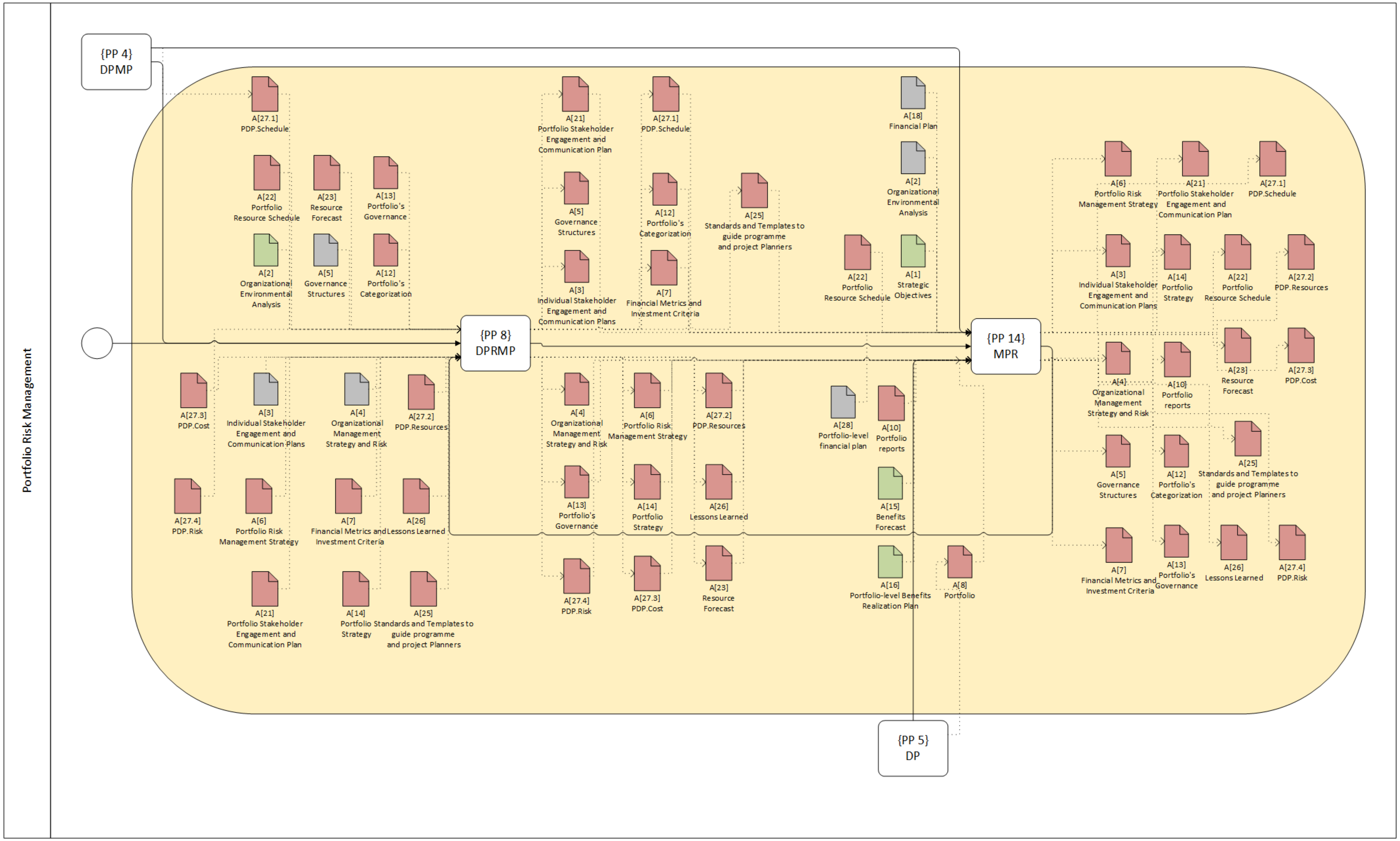

Figure 28. KA-5 Centric Dependency Analysis Mode

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The group of Centric Dependency Analysis Models: KA-1, KA-2, KA-3, KA-4 and KA-5 represents the tailored IT PfM framework, based on the PfM frameworks from PMI and OGC. The use, creation and update of a set of forty OGC PfM artefacts and proposal of an order of execution of the PMI PfM processes allows PfM professionals to perform their jobs objectively.

Traceability Map of an example artefact using UML State Machine Model

By the mapping in Table 21, it is noted that the most used and most updated artefact by all PMI PfM processes is A[27.1] ‘Portfolio Delivery Plan – Schedule’. Therefore, in order to show, as an example, the creation and the various updates of this particular artefact A[27.1], throughout the processes and respective knowledge areas, the researcher uses the UML State Machine Model (see Figure 29).

The UML State Machine Model (OMG, 2015) comes from the statecharts (Harel, 1987). This type of model is used to model the different states of an object during the execution of a process. A state can receive information indicating activities in the input, permanence, and exit of the state (exit/output). The concepts as superstate (or compound states) and substates, present in statecharts, are used in UML state machines model (Gross, 1998).

In Figure 29, superstate is, for example, ‘Portfolio Strategic Management’, with several states ‘PSM_1’, ‘PSM_2’, etc. Each state, e.g., PSM_1, represents the passage of the A [27.1] ‘Portfolio Delivery Plan – Schedule’ artefact for a given process. For example, the artefact A [27.1] is input in the process {PP2} DPC, but it is also output in this same process. Therefore, when the process {PP2} DPC is executed, the artefact A [27.1] is modified and a new output of A [27.1] is created.

Portfolio Strategic Management (PSM), Portfolio Governance Management (PGM), Portfolio Performance Management (PPM), Portfolio Communication Management (PCM) and Portfolio Risk Management (PRM) knowledge areas are considered the compound states or superstates (see Figure 29).

Within the Portfolio Strategic Management compound state or superstate, after passing PSM_1 state, the A[27.1] ‘Portfolio Delivery Plan – Schedule’ artefact may be executed in the other PSM processes, as can be also used as input artefact in PGM and PPM compound states (represented by a grey line). This artefact may also be input (initialized) in the PGM compound state.

After passing the PGM_1 state, A[27.1] ‘Portfolio Delivery Plan – Schedule’ artefact can input the subsequent processes into the PGM or can input the PPM, PCM or PRM composite states. A [27.1] ‘Portfolio Delivery Plan – Schedule’ artefact, when showing up in the PPM, PCM or PRM compound states, comes from the PSM or PGM compound states.

In summary, Figure 29 shows that, A[27.1] ‘Portfolio Delivery Plan – Schedule’, OGC PfM artefact interacts with sixteen PMI PfM processes, and therefore it is an essential artefact for PfM.

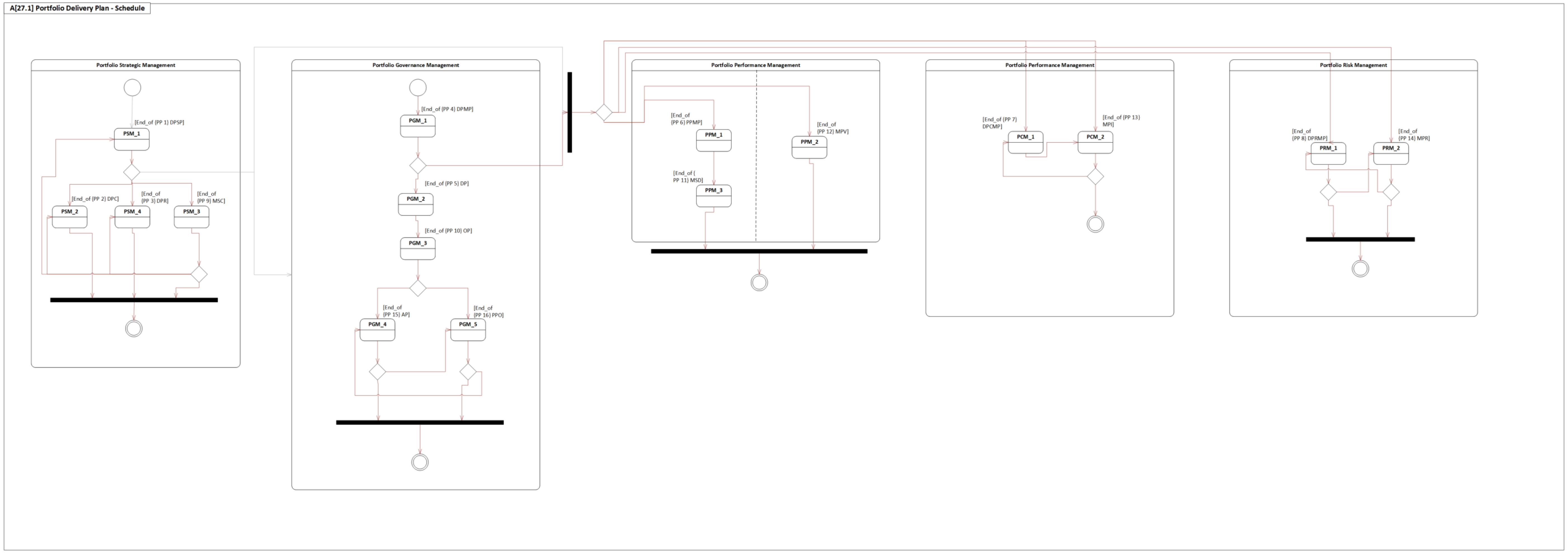

Figure 29. A[27.1] 'Portfolio Delivery Plan Schedule' artefact using UML State Machine Model

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5.4 Conclusions

This chapter contributes to individuals and organizations interested in increasing their performance in PfM, by presenting the mapping between OGC PfM artefacts and PMI PfM artefacts and the mapping between PMI PfM processes and OGC PfM artefacts, from the two worldwide recognized PfM frameworks: OGC (now Axelos) and PMI.

Nevertheless, OGC PfM framework has a broader collection of artefacts regarding how PfM processes should be performed. Therefore, this thesis, based on the researcher's extensive professional experience in PfM and in an in-depth analysis and discussion of the concepts and definitions of each artefact from PMI and OGC PfM frameworks, establishes a mapping between the artefacts from OGC PfM framework and PMI PfM framework. This thesis increases the understanding of how to execute PfM processes from artefacts, bringing mainly a contribution for practice.

A tailored IT PfM framework, based on processes from the PMI PfM framework and artefacts from the OGC PfM framework is proposed, through a previous mapping between artefacts from the PMI PfM framework and artefacts from the OGC PfM framework.

The tailored IT PfM framework proposed aims to help PfM professionals in understanding "how to" use the PfM processes from PMI PfM framework, and the order of execution of the processes, using a wide range of existing artefacts from OGC PfM framework.

The researcher presents the tailored IT PfM framework used BPMN representation. However, due to the complexity and richness of the artefacts, the researcher, additionally, presents a representation in UML State Machine of the most used and updated artefact in IT PfM framework, A[27.1] 'Portfolio Delivery Plan – Schedule' artefact. This representation allows showing all the details of the passages, through the different areas of knowledge and processes.

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CHAPTER 6

THE CASE STUDY ANALYSIS

Summary: In this chapter, the researcher analyses the CIT organization and one of its portfolios of study in this thesis. It is performed a detailed characterization of CIT Portugal. For the portfolio, the researcher analyses the R&D projects and a set of criteria used for the definition of sub-portfolios, 'Portfolio-A' and 'Portfolio-B'. The chapter ends with thoughts and considerations regarding both sub-portfolios, and the experimentation of the tailored IT PfM framework.

CHAPTER TABLE OF CONTENTS

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CHAPTER 6: THE CASE STUDY ANALYSIS

"Case studies are easier to plan than experiments, but are harder to interpret and difficult to generalize. A case study can show you the effects of a technology in a typical situation, but it cannot be generalized to every possible situation".

- Kitchenham et al.(1995, p.53)

6.1 Introduction

Industrial case studies are affected by the specific process standards, application area, practices, software tools, and other specific factors to the organization's context. Thus, the results of case studies are generally not generalized outside their specific context (Kitchenham, Dyba, & Jorgensen, 2004). Therefore, a case study is developed for experimentally assessing the researcher's contributions. In this thesis is the experimentation of the tailored PfM framework for IT projects context in a CIT organization.

The case study is developed in a non-profit association located in Portugal, whose mission is seeking the continuous recognition as a benchmark of excellence as R&D interface organization. This CIT organization is focused on applied research, oriented to the full satisfaction of the expectations of its associates, customers and partners, aiming at producing value in demanding and competitive markets in the field of Information and Communication Technology.

The vision of this CIT organization is to be a centre of technological interface of national and international reference, capable of being a continuous partner in the processes of innovation and research of the organizations. In this thesis, the fictional name of 'CIT Org' designates this organization.

CIT Org is dedicated to developing R&D activities through projects, classified as external projects, of the type of applied research; that is, between TRLs 4 and 7, in Information Technology.

For the aforementioned case study, the researcher identified, in July 2017, the portfolio of all the R&D projects of a given CIT Org department. This department is dedicated to develop projects to clients or in partnership in software engineering contexts.

6.2 Portfolio Selection Criteria’s Characterization

At CIT Org is used a set of criteria to manage resources through the project portfolio. In Table 22 are represented some of these criteria, which are: TRL initial, TRL end, project duration, whether it is a project with clients (services) or with partners, the cost of the project and if there are similar projects, among others.

Table 22. Project's Characterization

PROJECT		TRL			Duration_Complexity [threshold > 24 meses]	Client_ Partners	Cost_Complexity [threshold >100.000 €]	Most_ Similar_ Projects [threshold <1]
Id	Project	TRL_Initial	TRL_End	TRL_Variation				
1	Project A	5	7	2	1	1	1	0
2	Project B	5	7	2	1	1	0	0
3	Project C	3	5	2	1	1	0	0
4	Project D	3	5	2	1	0	0	0
5	Project E	2	4	2	0	0	0	0
6	Project F	5	7	2	1	0	0	1
7	Project G	4	7	3	0	1	1	1
8	Project H	6	8	2	0	1	0	1
9	Project I	4	7	3	1	0	1	2

In Table 22, the "Duration_Complexity", "Client_Partners" and "Cost_Complexity" columns are a Boolean value, where:

$$\text{if [Duration Complexity]} > 24 \text{ months; Duration\_Complexity} = 1 \quad \textbf{(1)}$$

The Project Duration is defined as the number of months taken to complete the project (Fung, 2015). At CIT Org, in the equation (1), the projects with a duration of more than 24 months are represented with Duration_Complexity=1, because these projects have a greater allocation of resources and a TRL variation of 2 or more. The complexity of a given project in CIT Org represents the degree of difficulty and the amount of time of reasoning and knowledge required to perform a given task (Perrow, 1965), that is, to implement a planned workflow concerning the project's objectives (Gidado, 1996). The R&D projects at CIT Org typically last between 6 and 36 months.

In Table 22, the "Duration_Complexity" criterion is greater than 24 months, so the value 1 is entered.

$$\text{if [Duration\_Complexity]} < 24 \text{ months; Duration\_Complexity} = 0 \quad \textbf{(2)}$$

At CIT Org, in equation (2), if the project has a duration of less than 24 months, the "Duration_Complexity" criterion is entered the value 0 in Table 22. Typically, these projects have low allocation resources, lower costs and small TRL's variation.

Clients are customer of a professional service provider (Business Dictionary, 2017).The R&D services, via projects that organizations such as CIT Org provide to its clients, include feasibility studies, prototype design, product customization and manufacturing analysis (Homburg, Fassnacht, & Guenther, 2003). These allow for the customization of solutions, with the aim of improving the products offered by customers to the market, or improving productive processes, with the aim of improving the competitive position of these same clients (Matthyssens & Vandenbempt, 1998; Windahl & Lakemond, 2010).

Companies tend to participate as part of a large research consortia with universities, laboratories and research centres (Archibugi & Coco, 2004; Cyert & Goodman, 1997), which are called R&D or R&D partnership. They are defined as the union of two or more parties, institutions or individuals, who carry out a separate task together (Aronson, Lechler, Reilly, & Shenhar, 2001; Arranz & de Arroyabe, 2008; Balachandra & Friar, 1997).

In Table 22, the projects are identified whether they were executed for clients or in a partnership. The equation (3), projects for clients, at CIT Org, are with a value of 1.

$$\text{if [Clients\_Partners]} = \text{“Client”; Clients\_Partners} = 1 \quad \textbf{(3)}$$

The equation (4), at CIT Org, the projects in partnership are with a value of 0.

$$\text{if [Clients\_Partners]} = \text{“Partners”; Clients\_Partners} = 0 \quad \textbf{(4)}$$

In Portugal, projects in the CIT Org whose consignee are clients have an increased complexity, than in the case of projects where the consignee is a partnership.

Ideally, cost estimates are based on Work Breakdown Structure (WBS) elements and are prepared for each work package. When the cost cannot be estimated, because an activity is very complex, the activity is further divided until it is possible (bottom-up estimation technique). When the project work is poorly defined or uncertain, the cost estimate is initially based on expert judgment and it is reviewed as the information becomes available (Nicholas & Steyn, 2017).

At CIT Org, if an R&D project involves a cost of more than 100.000 €, than, this project involves a large number of resources with complexity, than projects with costs lower than 100.000 €. For example, in construction project's cost, it is vital to estimate cost of materials, equipment, salary of workers, etc. In IT project's cost it is critical to estimate cost of software development, salary of IT staff (PMI, 2013a).

In Table 22, the projects are identified if were executed with a lower or higher cost than 100.000 €. The equation (5), at CIT Org, presents projects that have a cost of more than 100.000 € and that are inserted 1 value.

$$\text{if [Cost\_Complexity]} > 100000\text{ €; Cost\_Complexity} = 1 \quad \textbf{(5)}$$

The equation (6), at CIT Org, presents projects that have a cost lower than 100.000 € and that are inserted 1 value.

$$\text{if [Cost\_Complexity]} < 100000\text{ €; Cost\_Complexity} = 0 \quad \textbf{(6)}$$

The "Most Similar Projects" criteria represents the number of projects that are similar to projects in execution, and which were already part of the previous projects portfolio; if there are no similar projects, then it is a project with higher complexity.

At CIT Org, the technological similarity between the R&D projects in the portfolio enables the optimization of resources and work plans among the same R&D projects, allowing decreasing the complexity of the project that starts later, in relation to the project that gave rise to the specific technology.

In Table 22, the "Most_Similar_Projects" criteria show how many similar projects are developed regarding the selected project. Similar projects represent technological similarity, where human resources learn and gain experience, making the development of future projects less complex. The equation (7), at CIT Org, refers to projects that have similar past projects, and in "Most_Similar_Projects" column is inserted the number of similar projects.

$$\text{if [Most\_Similar\_Projects]} < 1;\ \text{Most\_Similar\_Projects} = 0;\ \text{Most\_Similar\_Projects}; \qquad \textbf{(7)}$$

For example, the project I has similarity to two other projects, so, Most_Similar_Project is equal to 2.

In the CIT Org chosen for the case study, the projects are developed for clients or partners, in average periods ranging from 6 to 36 months and whose tangible results may be the creation of a new approach, method, algorithm in IT, such as a new IT prototype or client's IT product evolution with prototype creation.

The complexity of the projects is related to the structural elements, dynamic elements and interaction of these elements by the categories of techniques, organizational and environmental domains (Botchkarev & Finnigan, 2015; Qazi, Quigley, Dickson, & Kirytopoulos, 2016). Therefore, the complexity of the projects in CIT Org are characterized according to the following criteria: (1) if projects are for clients or partnerships; (2) project duration; (3) project cost through resource allocation; (4) project result, whether it is the development of a new prototype/approach or evolution of an IT product of a given client/partner, through the creation of a prototype; (5) number of phases of the software development process that are the subject of R&D in the project; and (6) by the variation of TRL levels between the start and the end of the project.

In Table 23, project portfolio from CIT Org is characterized, too, by the dimension of the existence of efforts in R&D in the software development process, established by the RUP (Krutchen, 2004).

In 'applied research' projects, there are usually two phases for validating the results: laboratory demonstration and demonstration in the real environment, forcing the results to end in higher TRLs, typically 7. In the RUP these two phases are on the discipline "deployment".

In Table 23, the value "1" represents that there is resource allocation for that phase of software development process in the given project; the value "0" represents that there is no allocation of resources, i.e., this phase is not executed in one of the given projects.

Table 23. R&D Projects Characterization - SW Development Process

PROJECT		SW Development Process (Research dimension)						
						Deployment		
Id	Project	Business_ Modelling	Requirements	Design_and_ Conception	Implementation		Laboratory_ Demonstration	Real_Demonstration (end-user)
1	Project A	1	1	1	1	1	1	1
2	Project B	0	0	0	1	1	1	1
3	Project C	1	1	1	0	0	0	0
4	Project D	1	1	0	0	0	0	0
5	Project E	0	1	1	0	0	0	0
6	Project F	0	1	0	1	1	1	1
7	Project G	1	1	1	1	1	1	1
8	Project H	0	0	0	1	0	0	1
9	Project I	1	1	1	1	1	1	1

The RUP defines nine disciplines and four phases.

The RUP defines nine disciplines and four phases within the software development process (see Table 23). CIT Org adopted the following phases in R&D projects: business modeling, requirements, analysis and design, implementation, test and deployment. In the deployment phase, in some projects the subphase "laboratory demonstration" and the subphase "real demonstration" are explicit. In Figure 30, dark green tone correctly represents the disciplines of the RUP. The phases laboratory demonstration (in Table 23, LD acronym) and real demonstration (in Table 23, RD acronym) are represented in the RUP and in Figure 30 (clouds in shades of yellow tone), and intersect the testing and deployment disciplines, as well as the elaboration, construction, and transition phases.

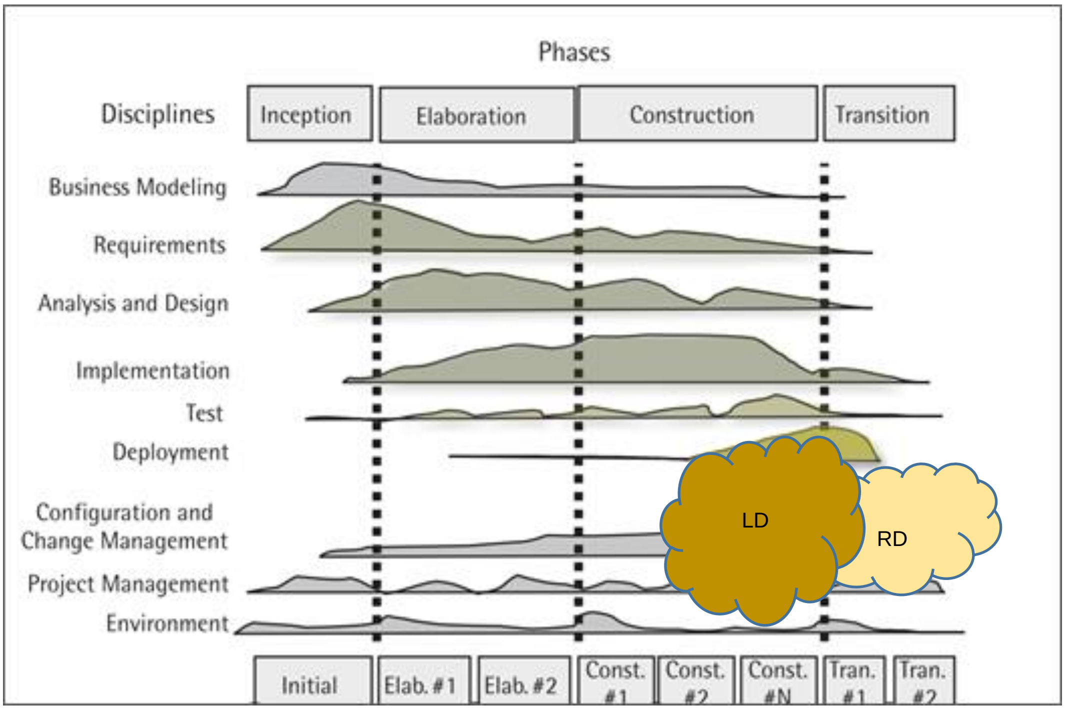

Figure 30. Mapping Disciplines and Phases with phases of the CIT Org for software development process «adapted from "IBM Rational Unified Process"» (IBM, 2003)

6.3 Mapping R&D Projects by Portfolio Selection Criteria

For this case study on CIT Org, during July 2017, were identified pool of projects of a given Department. This pool consists of nine R&D projects (all projects in progress in this period), briefly characterized in Table 22.

Project characterization is developed using IT project management terminology, and not operational research terminology.

Table 22 presents the criteria used at CIT Org to characterize the pool of projects for projects portfolio.

The Project A provides services to a client (Client_Partners=1) for the development of a new IT prototype, with a cost exceeding 100.000€ (Cost_Complexity=1), which involved the various stages of software development, for a period of 36 months (Duration_Complexity=1) and TRL 5 initial (TRL_Initial=5) and TRL 7 end (TRL_End=7). This project sought to develop a new prototype, and when the project started, there were no similar projects to be executed (Most_Similar_Projects=0).

The Project B also provides services to a client (Client_Partners=1) for the development of a new IT prototype, with a cost of less than 100.000€ (Cost_Complexity=0), which involved the various stages of software development, for a period of 36 months (Duration_Complexity=1) and TRL 5 initial (TRL_Initial=5) and TRL 7 end (TRL_End=7). This project sought to develop a new prototype, and when this started, there were no similar projects to be executed (Most_Similar_Projects=0).

The Project C provides services to a client (Client_Partners=1) to define a methodology for the development of IT products, costing less than 100.000€ (Cost_Complexity=0), that involves the various stages of software development, for a period of 36 months (Duration_Complexity=1) and TRL 3 initial (TRL_Initial=3) and TRL 5 end (TRL_End=5). This project sought to develop a new methodology, and when it began, there were no similar projects to be executed (Most_Similar_Projects=0).

The Project D is an European partnership (Client_Partners=0), known as funded projects (financing of investment projects for national and European programs). The work dealt with the definition of a methodology to develop IT products, with a cost of less than 100.000€ (Cost_Complexity=0).It involves the various stages of software development, for a period of 54 months (Duration_Complexity=1) and TRL 3 initial (TRL_Initial=3) and TRL 5 end (TRL_End=5). This project sought to develop a new IT methodology, and when the researcher started there were no similar projects to be executed (Most_Similar_Projects=0).

The Project E is a national partnership (Client_Partners=0), funded by member states of the European Commission, for the development of a new IT prototype, with a cost of less than 100.000€ (Cost_Complexity=0). It involved the various phases of the software development, for a period of 24 months (Duration_Complexity=0) and TRL 2 initial (TRL_Initial=2) and TRL 4 end (TRL_End=4). This project sought to develop a new prototype, and when this started, there were no similar projects to be executed (Most_Similar_Projects=0).

The Project F is an European partnership (Client_Partners=0), funded by the European Commission, for the development of a new IT prototype. Costing less than 100.000€ (Cost_Complexity=0), it involved some phases of software development, for a period of 36 months (Duration_Complexity=1) and TRL 5 (TRL_Initial=5) initial and TRL 7 end (TRL_End=7). This project sought to develop a new product, but there were already projects underway with similar skills and/or technologies that were used as a starting point for this project. This project is similar to one past project (Most_Similar_Projects=1).

Project G provides services to a client (Client_Partners=1) for the development of a new IT prototype, with a cost of over 100.000€ (Cost_Complexity=1). The project involved some phases of software development, for a period of 24 months (Duration_Complexity=0) and TRL 4 initial (TRL_Initial=4) and TRL 7 end (TRL_End=7). This project aimed at being an evolutive development of an already existing product; additionally, there were already projects underway with identical skills and/or technologies used as a starting point for this project. This project is similar to one past project (Most_Similar_Projects=1).

The Project H provides services to a client (Client_Partners=1) for the development of a new IT prototype, with costs lower than 100.000 € (Cost_Complexity=0), which involved some phases of software development, for a period of less than 24 months (Duration_Complexity=0) and TRL 6 initial (TRL_Initial=6) and TRL 8 end (TRL_End=8). This project intended to develop a new product, but one project already existed, with similar skills and/or technologies, that was used as a starting point for this project (Most_Similar_Projects=1).

The Project I is a national partnership (Client_Partners=0), funded by member states of the European Commission, for the development of a new IT prototype. With costs reaching over 100.000€ (Cost_Complexity=1), the project involved the various phases of the software development, for a period of 36 months (Duration_Complexity=1) and TRL 4 initial (TRL_Initial=4) and TRL 7 end (TRL_End=7). This project was intended to develop an evolution of an existing product, but there were already two projects, with similar skills and/or technologies, that were used as a starting point for this project (Most_Similar_Projects=2).

In Figure 31, the abovementioned projects are represented with solid grey and black lines, whose meanings are if the client or partner belongs to an IT or Non-IT area. The projects with solid grey line represents projects to a client or partner of the IT area. The projects with continuous black line represents projects of clients or partners of other Non-IT areas.

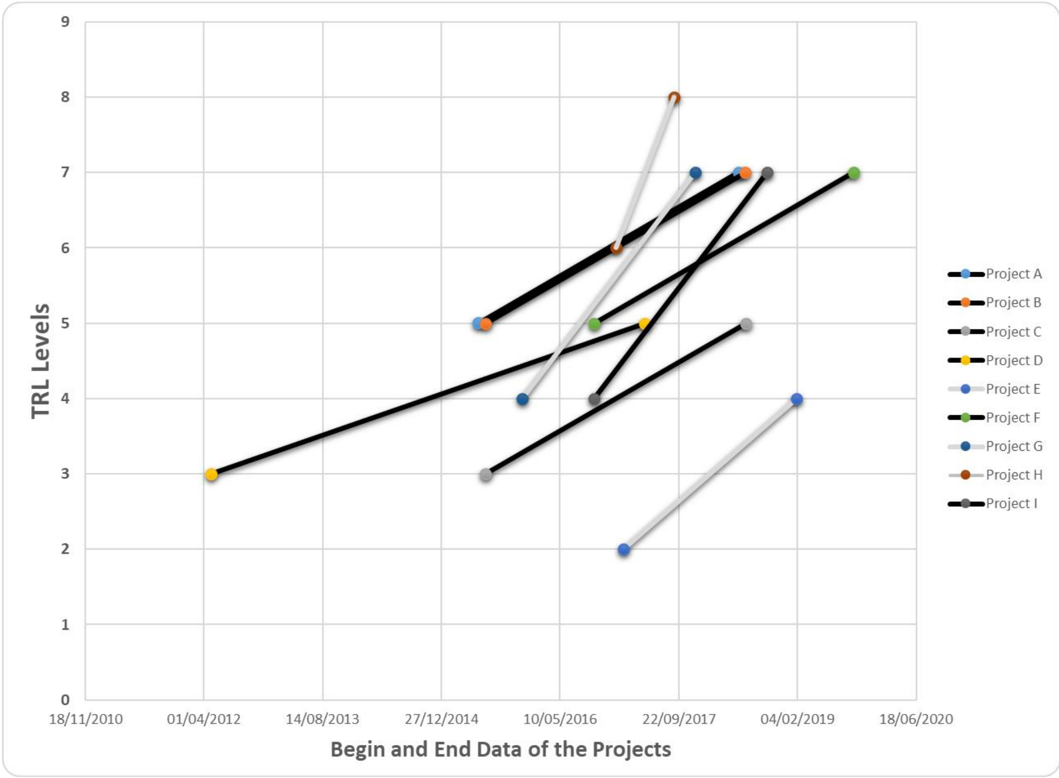

Figure 31. R&D Projects Characterization - TI or Non-IT organization

For projects whose results will be delivered to NIT client or partner, CIT Org must prepare its client or partner for delivery of a prototype or software approach. When the client or partner does not have capacity or capabilities to perform maintenance of the prototype or a software approach, it represents a post-project challenge, which CIT Org can help the NIT client or partner by adding an IT partner organization to the project, for the maintenance of the R&D result delivered.

In Figure 32, the line thickness represents whether the project has a cost (Human Resources allocation) greater or less than 100.000 €. In Figure 32, for projects with budgets higher than 100.000 € the line is thicker.

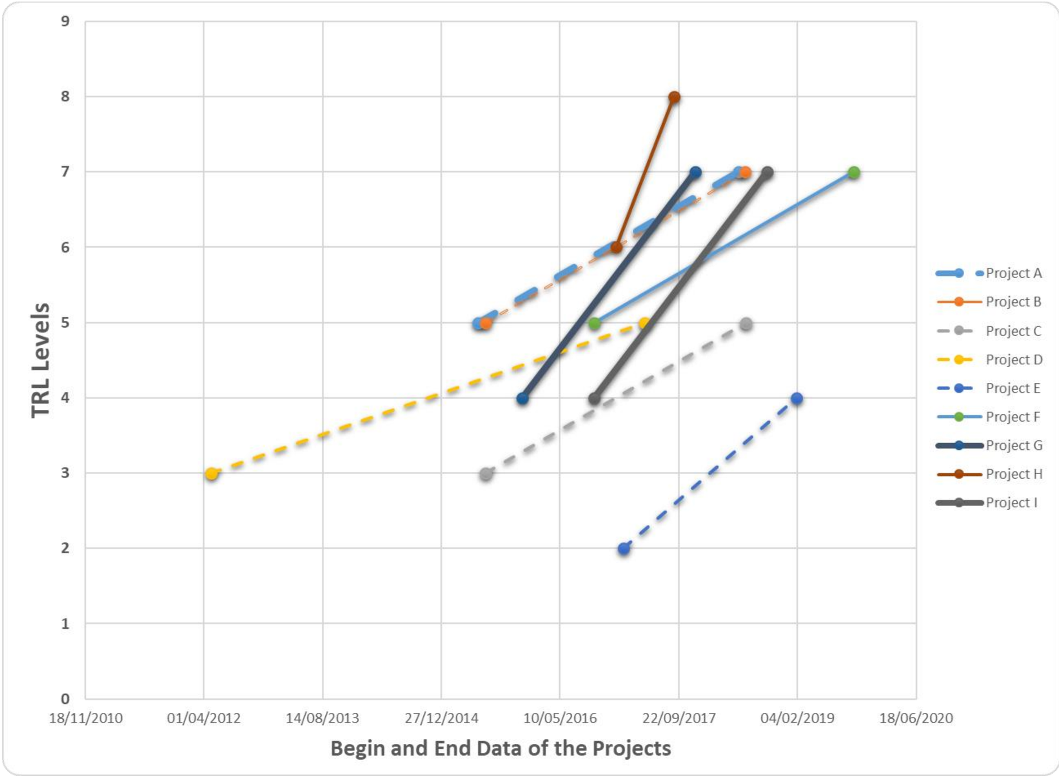

Figure 32. R&D Projects Characterization - Projects Cost and New Prototype or Upgrade Product

In addition, in Figure 32 have R&D projects characterization whose results are a new prototype or a new software approach, and these projects are represented with dotted lines. The continuous lines represent projects that will result in the upgrade of a given software product from a client or partner at CIT Org.

In the CIT Org, whose pool of R&D projects are analysed, the researcher observed that the greater the allocation of human resources through the phases of software development was, the more complex it is to implement the R&D project.

The projects that have, throughout the software development phases, the implementation and demonstration in a real scenario, in order to validate a TRL with an end equal to 8, represent a very high effort of accomplishment, since CIT

Org does not have the competences for such challenges. For the execution of these projects with a real demonstration, the researcher recommends the participation and collaboration of one company that is able make the commercial exploitation of the project's results.

The most complex projects for the criterion "phases of the software development process" (see Figure 33) rank as: Project A and Project I, later project F, and then Project G and Project H. Finally, Project B, Project C, Project D and Project E are the ones of least complex execution, for the criterion "phases of software development processes”. Therefore, a project is more complex, if more development phases are executed in this same project.

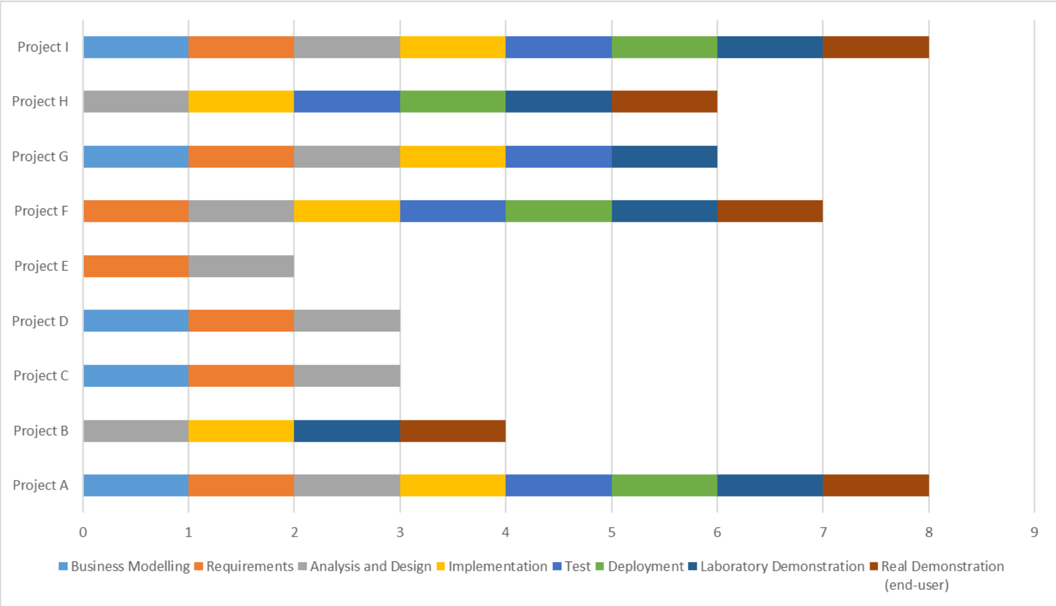

Figure 33. Projects and SW Development Processes phases within the software development process.

The application of TRL in R&D projects allows perceiving of the evolution of the research and innovation between the beginning and the end of the project. A project aiming to reach a higher level of TRL levels, which represent the advances (towards the development of a final product) in a given project for a given period of time, needs more resources to be executed. This will result in prototypes that are closer to products to be launched in the market.

Figure 34 shows the TRL variation of each of the projects of the case study at CIT Org. CIT Org, because it develops applied research projects, should carry out R&D projects between TRLs 4 and 7 (Migueis, 2017).

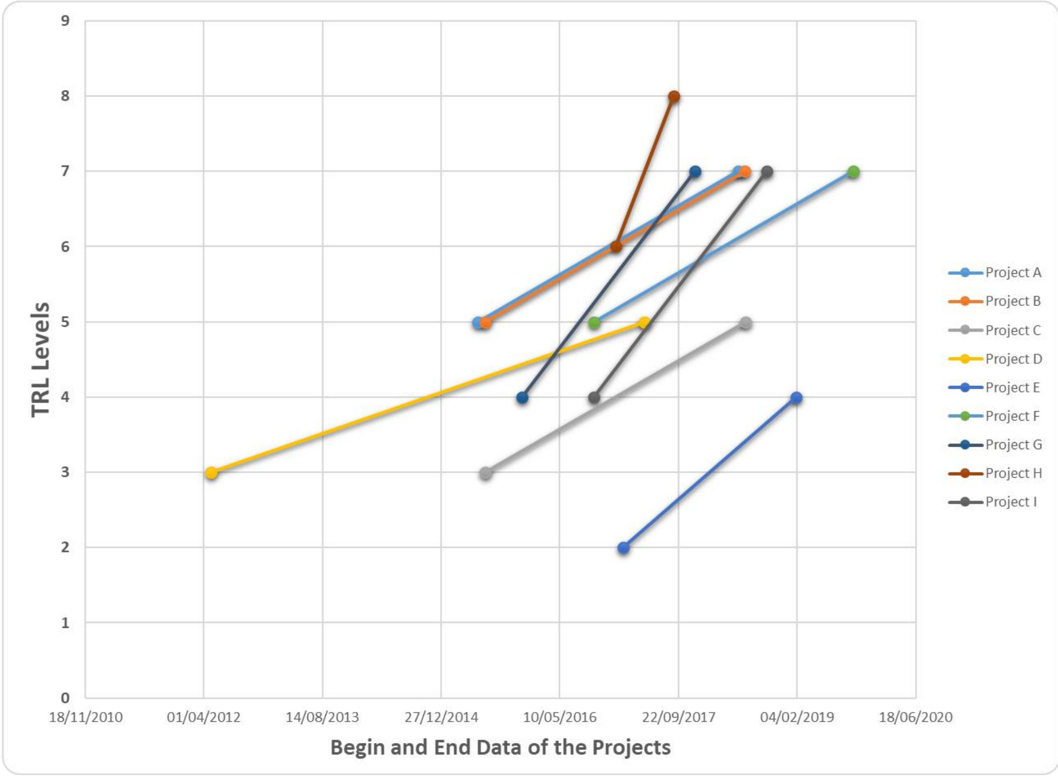

Figure 34: R&D Projects Characterization - TRL Variations

The Project E should not be implemented in the CIT Org, because the TRL initial is very low, and even the TRL end falls short of an applied research project, which is the type of projects that CIT Org should accept to carry out. CIT organizations, such as CIT Org, are dedicated to applied research projects and are not prepared to respond to the challenges of fundamental research, where the time to market the products resulting from the projects is much higher in comparison with the time to market, the products resulting from the projects from applied research.

The Project H, with the TRL 8 end, implies challenges of product development, to which a CIT organization cannot respond. Therefore, CIT Org should always involve partnerships, clients, whose goal is to transform the prototype developed in the R&D project in a product to be traded in the market, in this context corresponding to software companies.

Figure 35. R&D Projects Characterization - Mapping R&D Projects for TRL's shows in the grey rectangle that most of the projects are within these TRLs, and where all projects under CIT Org should have been.

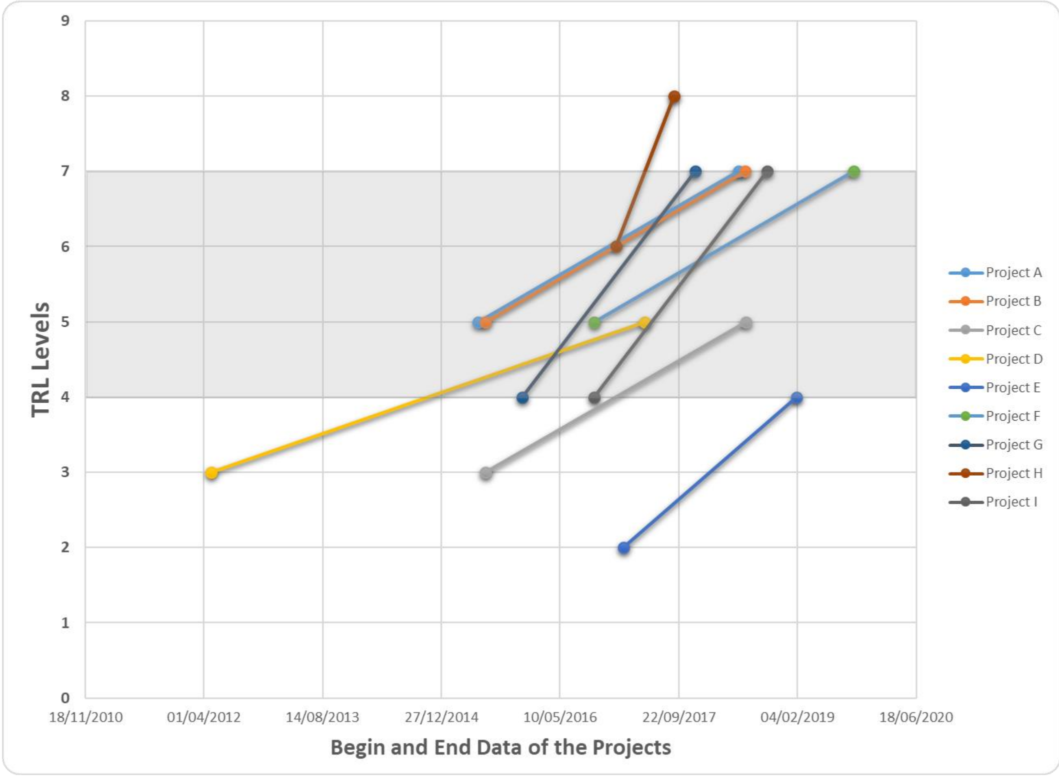

Figure 35. R&D Projects Characterization - Mapping R&D Projects for TRL's

The Project H, as project D, project C, and project E should not be in the CIT Org project portfolio, when analysed by the variation of TRLs.

The Project H, because it has a TRL with an end equal to 8, requires the commercialization of the products or services resulting from the project, so CIT Org does not have the competences, and nor is it its mission to help companies to achieve this type of project results (TRL of 8).

The Project D starts at a low TRL, creating primary constraints for CIT Org teams that are not prepared to respond to the challenges of fundamental research projects, directing a significant effort to the researchers responsible at CIT Org in the initial phase of the project. However, this project is a long-term project (project duration is 52 months), allowing CIT Org to make the upgrade from the initial TRL, TRL 3, to the end TRL, TRL 5.

The Project C has the same constraints as project D with the aggravation of having been executed in a shorter period of time. For a CIT Org these projects should be avoided, as they have challenges that the CIT Org teams are not able to respond to, and the organization's mission and strategy is to develop prototypes for companies through applied research projects. As this project is not applied research should not be carried out or executed.

The Project E should also not be carried out by CIT Org, because, in addition to being a fundamental research project, starting in TRL 2, there is no sponsor with a problem to answer, thus increasing doubt about the results of the project, that is, on the evolution of TRLs to higher indexes.

6.4 Creating R&D Project Portfolios in Information Technology

For the selection of portfolios of R&D projects in CIT Org, a set of criteria is used: (1) TRL Variation; (2) the phases of the software development process: Business Modeling (BM), Requirements (R), Analysis and Design (AD), Implementation (I), Test (T), Deployment (D), Laboratory Demonstration (LD), Real Demonstration (RD); (3) Duration Complexity (PP); (4) Client or Partner (CP); (5) Cost Complexity (C); and (6) Most Similar Projects (MP).

Some mathematical functions are used to obtain the portfolios at CIT Org.

In equation (8), the "TRL initial" criterion represents the start TRL at the beginning of the project. The "TRL end" represents the end TRL at the end of the project. The "TRL_variation" criterion represents the TRL variation.

$$[\text{TRL\_Variation}] = \text{TRL\_E} - \text{TRL\_I} \quad \textbf{(8)}$$

In equation (9) the sum of the phases of the development process is summed for each project. Then the values of the following criteria are added (sum function): “Duration_Complexity”, “Client_Partners”, “Cost_Complexity” and “Most_similar_projects”; this calculation is saved in a variable called SwDP.

$$SwDP = \sum(BM; R; AD; I; T; D; LD, RD, MP, PP, CP, C) \quad \textbf{(9)}$$

As “TRL_variation” is a criterion of greater weight for the PfM in CIT Org, in equation (10) a criterion called "TRL_Complexity" (in function, TRL_C) is created, where TRL_Complexity is equal a 0, when TRL_variation is more than 2.

$$\text{If } [\text{TRL\_Variation}] > 2; (\text{TRL\_C}=1); (\text{TRL\_C}=0) \quad \textbf{(10)}$$

In Table 24, there are two projects with the variation of TRL, "TRL_Variation", superior to 2, Project G and Project I, that is, these projects have a technical complexity and an effort allocation higher, than the remaining projects.

In Table 24, in the "Portfolio" column, two sub-portfolios are defined depending on the complexity of the project execution, ‘Portfolio-A’, sub-portfolio of R&D projects with greater complexity at the project level, and ‘Portfolio-B’, sub-portfolio of R&D projects, where the projects are of less complexity, taking into account all the identified criteria, with the following equation (11):

$$[Portfolio] = if\ (\ SwDP > 6; \text{"Portfolio-A"}; if\ (TRL\_C < 1; \text{"Portfolio-B"};\text{"}Portfolio\text{-}A\text{"})) \quad \textbf{(11)}$$

In equation (11), for the variable SwDP, when greater than 6, it represents that the sum of the several criteria is greater than half of all the criteria, when the maximum value is applied; therefore the portfolio is of type ‘Portfolio-A’, otherwise, when the criterion SwDP is less than 6, then ‘Portfolio-B’.

If SwDP is less than 6, but has a TRL_C higher 1, then the project will be from 'Portfolio-A', otherwise it's also 'Portfolio-B'.

With the fulfilment of all criteria identified by the various projects of the July 2017 project pool at CIT Org: (1) Portfolio-A, characterized by the most complex projects: Project A, Project B, Project F, Project G and Project I; and, (2) Portfolio-B, characterized by less complex projects: Project C, Project D, Project E and Project H.

The ‘Risk’ criterion is not used, because all the projects selected for a portfolio have already been accepted, so, CIT Org does not consider the “Risk” criterion for the PfM.

Table 24. IT Project Portfolio in CIT Org (July@2017)

PROJECT		TRL			SW Development Process (Research dimension)														
									Deployment										
Id	**Project**	**TRL_Initial**	**TRL_End**	**TRL_Variation**	**Business_ Modelling**	**Requirements**	**Design_and_ Conception**	**Implementation**		**Laboratory_ Demonstration**	**Real_ Demonstration (end-user)**	**Duration_ Complexity** *[threshold > 24 meses]*	**Client_ Partners**	**Cost_ Complexity** *[threshold >100.000 €]*	**Most_ Similar_ Projects** *[threshold <1]*	**Total** *(Parameter's sum)*	**Portfolio Criteria**	**TRL_ Complexity** *[threshold>2]*	**Portfolio**
1	Project A	5	7	2	1	1	1	1	1	1	1	1	1	1	0	11	4	0	Portfolio -A
2	Project B	5	7	2	0	0	0	1	1	1	1	1	1	0	0	7	3	0	Portfolio -A
3	Project C	3	5	2	1	1	1	0	0	0	0	1	1	0	0	6	2	0	Portfolio -B
4	Project D	3	5	2	1	1	0	0	0	0	0	1	0	0	0	4	1	0	Portfolio -B
5	Project E	2	4	2	0	1	1	0	0	0	0	0	0	0	0	3	0	0	Portfolio -B
6	Project F	5	7	2	0	1	0	1	1	1	1	1	0	0	1	8	2	0	Portfolio -A
7	Project G	4	7	3	1	1	1	1	1	1	1	0	1	1	1	11	3	1	Portfolio -A
8	Project H	6	8	2	0	0	0	1	0	0	1	0	1	0	1	5	1	0	Portfolio -B
9	Project I	4	7	3	1	1	1	1	1	1	1	1	0	1	2	12	3	1	Portfolio -A

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6.5 Experimenting the framework for the PfM

After the creation of the R&D projects' portfolio in a CIT Org, through two sub-portfolios of R&D projects, "Portfolio-A" and "Portfolio-B", it is necessary to validate the tailored IT PfM framework, formulated in Chapter 5.

The tailored IT PfM framework can help organizations to improve its competitive advantage, that is, organizations can increase the objectivity, accountability, and transparency of its strategic decision-making process (Bitman & Sharif, 2008)

The tailored IT PfM framework formulated in Chapter 5 is committed at the processes with PMI PfM framework, and artefacts with OGC PfM framework. The OGC PfM framework is applied to the scope of IT project portfolios. Therefore, the framework formulated in Chapter 5 already answers how to manage IT project portfolios, but does not respond to managing IT project portfolios at CIT Org.

Therefore, in order to experiment the tailored IT PfM framework formulated in Chapter 5 for the CIT organization identified, CIT Org, the researcher initiated a mapping of the artefacts defined in Chapter 5, if they are used or are framed in the project portfolios in this CIT Org. Since the two sub-portfolios, 'Portfolio-A' and 'Portfolio-B', have different characteristics, a mapping of the pertinence of these artefacts in these sub-portfolios is done.

Table 25 is represented by the mapping between the artefacts identified in Chapter 5 for tailored IT PfM framework, and its pertinence of use at CIT Org, for the 'Portfolio-A' and 'Portfolio-B' sub-portfolios.

In Table 25, the artefacts OGC.A [15] 'Benefits Forecast', OGC.A [17] 'Portfolio's Business Case' and OGC.A [18] 'Financial Plan' (Dark Grey Tones) do not apply to CIT Org, because: (1) 'profit' is to be reinvested, and in this context the PfM does not use the "profit" criterion as a strategy for the management of its project portfolios; (2) CIT Org is a non-profit organization, so return on investment metrics are not yet used to measure the return on the execution of its projects; (3) projects in the CIT Org under study are not only of the "investment" type or the "internal" type (creation of a time initiative to respond to an internal need of the CIT Org), but of business exploration, and in this context all proposals become a project, through the financial viability of partners or clients; and (4) OGC.A [7] ‘Financial Metrics and Investment Criteria', part of this 'Investment Criteria' artefact is used as an artefact for PfM; the other part of the artefact, 'Financial Metrics', is not used, as previously mentioned.

In the distinction of the sub-portfolios, 'Portfolio-A' and 'Portfolio-B', and the different requirements between the sub-portfolios, among which, project duration, TRLs variations, software development phases, cost, etc. (referred to in previous sub-chapters), the artefacts OGC.A [2.1] ‘SWOT analysis’, OGC.A [2.2] ‘PESTLE analysis’ and OGC.A [16] ‘Portfolio-level Benefits Realization Plan’, are not relevant for portfolios with low project execution complexity (see Table 26), such as for 'Portfolio-B'.

In the study of the CIT Org, it is pertinent to include an input artefact, 'Projects Pool', which represents the projects approved at CIT Org.

Table 25. Mapping between PfM artefacts and use in CIT Org (Axelos, 2011)

OGC Artefacts		CIT Organization *(if used, or not)*	Glossary	Portfolio-A	Portfolio-B
OGC.A[1] Strategic Objectives	OGC.A[1.1] Market Stading	Yes	desired share of the present and new markets	Y	Y
	OGC.A[1.2] Innovation	Yes	development of new goods and services, and of skills and methods required to supply them	Y	Y
	OGC.A[1.3] Human Resources	Yes	selection and development of employees	Y	Y
	OGC.A[1.4] Financial Resources	Yes	identification of the sources of capital and their use	Y	Y
	OGC.A[1.5] Physical Resources	Yes	equipment and facilities and their use	Y	Y
	OGC.A[1.6] Productivity	Yes	use of the resources relative to the output	Y	Y
	OGC.A[1.7] Social Responsability	Yes	awareness and responsiveness to the effects on the wider community of the stakeholders	Y	Y
	OGC.A[1.8] Profit Requirements	Yes	achievement of the measurables financial well-being and growth	Y	Y
OGC.A[2] Organizational Environmental Analysis	OGC.A[2.1] SWOT analysis	Yes	Acronym for strengths, weaknesses, opportunities and threats. A technique to determine favourable and unfavourable factors in relation to business change or current state	Y	N
	OGC.A[2.2] PESTLE analysis	Yes	Acronym for political, economic, social, technological, legal and environmental. A techinique used generally in organizational change management to undertake an environmental scan at a strategic level.	Y	N
	OGC.A[2.3] Porter's five forces analysis	Yes	rivalry, threat of substitutes, buyer power, supplier power and barriers to entry	Y	Y
OGC.A[3] Individual Stakeholder Engagement and Communication Plans		Yes	Improved engagement and communication between relevant stakeholders, including senior managers, in understanding and meeting organizational needs and expectations and in communicating strategic objectives (and the means by which they will be achieved) to all those involved.	Y	Y
OGC.A[4] Organizational Management Strategy and Risk		Yes	Risk management at a portfolio level encompasses the following main elements: Implementing standards which apply to all change initiatives within the portfolio and which align to the organizational risk management policy. A risk management strategy should be agreed at portfolio level and should be included in the portfolio management	Y	Y
OGC.A[5] Governance Structures		Yes	Encompasses the structures, accountabilities and policies, standards and processes for decision-making within an organization in order to answer the key strategic questions 'Are we doing the right things?', 'Are we doing them the right way?' and 'Are we realizing the benefits?'	Y	Y
OGC.A[6] Portfolio Risk Management Strategy		Yes	Standard roles and processes for portfolio risk management should be incorporated into the portfolio management framework. These processes should be consistent with any existing organizational risk management policy.	Y	Y
OGC.A[7] Financial Metrics and Investment Criteria		Y/N	Investment criteria that are used to prioritize initiatives should be tailored to suit each portfolio category or segment. For example, financial metrics are often used for revenue generation and cost-saving categories. In contrast, service/product enhancement categories may use criteria based on scale of enhancement per £/$/€ m invested. Many organizations employ financial metrics to prioritize initiatives such as 'net present value' (NPV), 'internal rate of return' (IRR) or 'payback'.	Y/N	N
OGC.A[8] Portfolio		Yes	The totality of an organization's investment (or segment thereof) in the changes required to achieve its strategic objectives.	Y	Y
OGC.A[9] Portfolio Maps		Yes	Collate all prioritization information and analyse	Y	Y
OGC.A[10] Portfolio reports		Yes	Ensure that the status of each of the top portfolio-level is incorporated into the portfolio dashboard and that actions are reviewed regularly and updated.	Y	Y
OGC.A[11] Portfolio Scope		Yes	Collecting consistent data on the scope of the current portfolio is greatly aided where clear guidance exists about what constitutes a project or programme and what type of initiatives are to be included in the portfolio.	Y	Y
OGC.A[12] Portfolio's Categorization		Yes	Splitting a portfolio into organizationally appropriate categories or segments -for examples, by initiative type or investment objective. The organization's investment criteria can be tailored to suit each category of investment	Y	Y
OGC.A[13] Portfolio's Governance		Yes	Encompasses the structures, accountabilities and policies, standards and processes for decision-making within an organization in order to answer the key strategic questions 'Are we doing the right things?', 'Are we doing them the right way?' and 'Are we realizing the benefits?' to portfolio	Y	Y
OGC.A[14] Portfolio Strategy		Yes	A collection of top-level strategic information that provides total clarity to all stakeholders regarding the content and long-term objectives of the portfolio. The portfolio strategy is and important communication tool.	Y	Y
OGC.A[15] Benefits Forecast		No	Benefits forecast are realized in practice and value created is optimized from our accumulated investment in change	N	N
OGC.A[16] Portfolio-level Benefits Realization Plan		Yes	To summarize the benefits forecast to be realized in the year ahead and so provide a clear view of the planned returns from the organization's accumulated investment in change.	Y	N
OGC.A[17] Portfolio's Business Case		No	Portfolio's Business cases should only include tangible financial benefits (commonly referred to as 'hard benefits'), separated into three categories: (1) Incremental revenue – all types of additional revenue, including where increased volumes and fee margins result in an increased revenue budget or forecast. (2) Cost saves – all types of cost savings, resulting in a reduction in budgeted and forecast costs as part of the performance management process. (3) Other – all additional tangible financial benefits resulting in a positive impact to the business's profit and loss accounts, such as balance sheet improvement leading to a proven 'profit and loss' impact.	N	N
OGC.A[18] Financial Plan		No	This will include the required capital and operating expenditure to complete the initiative and the consequent financial requirements post implementation – i.e. the financial impact on BAU including depreciation and cost of capital charges where applicable.	N	N
OGC.A[19] Portfolio's Performance		Yes	Portfolio management should align with the organization's performance management system: (1) Utilizing the expertise of the organization's performance management function in designing and implementing new portfolio performance metrics and driver-based models linking change initiatives, and their benefits, to the organization's strategic objectives; (2)Ensuring that the performance management function is engaged at an early point in the development of business cases and that it validates claimed impacts on organizational performance in the context of the planned impact of the existing portfolio; (3) Incorporating the anticipated impact of the portfolio on strategic objectives in the organization's performance targets; (4) Making appropriate use of the existing management information system in designing the content and format of portfolio reporting; (5) Aligning performance and portfolio reporting, in terms of both timing and content, to ensure consistent messages and effective decision-making.	Y	Y
OGC.A[20] Portfolio-level Performance Metrics		Yes	Outline of the high-level benefits the portfolio is designed to achieve and the metrics to be used to assess their realization.Benefits eligibility guidance – the detailed rules on the identification, classification, quantification, valuation and validation of benefits.	Y	Y
OGC.A[21] Portfolio Stakeholder Engagement and Communication Plan		Yes	Statement of the objectives of portfolio stakeholder engagement and communications. Description of the key stakeholder groups analysed by interest and influence. Media to be used for each group.	Y	Y
OGC.A[22] Portfolio Resource Schedule		Yes	Profiled comparison of demand and supply for constrained resources throughout the planning period, highlighting periods of slack and under-capacity.	Y	Y
OGC.A[23] Resource Forecast		Yes	Understand the demand – this requires that consideration be given to the resource requirements including staff and skills (types and timing) of not only the current live programmes and projects, but also those in the development pipeline. This in turn requires that initiatives forecast resource demands accurately and consistently. The portfolio office will therefore need to develop standards for consistent resource forecasting and compile a portfolio resource schedule from the plans of individual initiatives.	Y	Y
OGC.A[24] Portfolio Skills Register		Yes	Understand the supply – for example, complete a simple portfolio skills register recording key staff skills, experience and current availability.	Y	Y
OGC.A[25] Standards and Templates to guide programme and project Planners		Yes	Set portfolio-wide standards for resource forecasting: Consistent forecasting is essential, so define standards and templates to guide programme and project planners	Y	Y
OGC.A[26] Lessons Learned		Yes	A commitment to continuous improvement, including identifying improvements to the portfolio management practices via membership of appropriate professional groups, capturing lessons learned from robust post-implementation reviews, submissions under the champion–challenger model and periodic portfolio effectiveness reviews	Y	Y
OGC.A[27] Portfolio Delivery Plan	OGC.A[27.1] Schedule	Yes	A collection of tactical regarding the planned delivery of the portfolio based on the overarching portfolio strategy. The portfolio delivery plan usually focuses on the forthcoming year in detail in terms of schedule to be realized	Y	Y
	OGC.A[27.2] Resources	Yes	A collection of tactical regarding the planned delivery of the portfolio based on the overarching portfolio strategy. The portfolio delivery plan usually focuses on the forthcoming year in detail in terms of resource plans to be realized	Y	Y
	OGC.A[27.3] Cost	Yes	A collection of tactical regarding the planned delivery of the portfolio based on the overarching portfolio strategy. The portfolio delivery plan usually focuses on the forthcoming year in detail in terms of costs to be realized	Y	Y
	OGC.A[27.4] Risk	Yes	A collection of tactical regarding the planned delivery of the portfolio based on the overarching portfolio strategy. The portfolio delivery plan usually focuses on the forthcoming year in detail in terms of risks and benefits to be realized	Y	Y
OGC.A[28] Portfolio-level financial plan		Yes	To summarize the financial commitments inherent in the approved portfolio for the year ahead as a basis for formal senior management budgetary approval.	Y	Y
Projects Pool		Yes	In CIT organizations a project represents an approved business with budget, client or partner, activity planning and results expected and scope defined. That is, project portfolio management always starts with a pool of projects already in the portfolio.	NA	NA

Table 26 shows the relevance of the execution of the processes from PfM at CIT Org (under study). By the analysis, all PfM processes are pertinent to be executed at CIT Org, but with different relevance to the sub-portfolios, 'Portfolio-A' and 'Portfolio-B', due to the particular characteristics of each of these sub-portfolios.

In the ‘Portfolio-A’ and ‘Portfolio-B’ columns, when is the lines contain 'H' (see Table 26), the process has a high impact on the success of the PfM of the sub-portfolio; while "L" means the process has a low impact on the successful implementation of PfM of the sub-portfolio.

All PfM processes are perceived by the researcher as relevant to manage portfolios with high project execution complexity, in this case study ‘Portfolio-A’. While for portfolios with low project execution complexity, 'Portfolio-B', only the following processes are perceived by the researcher as mandatory: {PP 2} DPC ‘Develop Portfolio Charter’, {PP 3} DPR ‘Define Portfolio Roadmap’, {PP 4} DPMP ‘Develop Portfolio Management Plan’, {PP 5} DP ‘Define Portfolio’, {PP 7} DPCMP ‘Develop Portfolio Communication Management Plan’, {PP 9} MSC ‘Manage Strategic Change’, {PP 13} MPI ‘Manage Portfolio Information’, {PP 14} MPR ‘Manage Portfolio Risks’, and {PP 15} AP ‘Authorize Portfolio’.

Through the criteria for the creation of ‘Portfolio-B’, such as low cost, low resource allocation and low TRL variation, the following processes may not be performed while maintaining the performance of PfM: {PP 1} DPSP ‘Develop Portfolio Strategic Plan’, {PP 6} DPPMP ‘Develop Portfolio Performance Management Plan’, {PP 8} DPRMP ‘Develop Portfolio Risk Management Plan’, {PP 10} OP ‘Optimize Portfolio’, {PP 11} MSD ‘Manage Supply and Demand’, {PP 12} MPV ‘Manage Portfolio Value’, and {PP 16} PPO ‘Provide Portfolio Oversight’.

Table 26. The Mapping between PfM processes and use in CIT Org (PMI, 2013c)

Portfolio Process (PMI)		CIT Organization *(if used, or not)*	Glossary	Portfolio-A *Low impact (L) / High impact (H)*	Portfolio-B *Low impact (L) / High impact (H)*
Defining Process Group	PSM **{PP 1}** **DPSP** S,M,C,I	Yes	Evaluating the high-level organization strategy/investment decisions and defining the strategy in portfolio-related strategic goals and objectives in the portfolio strategic plan.	H	L
	PSM **{PP 2}** **DPC** S,M,C,I	Yes	Creating the portfolio charter and identifying the portfolio structure and portfolio management team (if applicable) to align w ith the portfolio strategic plan.	H	H
	PSM **{PP 3}** **DPR** S,M,C,I	Yes	Creating a high-level schedule show ing the strategic plan for components to be implemented over time w ith any dependencies betw een them so that management may evaluate any conflicts or gaps betw een the roadmap and the organizational strategy and objectives.	H	H
	PGM **{PP 4}** **DPMP** S,M,C,I	Yes	Defining portfolio components, developing the portfolio management organization structure, and creating the portfolio management plan.	H	H
	PGM **{PP 5}** **DP** S,M,C,I	Yes	Creating qualified portfolio components and organizing them for ongoing evaluation, selection, and prioritization	H	H
	PPM **{PP 6}** **DPPMP** S,M,C,I	Yes	Developing the performance management plan as to how portfolio value is defined and realized through the portfolio measurements and targets, alignment to organizational strategy and objectives, and roles and responsibilities in executing the plan	H	L
	PCM **{PP 7}** **DPCMP** M,C,I	Yes	Includes portfolio stakeholders' identification as w ell as planning effective solutions to satisfy the communication requirements.	H	H
	PRM **{PP 8}** **DPRMP** S,M,C,I	Yes	Planning risk management, including the identification of portfolio risks, portfolio risk ow ners, risk tolerance, and the creation of risk management processes.	H	L
Aligning Process Group	PSM **{PP 9}** **MSC** M,C,I	Yes	Evaluating and determining the responses to ongoing changes in organization strategy or portfolio components, and updating the portfolio management plan and subsidiary plans to reflect the impacts and response for portfolio management processes.	H	H
	PGM **{PP 10}** **OP** S,M,C,I	Yes	Review ing, analyzing, and changing portfolio components to create the optimal balance to achieve the organizational strategy and objectives	H	L
	PPM **{PP 11}** **MSD** S,M,C,I	Yes	Identifying and allocating the required portfolio resources capacity and capabilities according to each component proposal or plan.	H	L
	PPM **{PP 12}** **MPV** S,M,C,I	No	Measuring, capturing, validating, and reporting portfolio value at an aggregate level delivered by portfolio components w ith the goal of maximizing return on investment (w ithin an acceptable level of risk).	H	L
	PCM **{PP 13}** **MPI** M,C,I	Yes	Executes the communication plan by collecting data, translating data into meaningful information, and supplying it to the identified stakeholders in a timely and effective manner.	H	H
	PRM **{PP 14}** **MPR** M,C,I	Yes	Executing the portfolio risk management plan, including assessing, responding to, and monitoring risks.	H	H
Authorizing and Controlling Process Group	PGM **{PP 15}** **AP** S,M,C,I	Yes	Allocating resources to develop component proposals, authorizing components to expend resources and to communicate portfolio decisions	H	H
	PGM **{PP 16}** **PPO** S,M,C,I	Yes	Monitoring the portfolio to ensure alignment w ith the organizational strategy and objectives; making governance decisions in response to portfolio performance, portfolio component changes, and issues and risks to ensure the delivery of the portfolio is in line w ith the portfolio roadmap, current progress, and conditions (including resources).	H	L

The researcher, through Table 25 and Table 26, maps the processes to be executed for PfM sub-portfolios: 'Portfolio-A' and 'Portfolio-B' (see Table 27).

Table 27. The mapping between PfM processes and artefacts for CIT Org

Portfolio Process (PMI) / Artefacts (OGC)	PMI-Defining Process Group								PMI-Aligning Process Group						PMI-Authorizing and Controlling Process Group	
	PSM {PP 1} DPSP S,M,C,I	PSM {PP 2} DPC S,M,C,I	PSM {PP 3} DPR S,M,C,I	PGM {PP 4} DPMP S,M,C,I	PGM {PP 5} DP S,M,C,I	PPM {PP 6} DPPMP S,M,C,I	PCM {PP 7} DPCMP M,C,I	PRM {PP 8} DPRMP S,M,C,I	PSM {PP 9} MSC M,C,I	PGM {PP 10} OP S,M,C,I	PPM {PP 11} MSD S,M,C,I	PPM {PP 12} MPV S,M,C,I	PCM {PP 13} MPI M,C,I	PRM {PP 14} MPR M,C,I	PGM {PP 15} AP S,M,C,I	PGM {PP 16} PPO S,M,C,I
OGC ARTEFACT'S																
OGC.A[1] Strategic Objectives – OGC.A[1.1] Market Stading	IN													IN		
OGC.A[1.2] Innovation	IN													IN		
OGC.A[1.3] Human Resources	IN													IN		
OGC.A[1.4] Financial Resources	IN													IN		
OGC.A[1.5] Physical Resources	IN													IN		
OGC.A[1.6] Productivity	IN													IN		
OGC.A[1.7] Social Responsability	IN													IN		
OGC.A[1.8] Profit Requirements	IN													IN		
OGC.A[2] Organizational Environmental Analysis – OGC.A[2.1] SWOT analysis	IN	IN		IN		IN		IN						IN		
OGC.A[2.2] PESTLE analysis	IN	IN		IN		IN		IN						IN		
OGC.A[2.3] Porter's five forces analysis	IN	IN		IN		IN		IN						IN		
OGC.A[3] Individual Stakeholder Engagement and Communication Plans	IN			IN		IN	IN	I/O						OUT		
OGC.A[4] Organizational Management Strategy and Risk	IN			IN		IN	IN	I/O						OUT		
OGC.A[5] Governance Structures	IN			IN		IN	IN	I/O						OUT		
OGC.A[6] Portfolio Risk Management Strategy	IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O		OUT	I/O	I/O	OUT	I/O
OGC.A[7] Financial Metrics and Investment Criteria	IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O		OUT	I/O	I/O	I/O	I/O
OGC.A[8] Portfolio	OUT		IN		I/O		IN			I/O	I/O	OUT	IN	IN	I/O	I/O
OGC.A[9] Portfolio Maps			I/O	IN	I/O		IN		I/O	I/O		IN				IN
OGC.A[10] Portfolio reports							IN			I/O	I/O	I/O	I/O	I/O	I/O	I/O
OGC.A[11] Portfolio Scope		OUT	OUT	IN	IN				OUT	IN						IN
OGC.A[12] Portfolio's Categorization	IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O		OUT	I/O	I/O	OUT	I/O
OGC.A[13] Portfolio's Governance	IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O	OUT	OUT	I/O	I/O	OUT	I/O
OGC.A[14] Portfolio Strategy	I/O	I/O	IN	I/O	IN	I/O	I/O	I/O	I/O	I/O		I/O	I/O	I/O	OUT	I/O
OGC.A[15] Benefits Forecast										IN			IN	IN		
OGC.A[16] Portfolio-level Benefits Realization Plan										IN			IN	IN		
OGC.A[17] Portfolio's Business Case																
OGC.A[18] Financial Plan										IN			IN	IN	I/O	I/O
OGC.A[19] Portfolio's Performance							IN			IN	OUT	I/O	IN			I/O
OGC.A[20] Portfolio-level Performance Metrics							IN			IN	OUT	I/O	IN			I/O
OGC.A[21] Portfolio Stakeholder Engagement and Communication Plan	IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O		OUT	I/O	I/O	OUT	I/O
OGC.A[22] Portfolio Resource Schedule	IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O
OGC.A[23] Resource Forecast	IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O
OGC.A[25] Standards and Templates to guide programme and project Planners	IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O		OUT	I/O	I/O	OUT	I/O
OGC.A[26] Lessons Learned	IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O		OUT	I/O	I/O	OUT	I/O
OGC.A[27] Portfolio Delivery Plan – OGC.A[27.1] Schedule	OUT	I/O	IN	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O
OGC.A[27.2] Resources	IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O		OUT	I/O	I/O	OUT	I/O
OGC.A[27.3] Cost	IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O		OUT	I/O	I/O	I/O	I/O
OGC.A[27.4] Risk	IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O		OUT	I/O	I/O	OUT	I/O
OGC.A[28] Portfolio-level financial plan										IN			IN	IN	I/O	I/O
Projects Pool	IN	IN														

In Table 27, lines with dark greyscale tones represent artefacts that are not necessary for executing PfM at CIT Org. The "Projects Pool" artefact (green tone) is an artefact that should be used as input in the initial PfM processes, within the scope of portfolio defining process group.

In Table 27, rows and columns with light grey tones cannot be considered (process and artefacts), when implementing the sub-portfolio ‘Portfolio-B', because of the characteristics of this sub-portfolio.

Knowledge Area Centric Dependency Analysis applied CIT organization

The area defined at Figure 36, in yellow tone, represents the KA-1 Centric Dependency Analysis Model, i.e., processes executed in the *Portfolio Strategic Management* knowledge area. The processes and iterations outside the yellow tone represent iterations with other processes and artefacts in other *knowledge management area*.

In Figure 36, the red tones area represents the processes and artefacts that are used for PfM of the 'Portfolio-A'. The blue tones area represents the processes and artefacts required to execute the 'Portfolio-B'.

Light grey tones artefacts are dispensable from use for PfM at CIT Org. The dark grey artefact should be used by the ‘Portfolio-A’ sub-portfolio, and optionally in the 'Portfolio-B' sub-portfolio.

The green tone corresponds to new artefacts that have been added in CIT Org, but that may be, also, adopted to other contexts.

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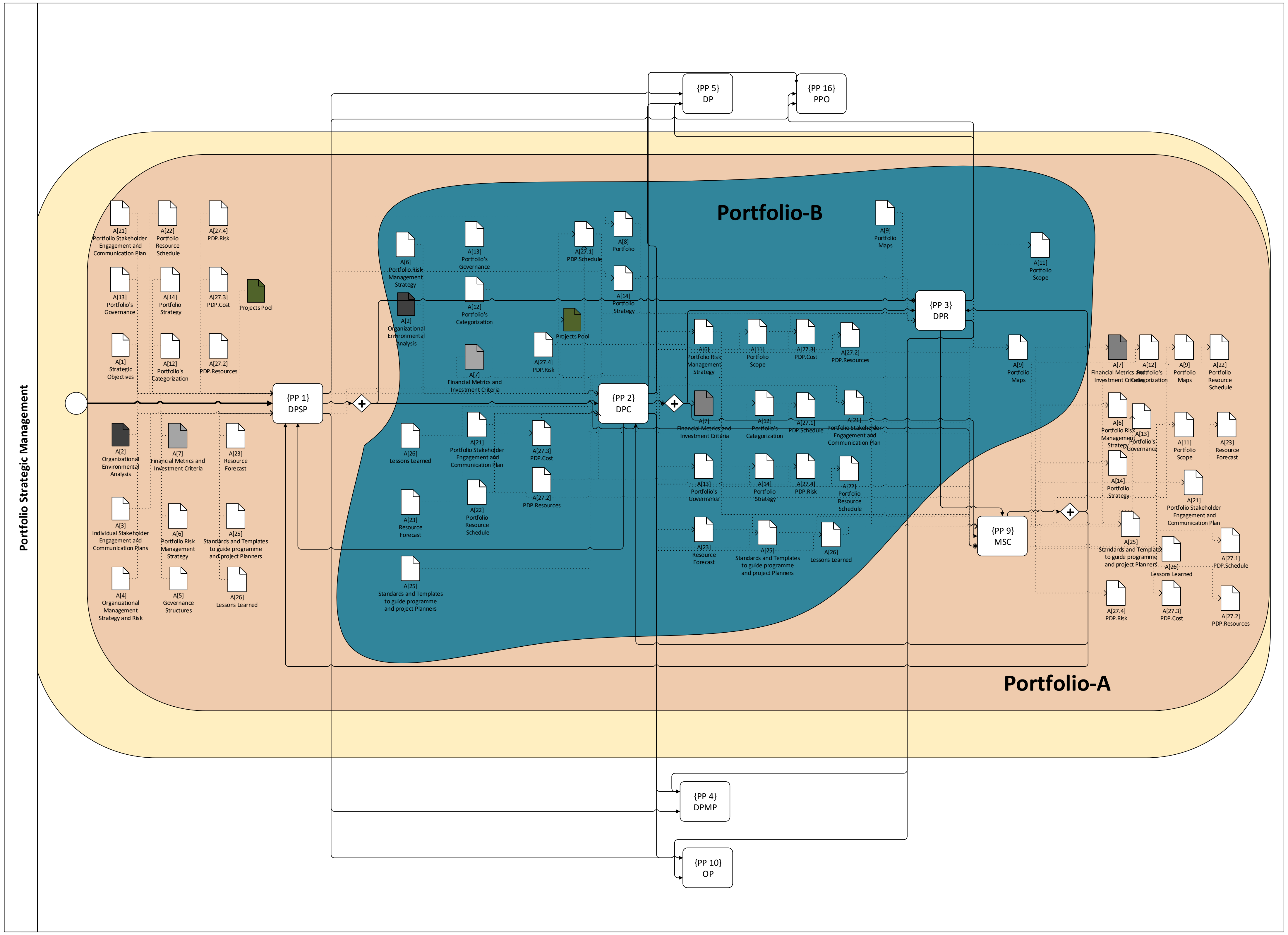

Figure 36. KA-1 Centric Dependency Analysis Model for CIT Org

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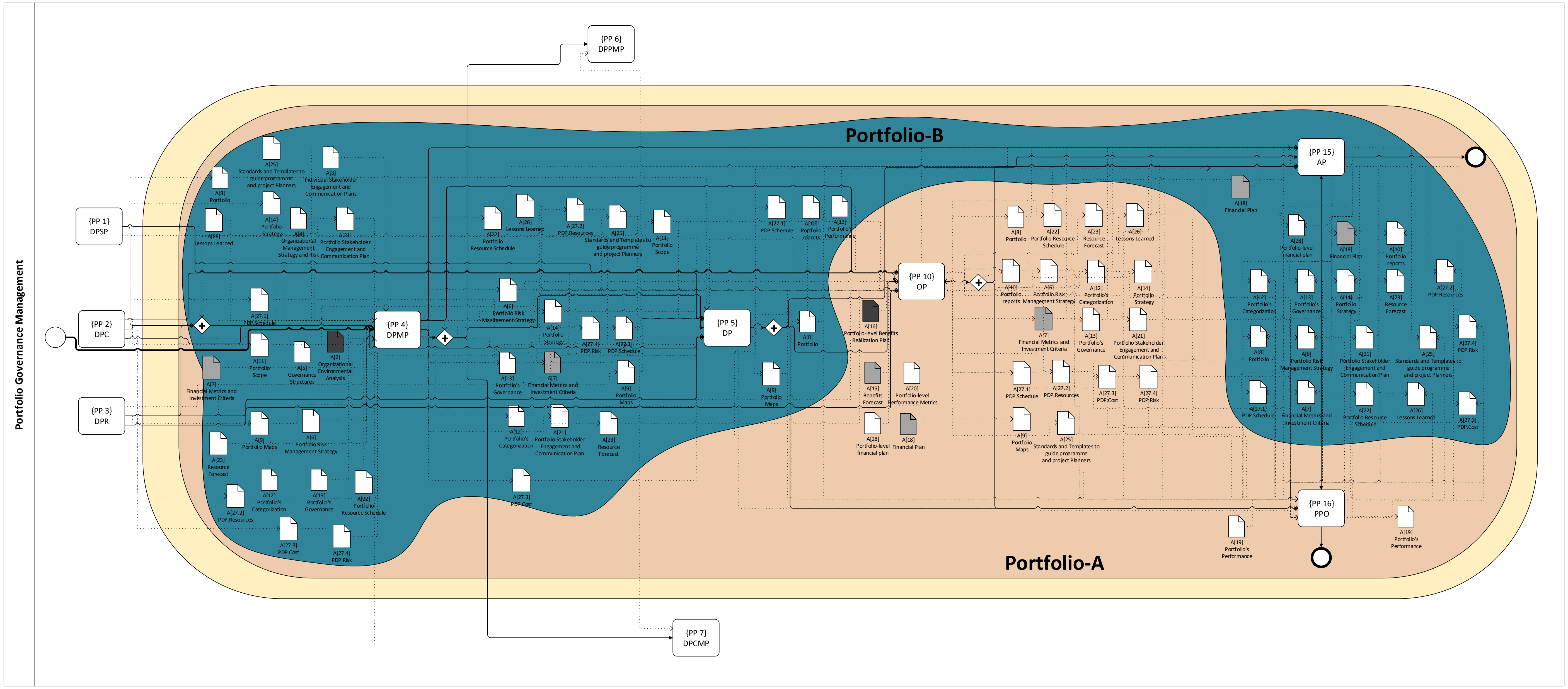

Figure 37. KA-2 Centric Dependency Analysis Model for CIT Org

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Figure 36 shows KA-1 Centric Dependency Analysis Model at CIT Org, where 'Portfolio-A' must execute processes: {PP 1} DPSP, {PP 2} DPC, {PP 3} DPR and {PP 9} MSC; and use all the artefacts for the *Portfolio Strategic Management knowledge area*. Regarding PfM of the 'Portfolio-B', it should only execute part of the processes and use part of the artefacts, i.e., it must execute the processes {PP 2} DPC and {PP 3} DPR, and the input and output artefacts of these processes.

Figure 37 shows the KA-2 Centric Dependency Analysis Model at CIT Org, where *Portfolio Governance Management knowledge area* has the following processes: {PP 4} DPMP, {PP 5} DP, {PP 10} OP and {PP16} PPO. The shaded area in yellow tones represents processes grouped in this area of knowledge. The shaded area in red tones represents which processes and related artefacts should be used for PfM of the 'Portfolio-A'. The shaded area in blue tones represents, exclusively, processes and artefacts that should be used for PfM 'Portfolio-B'.

Figure 38 shows the KA-3 Centric Dependency Analysis Model at CIT Org with following processes: {PP 6} DPPMP, {PP 11} MSD and {PP 12} MPV; and artefacts in the *Portfolio Performance Management knowledge area* (shaded area in yellow tones). For PfM of the 'Portfolio-A', it is advised to execute all processes and use all the artefacts. For PfM of the 'Portfolio-B', it does not require the execution of the processes and the use of the artefacts of the *Portfolio Performance Management knowledge area*. Consequently, the researcher concludes that, although this area of knowledge is important for PfM, within the context of the 'Portfolio-B', low project execution complexity, these processes and artefacts do not have a high impact in the PfM, because the portfolio project' has a low impact on CIT Org strategies.

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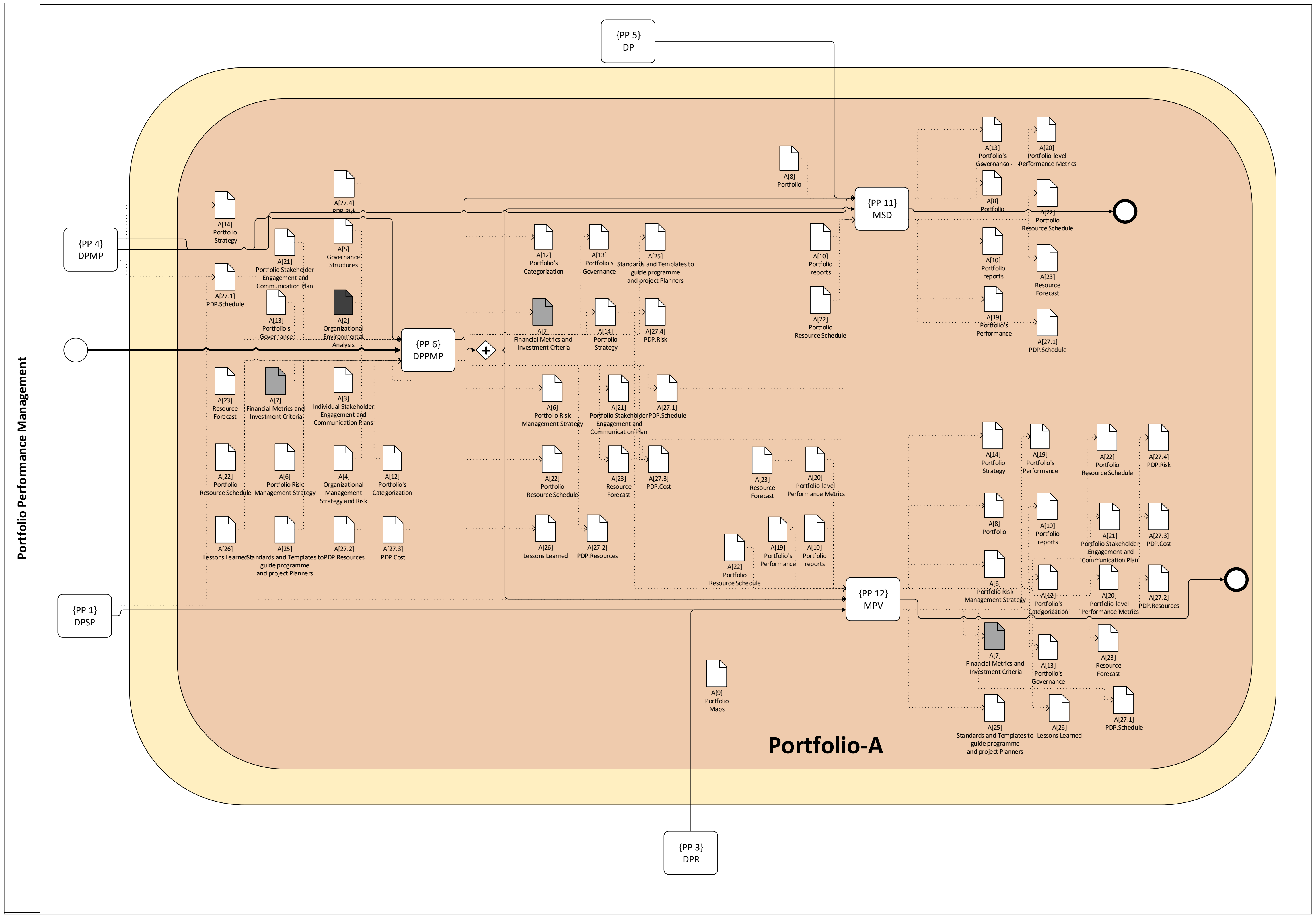

Figure 38. KA-3 Centric Dependency Analysis Model for CIT Org

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Figure 39 shows the KA-4 Centric Dependency Analysis Model, which represents the *Portfolio Communication Management knowledge area* processes, {PP 7} DPCMP and {PP 13} MPI. This *area of knowledge* differs from the others, because both sub-portfolios, 'Portfolio-A' and 'Portfolio-B', must use all processes and all artefacts of this knowledge area.

Figure 40 represents KA-5 Centric Dependency Analysis Model, *Portfolio Risk Management knowledge area* and its processes: {PP 8} DPRMP and {PP 14} MPR, where ‘Portfolio-A’ must use all processes and all artefacts of this knowledge area. ‘Portfolio-B’ must use only {PP14} MPR process.

For PfM of the ‘Portfolio-A’, a portfolio with high project execution complexity, it is necessary to execute all the processes and use all the artefacts indicated in Table 16, and defined in the framework of Chapter 5. In Figure 41, it is mentioned which are the processes that must be executed for PfM of the 'Portfolio-B', a portfolio with low project execution complexity, thus reducing the number of processes to be maintained and executed for a low-complexity portfolio, as well as fewer artefacts to be maintained. This characterization can be visualized in Figure 41, Global Portfolio Process Dependency Analysis Graph with annotated 'Portfolio-B' at CIT Org, with low project execution complexity.

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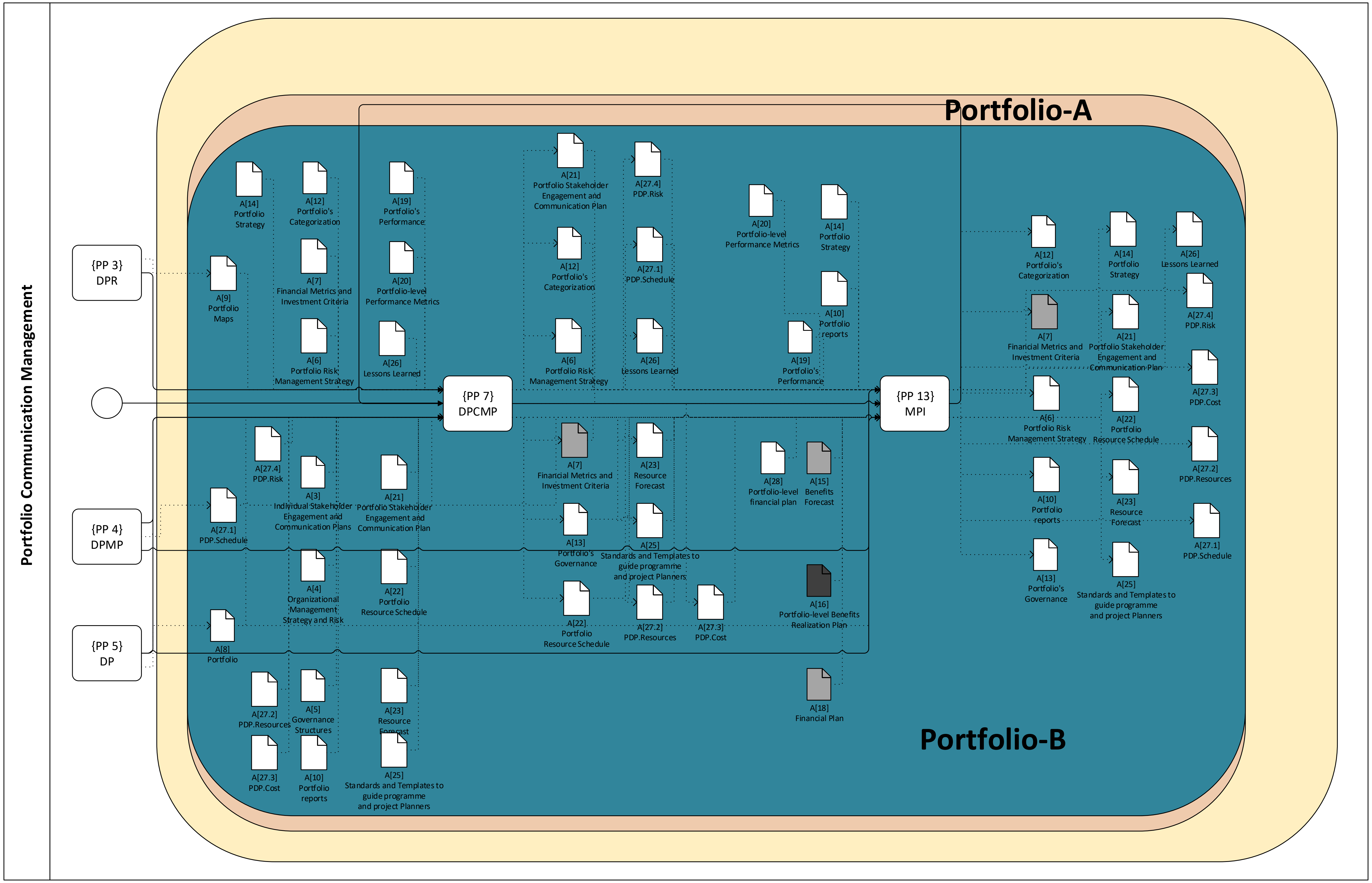

Figure 39. KA-4 Centric Dependency Analysis Model for CIT Org

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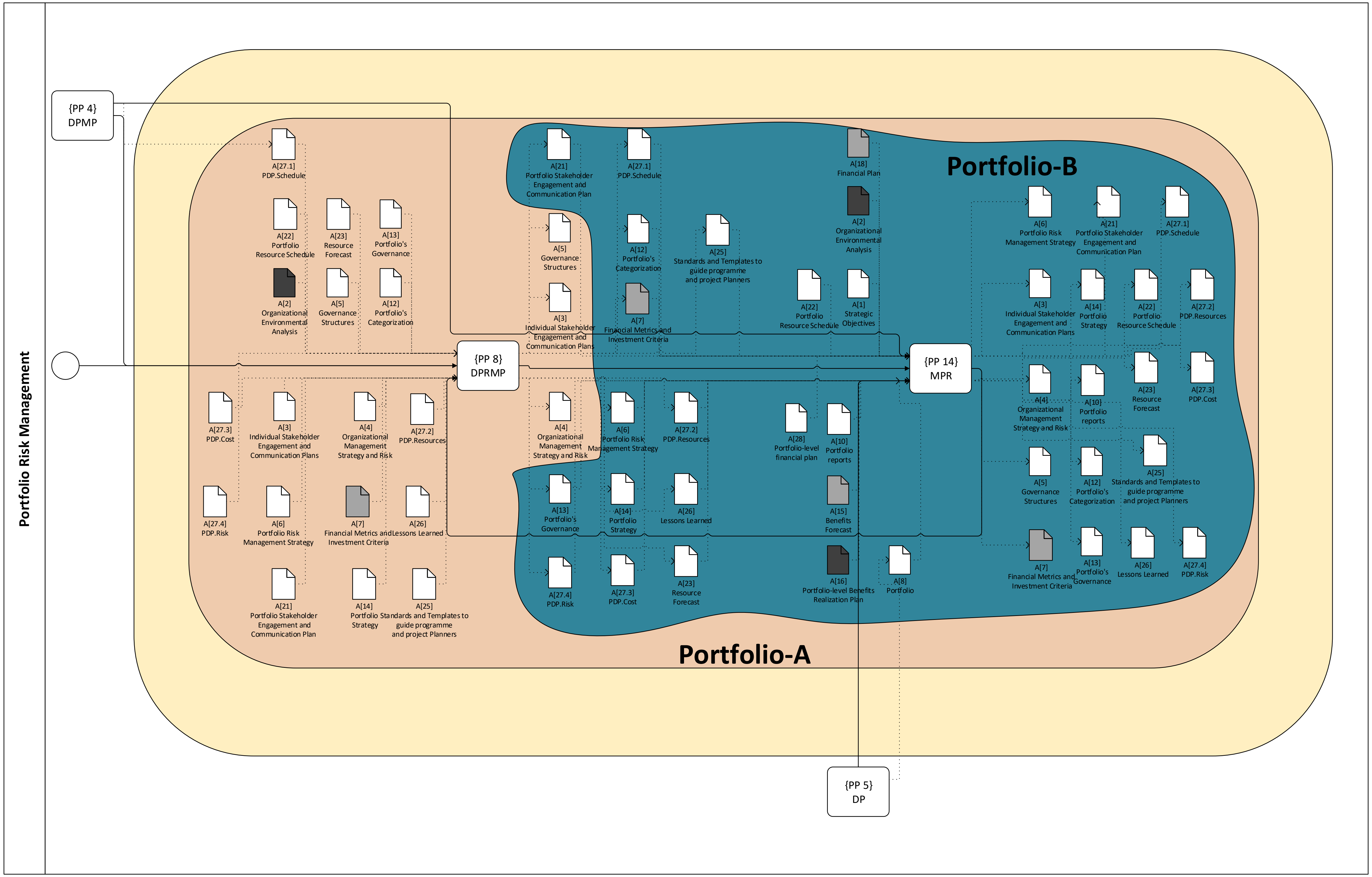

Figure 40. KA-5 Centric Dependency Analysis Model for CIT Org

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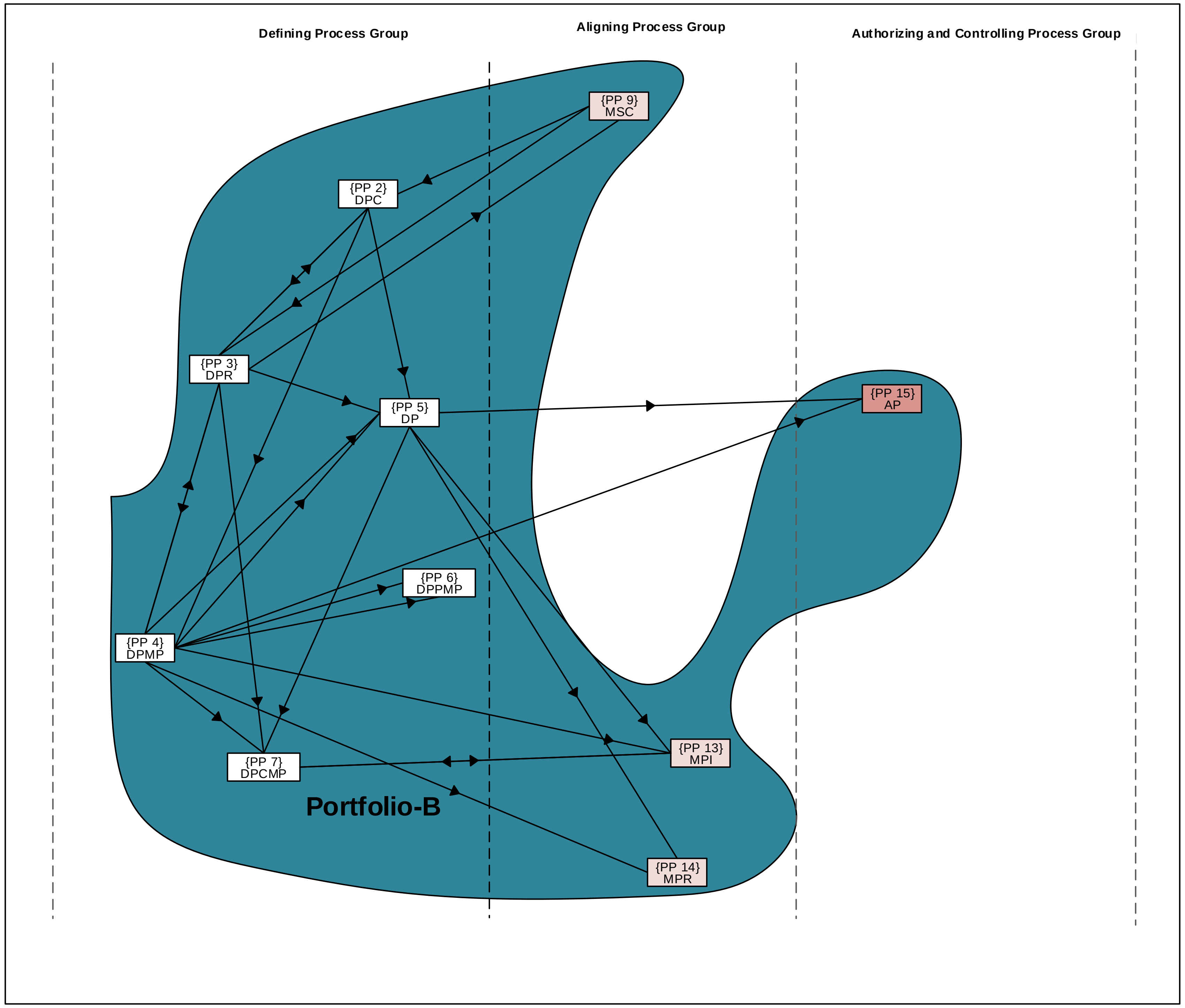

Figure 41. Global Portfolio Process Dependency Analysis Graph with annotated ‘Portfolio-B’ sub-portfolio at CIT Org

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6.6 Conclusions

The tailored IT PfM framework, based on PMI processes from the PMI PfM framework and OGC artefacts from the OGC PfM framework, is presented and experimented in the context of a CIT organization, named CIT Org.

For the experimentation of the IT PfM framework, the case study starts with the characterization of the CIT organization, CIT Org, its R&D projects in Information Technology and, later, using one of the departments that manage projects and its portfolio.

After characterizing each of the projects, it is possible to conclude the existence of two sub-portfolios, 'Portfolio-A' and 'Portfolio-B'. According to their characteristics, the sub-portfolios can be managed in a different way, depending on the portfolio projects execution complexity.

In this context of two sub-portfolios, 'Portfolio-A' and 'Portfolio-B', two studies were carried out to confirm if it is pertinent to execute all the processes identified in the framework (see Chapter 5), as well as if it is necessary to use all artefacts in both sub-portfolios.

For 'Portfolio-A', sub-portfolio with high project execution complexity, in terms of the various classification criteria, the researcher presents the following conclusions: (1) all the processes identified in the tailored IT PfM framework developed in Chapter 5 are relevant; (2) all processes must be executed for this portfolios; (3) the artefacts OGC.A[7] 'Financial Metrics and Investment Criteria' (only part of the artefact: 'Financial metrics'), OGC.A [15] 'Benefits Forecast', OGC.A [17] 'Portfolio's Business Case' and OGC.A [18] 'Financial Plan' are not relevant for CIT Organizations under study, and, therefore, these artefacts are removed from the IT PfM framework; and, (4) the 'Projects Pool' artefact is added as input for the processes {PP 1} DPSP and {PP 2} DPC, due to their relevance in CIT Organizations.

For ‘Portfolio-B’, sub-portfolio with the high project execution complexity, the researcher concludes: (1) the framework defined in Chapter 5 is very comprehensive and demanding to manage low complexity portfolios; in this context, it is demonstrated the pertinence of decreasing the number of processes to be performed and artefacts to be used; (2) the lower project execution complexity, the PfM processes to be performed are: {PP 2} DPC, {PP 3} DPR, {PP 4} DPMP, {PP 5} DP, {PP 7} DPCMP, {PP 9} MSC, {PP 13} MPI, {PP 14} MPR and {PP 15} AP; (3) in the context of CIT Organizations, and in particular of the 'Portfolio-B' sub-portfolio, the artefacts listed in the previous point have been withdrawn due to the lack of relevance of use; and, (4) there is also no need to use the artefacts OGC.A [2.1] SWOT analysis, OGC.A [2.2] ‘PESTLE analysis’ and OGC.A [16] ‘Portfolio-level Benefits Realization Plan’.

CHAPTER 7

CONCLUSION

Summary: This chapter concludes the written part of this thesis. First, the researcher performs a critical analysis of the initial research question pursued and the proposed objectives. Following there is a synthesis of the contributions of this work to the universal body of knowledge, alongside the publications achieved along the research chronogram time span. Finally, the limitations imposed, the lessons learned and the opportunities left open in the future work topics are finalized.

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CHAPTER 7: CONCLUSION

"All art and all research, as well as, every action and every choice, aims at any asset; and so it has been said, with much rightness that good is that to which all things tend".

– Aristoteles

7.1 Critical Analysis

Technological interface centres in the IT domain develop R&D projects to create and evolve company products, or dematerialize complex company processes using technology corresponding to the central element of their competitiveness.

With the aim of creating a tailored IT PfM framework, which enables professionals to manage and better control IT project portfolios, and to correspond the generalization of existing PfM processes to the specificity of IT projects and CIT organizations, an adaptation of two frameworks in PfM is created: PMI and OGC for IT projects in CIT organizations.

The researcher founded the PMI PfM framework to be a complete standard in the process descriptions of project portfolio management, but that it gave limited guidance to professionals in how to execute these processes in their daily work practices. The OGC PfM framework has a generic practices description from project portfolio management, but also an interesting collection of artefacts, which corresponds to how professionals perform project portfolio management.

Both the PMI PfM framework and the OGC PfM framework, as recent frameworks, also have, as can be observed in the previous chapters, some failures of systematization of all the practices that a project portfolio manager should be able to carry out.

The research work is conducted using the DSRP model, where a case study in a CIT organization is used to experiment the IT PfM framework proposed.

7.2 Considerations of the recent evolution of the PMI PfM Framework

As recently as October 2017 (date of submission of the thesis), the PMI released a new version of “Standard for Portfolio Management” (PMI, 2017) with a particular focus on: (1) harmonizing key sections and concepts with other PMI foundational standards; (2) aligning with the PMI Lexicon of Project Management Terms; (3) developing the recommendations of experts; and, (4) aligning with the ISO 21504:2015 (ISO, 2015) on Project, Programme and Portfolio Management, guidance on Portfolio Management

In the third edition (2013), PMI PfM framework included the concept of “Process Groups”: ‘*defining*’, ‘*aligning*’, and ‘*authorizing and controlling*’. Now, in the fourth edition (2017), the “Process Groups” become “Portfolio Life Cycle” with: ‘*initiation*’, ‘*planning*’, ‘*execution*’, ‘*optimization*’, and ‘*monitor and control*’. “Portfolio Management Knowledge Areas” has become, in the fourth edition, "Portfolio Management Performance Domains", which represents the collection of good practices, similar to the OGC PfM framework.

Table 28 presents the structural changes between the third and fourth editions of the Standard for Portfolio Management from PMI.

Table 28. Structural Changes PMI@2017

3rd edition, 2013	4th edition, 2017
Portfolio Management Process Groups	Portfolio Life Cycle
Defining Process Group • Aligning Process Group • Authorizing and Controlling Process Group	Initiation • Planning • Execution • Optimization • Monitor and Control
Portfolio Strategic Management	Portfolio Strategic Management
Portfolio Governance Management	Portfolio Governance
Portfolio Performance Management	Portfolio Capacity and Capability Management Portfolio Value Management
Portfolio Communication Management	Portfolio Stakeholder Engagement
Portfolio Risk Management	Portfolio Risk Management

In the fourth edition of the Standard for Portfolio Management from PMI, a new concept, "*Portfolio Value Management*" has been introduced, without any comparison to the third edition.

Table 29 presents the sixteen performance domains of the Standard for Portfolio Management from PMI with its key activities.

Table 29. Portfolio management performance domain and its key activities (PMI, 2017)

Portfolio Management Performance Domains	**key activities**
Portfolio Strategic Management	Develop Portfolio Strategic Objectives
	Define Strategic Risk Appetite
	Define Portfolio Roadmap
	Optimize Portfolio
	Define Portfolio Charter
	Manage Strategic Alignment
Portfolio Governance Management	Design Portfolio Governance
	Optimize Portfolio Governance
Portfolio Capacity and Capability Management	Manage Capacity
	Plan Capacity
	Manage Supply and Demand
	Optimize Supply and Demand
	Assess Capability
	Develop Capability
	Balance Capacity and Capability
Portfolio stakeholder Management	Define and Identify of Portfolio Stakeholders
	Analyse of Portfolio Stakeholders
	Plan Stakeholder engagement
	Identify Communications Management Approaches
	Manage Portfolio Communications
Portfolio Value Management	Manage value
	Assure Value
	Safeguard Value
	Negotaite Expected Value
	Realize Value
	Report Value
	Maximize Return
	Measure Value Performance
Portfolio Risk Management	Develop Portfolio Risk Management Plan
	Manage Portfolio Risks

7.3 Synthesis of Research Efforts

In this thesis, the researcher intend, by using PfM frameworks, to contribute to a tailored IT PfM framework.

To achieve the research objectives, the steps shown in Figure 1 were followed. The first step, identifying motivation, has been presented in section 1.2. The remaining steps are performed several times. Thus, the research work was divided into several phases, where each stage consists of steps 2 through 6, as shown in Table 30.

Thus, the research work was divided into the following stages:

(1) Mar 2015 to Jun 2016: systematization of PfM processes and artefacts through the creation of dependency and mapping between processes and artefacts from the PMI PfM framework. Thereafter the same mapping applied to the OGC PfM framework;

(2) Jul 2016 to Dec 2016: Crossing the dependency mapping between processes and artefacts of the PMI PfM framework with the OGC PfM framework;

(3) Feb 2017: IT project characterization at CIT Org. At this stage, IT projects were characterized at CIT Org, as were the relationship between projects and decisions related with PfM. In this context, the IT project characterization was important to demonstrate what criteria may require PfM;

(4) May 2017: IT PfM Framework. At this stage, taking as a starting point the "outputs" of the above points the IT PfM framework at CIT Org was established;

(5) Jul 2017: Experimenting the tailored IT PfM framework, based on the IT project characterization at CIT Org, using the IT PfM framework. Completion of the research work and its conclusions;

(6) Oct 2017: Completion of the research document;

(7) Research work management (January 2013 - October 2017): This step was horizontal to the entire research work. The main deliverables were: (1) presentations of the work; and (2) a continuous phase of publications at conferences and writing of the thesis.

In Design Science Research, the last step of each cycle is to communicate the results. At the end of each cycle, the communication of the developments and conclusions were expected (see Table 30).

Table 30.Research execution chronogram

Research Work Stages	2013	2014				2015				2016				2017			
	Jan 13 a Dec 13	1º Qrt	2º Qrt	3º Qrt	4º Qrt	1º Qrt	2º Qrt	3º Qrt	4º Qrt	1º Qrt	2º Qrt	3º Qrt	4º Qrt	1º Qrt	2º Qrt	3º Qrt	4º Qrt
Literature Review	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Systematize processes and artefacts from project portfolio management					■	■	■	■	■	■	■						
Crossing the dependencies maps between processes and artefacts of PMI with the OGC PfM standards									■	■	■	■	■				
Characterization of IT projects in CIT organizations													■	■			
Project Portfolio Management Framework						■	■	■	■	■	■	■	■	■	■	■	
Evaluate the results, draw conclusions														■	■	■	
Complete the research document (thesis)															■	■	■
Research work management	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

7.4 Synthesis of Scientific Results

This thesis provide several contributions to the field of study. Among these contributions are:

- **PMI PfM framework Dependencies**
- **OGC PfM framework Dependencies**
- **PMI and OGC Mapping**
- **PMI and OGC Dependency Analysis**
- **Tailored IT Project Portfolio Management Framework for CIT organization**

During this thesis, the researcher produced a number of presentations and publications. The doctoral proposal was presented at the Symposium for PhD students in Software Engineering, SEDES'2016, IEEE CS Press, while the publications produced are as follows:

- Lima, A., Monteiro, P., Fernandes, G., Machado, R.J.: Dependency Analysis Between PMI Portfolio Management Processes. Lecture Notes in

Computer Science, vol 9790, pp.288-300, Springer. (presented in ICCSA'2016);

- Lima, A., Monteiro, P., Fernandes, G., Machado, R.J.: Mapping Between Artefacts and Portfolio Processes from the PMI Standard for Portfolio Management. Lecture Notes in Business Information Processing, vol 284, pp. 117-130, Springer. (presented in 9th SIGSAND/PLAIS EuroSymposium'2017);
- Lima, A., Machado, R.J., Fernandes, G.: Input and output artefacts in portfolio practices from the OGC standard for Management of Portfolios, pp.1-8, IEEE CS Press (presented in ICCSA'2017).
- Lima, A., Fernandes, G., Machado, R.J.: Mapping between PMI and OGC Artefacts for Project Portfolio Management. IEEE CS Press (presented in 9th International Conference on Intelligent Systems 2018).

Additionally, the researcher expects three publications from this dissertation, related to the results and conclusions of the case study analysis.

7.5 Future Work

The research work carried out throughout this PhD thesis not, completely, cover all the possible and pertinent research topics relative to the exhaustive analysis of the use of PMI and OGC implementations.

Additional research tracks and efforts might be considered for those who would like to use this thesis as a baseline for future work, namely:

(1) The creation of templates and guidelines for each of the artefacts needed to implement PfM processes in CIT organizations;

(2) The mapping of templates/guidelines with the artefacts, in order to objectively respond to the portfolio manager's tasks;

(3) The deepening of scope of activities within each of the PfM processes, in order to adapt to each of the organizational contexts;

(4) The implications for PfM of the projects in the portfolio to follow different approaches, such as agile or waterfall.

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