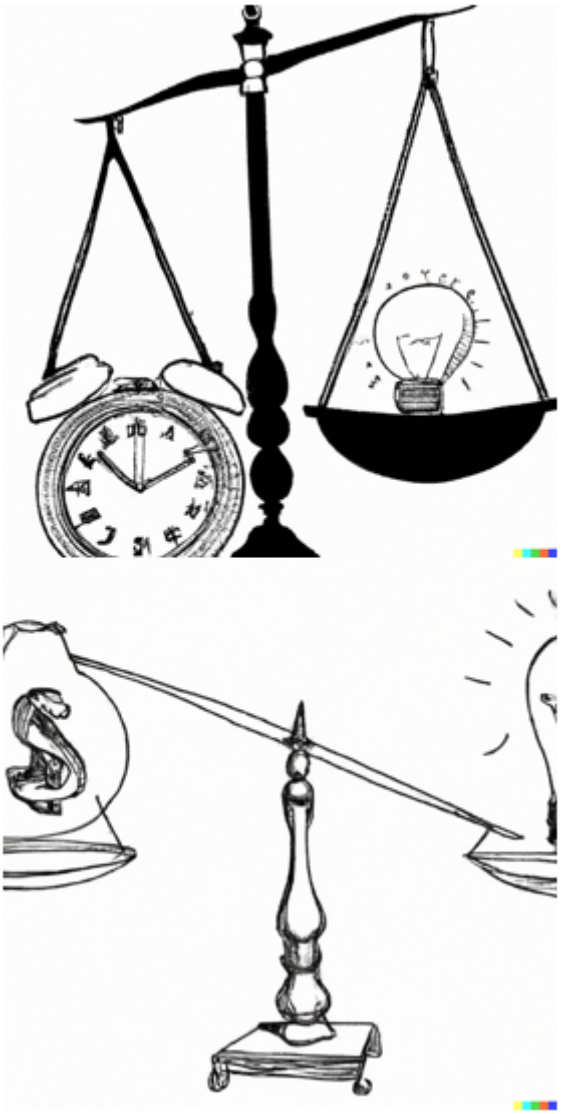
SECURITY WITH NEW PRODUCTS

A CASE STUDY ANALYSIS ON INNOVATION PORTFOLIO MANAGEMENT AT THE DUTCH MINISTRY OF DEFENSE



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A CASE STUDY ANALYSIS ON INNOVATION PORTFOLIO MANAGEMENT AT THE DUTCH MINISTRY OF DEFENSE

Thesis

Master thesis submitted to Delft University of Technology in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Management of Technology
Faculty of Technology, Policy and Management

by

Samuel MOUTON

Student number: 4567447
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Graduation committee:
First supervisor: Dr. W.W. Veeneman, Section Organization & Governance
Second Supervisor: Dr. A.C. Smit, Section Economics of Technology and Innovation
Organization Advisor: kapitein-luitenant ter zee M.E. vd Eerden, Departement FRONT

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ABSTRACT

(Innovation) portfolio management literature is extensive but barely touched upon in the public context. Portfolio management is instrumental in resource allocation and strategic decision-making, directing investments toward strategic priorities. This thesis explores how innovation portfolio management (IPM) is performed at the Dutch Ministry of Defense, and a comparison is made with private and public sector literature available.

Key findings illuminate pronounced disparities between the MoD's IPM methodologies and those established in the private sector. Notably, the MoD's IPM framework places subjective risk-reward metrics at the forefront of decision-making, diverging from conventional private sector emphasis on monetary considerations. Furthermore, the MoD's IPM approach primarily revolves around project-level evaluations, constraining portfolio-level prioritization decision-making. The conspicuous absence of a articulated innovation strategy and the decentralized nature of portfolio oversight serve as additional distinguishing features of the MoD's IPM practices.

Moreover, the MoD's unique procurement model, which relies extensively on external development, and its innovation strategy, predominantly shaped by market dynamics, set it apart from IPM practices commonly observed in the private sector. Existing public sector literature has provided valuation methodologies across diverse sectors; however, these contributions have often neglected to provide a comprehensive understanding of how IPM is executed and have been relatively under-referenced.

Within the MoD, this thesis reveals that the valuation of IPM, while exhibiting variations among different departments, predominantly relies on multi-criteria analysis (MCA) with a retrospective focus. Notably, subjective measures such as *relevance* and *urgency* are employed as yardsticks for assessing project value.

This research enhances our understanding of IPM in the public sector and underscores the need to further explore and refine IPM methodologies within public organizations. It highlights the distinctive characteristics of IPM within the MoD and emphasizes the importance of aligning IPM practices with organizational objectives and strategies to optimize resource allocation and decision-making. With the results of this thesis, public entities have guidance on how to organize portfolio management and how prioritization can be performed.

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1

INTRODUCTION

This chapter serves as an introduction to the research endeavor, delineating the underlying motivations, articulated objectives, and the central research inquiry alongside its subsidiary inquiries. By the chapter's conclusion, the reader will attain a lucid comprehension of the research's overarching goals and gain insight into the subsequent structure and content of the thesis.

1.1. RESEARCH OBJECTIVE AND RESEARCH MOTIVATION

The aim of this research is to offer insights into innovation portfolio management (IPM) in the public sector, specifically the Dutch Ministry of Defense (MoD). IPM is a decision-making process that can support organizations in making conscious decisions on their R&D endeavors.

Innovation portfolio management can be defined in different ways but the most popular definition, and used in this paper is:

"portfolio management is a dynamic decision process, whereby a business's lists of active new product (R&D) projects is constantly updated and revised. In this process, new projects are evaluated, selected, and prioritized; existing projects may be accelerated, killed, or deprioritized; and resources are allocated and reallocated to the active projects" [Cooper et al., 2000].

Portfolio management within the public sector is not uncommon however the topic of portfolio management in the public sector has received far less attention than in the private sector[Linquiti, 2015, Roberts and Hamilton Edwards, 2023, Baškarada and Hanlon, 2018, Maceta and Berssaneti, 2020]. Practical examples of how to perform portfolio management as well as the factors that play a role in creating balance within a portfolio for the public sector are lacking.

Moreover, the difference between portfolio management in the public sector and private sector has received limited attention in the literature [Roberts and Hamilton Edwards, 2023, Maceta and Berssaneti, 2020, Baškarada and Hanlon, 2018].

This study delves into the intricacies of the IPM management process employed by the Dutch Ministry of Defense (MoD). Ministries of Defense, recognized as prominent innovators within the public sector, boast substantial research and development (R&D) budgets sanctioned by government authorities[Chesbrough and Vanhaverbeke, 2018] [Horowitz and Pindyck, 2022, Nato innovation Fund,]. Ministries of Defense are required to innovate due to the ever-changing threats by advancing technologies. The Dutch MoD and military organizations around the world are attempting to change their R&D process rapidly to accustom to emerging technologies and get commercial technologies into military applications [NATO, 2021]. The Dutch Ministry of Defense's R&D strategy is distinguished into two tracks. The introduction of platforms and weapon systems results from long-term R&D trajectories of large equipment. Relevant and available civilian technologies on the other hand can be made militarily applicable in a relatively short time frame. The importance of this short trajectory, referred to as *kort-cyclische innovatie*(KCI), has increased in recent years [NATO, 2021, Ministerie van Defensie, 2020b]. The short-cycle innovation strategy is based on NATO's vision of more public-private collaborations for innovation and encouragement from literature for increased multi-actor engagement for innovation [NATO, 2021, Chesbrough and Vanhaverbeke, 2018].

Short-cycle innovation has different characteristics to that of classic R&D projects creating new challenges for the MoD regarding its R&D strategy. The main difference lies in its increased cooperation with different partners (knowledge institutions and private companies), lower initial investment, and a more significant number of projects being started. Currently, there are over one thousand short-cycle projects in which the MoD is involved. To ensure that the MoD undertakes suitable projects it's vital to align its projects to its strategy and balance its resources. Innovation portfolio management can support decision-makers in the choice of the right balance of projects.

By scrutinizing the Dutch MoD's IPM procedures, this investigation not only sheds light on the MoD's IPM practices but also offers potential insights into portfolio management methodologies applicable to diverse public sectors. Notably, it explores how risk assessment and portfolio balance considerations may significantly diverge between public and private sector contexts. This thesis contributes valuable insights into the evaluation criteria and methodologies prevalent in the public sector, thereby enriching our understanding of IPM. Furthermore, it illuminates the distinctions between portfolio management in the public sector, as exemplified by the MoD, and the predominantly private-sector-oriented literature on the subject.

1.1.1. RESEARCH OBJECTIVE

The objectives of this paper are to:

- Identify how innovation portfolio management at the MoD is performed.
- Identify ways to balance portfolios in the private sector.
- Identify portfolio management literature in the public sector.
- Identify the key differences between IPM performed in the MoD with IPM literature available.
- Identify key similarities and differences for IPM in the public sector and IPM at the MoD.

1.2. RESEARCH QUESTIONS

To accomplish the primary objective of the proposed thesis, it is imperative to formulate a significant research question. In conjunction with the main research question, incorporating sub-questions can greatly contribute to the research endeavor by providing essential information necessary to fulfill the research objective. Presented below is the research question alongside its associated sub-questions, accompanied by supplementary elucidation.

1.2.1. MAIN RESEARCH QUESTION

The main research question is based on the research objective outlined. Several sub-questions are needed to understand the primary research objective better and fully answer the primary research question. Next, the primary research question as well as the sub-question are presented with more clarification:

- How does innovation portfolio management in the public sector, as exemplified by a case study within the Ministry of Defense, differ from private sector innovation portfolio management literature?

The exploratory nature of this research is further structured through previous research primarily taken from IPM literature in the private sector. Portfolio management encompasses the astute allocation of resources, encompassing both financial capital and human resources, as well as the judicious selection of projects to cultivate a continuous stream of projects with a significant impact on the organization [Cooper et al., 2000].

As previously mentioned it is required to understand an organization its portfolio management through an understanding of different layers within the organization from project management to strategic considerations. The framework by Cooper (2017) suggests the split of portfolio management by business innovation strategy, Strategic portfolio decision-making, and tactical portfolio decision-making [Cooper, 2017b]. This framework further elaborated in chapter 2, will be used as a leading guideline to understanding how IPM is performed within the MoD. The sub-questions (SQ) that follow from this are set out hereafter.

1.2.2. SUB-QUESTIONS

1. How is innovation portfolio management performed at the MoD?
2. How is strategic innovation portfolio decision-making performed at the MoD?
3. How is tactical innovation portfolio decision-making performed at the MoD?
4. How does IPM at the MoD differ from IPM in the private sector?
5. How does IPM at the MoD differ from IPM in the public sector?

Along with the "how" questions it is important to consider the "why" questions for the previously stated questions. For example, it is interesting to know why the IPM is performed in the way it is done and why this might differ from private sector practices. The questions of my thesis will incorporate both.

1.2.3. ACADEMIC RELEVANCE AND RESEARCH CONTRIBUTION - BASED ON MOT CRITERIA

Literature pertaining to (innovation) portfolio management (IPM) within the public sector remains conspicuously underexplored in comparison to the wealth of research available in the private sector [Roberts and Hamilton Edwards, 2023, Linquiti, 2015]. The dearth of comprehensive insights into the IPM process, methodological approaches, and practical illustrations of IPM in public sector contexts has left a knowledge gap. To address this deficiency, the thesis research embarks on an in-depth exploration of the complete IPM process as implemented within the Ministry of Defence (MoD).

During one of the preliminary interviews conducted to gain insights into IPM within the Ministry of Defense (MoD), a senior executive responsible for portfolio management referred to the optimal utilization of taxpayer's money as "Profit in the public market". Only recently the MoD has officially implemented portfolio management as a strategic process within its management cycle. This was done via a published strategy highlighting the significance of project, program, and portfolio management (P3M) as a key driver for effective management in an internal briefing within the MoD. Thus, it becomes imperative to investigate the current state of IPM in the public sector and find potential comparisons and deviations to the available literature.

With the rise in military budgets due to the ongoing war in Ukraine, the need for a robust decision-making process for innovation becomes paramount to accelerate the pace of innovation while safeguarding the efficient utilization of government funds. Given the lack of insights in the existing literature regarding IPM practices in the public sector, this study aims to contribute practical knowledge by presenting a tangible example of portfolio management in the public sector, specifically within MoD.

1.3. STRUCTURE OF THE REPORT

This section has provided an overview of the thesis's scope. The subsequent chapter will offer an in-depth exploration of IPM theory, encompassing the primary theoretical framework employed in this research and an extensive review of existing literature related to IPM in the private and public sectors. Subsequently, the methodology employed in this research will be expounded upon in the dedicated methods chapter3. Chapter 4 will present the research findings, followed by interpretations of these results. Chapter 5 will engage in a comparative analysis between the research outcomes and existing literature, both in the private and public sectors. Additionally, it will address limitations encountered during the study and outline future research prospects within the realm of IPM, along with tailored recommendations for the MoD. The final chapter will provide a reflective synthesis of the thesis's journey, culminating in a comprehensive conclusion summarizing the research findings. The bibliography and appendices can be found in subsequent sections.

2

INNOVATION PORTFOLIO MANAGEMENT - THEORY IN THE PUBLIC CONTEXT

The previous chapter provided the scope for this research. This chapter will elaborate on the framework of Cooper (2017) that was briefly mentioned and delve deeper into the understanding of innovation portfolio management both within the private as well as public sector literature.

2.1. KEY DEFINITIONS IN INNOVATION PORTFOLIO MANAGEMENT

Through a literature review, the primary portfolio management standards and methods found include ISO 21.504:2005, the Management of Portfolio (MoP) Guide, and PMI's Standard for Portfolio Management[Axelos, 2011, De Rezende and Gonçalves, 2017]. Without discussing all these standards and methods at length it is important to note that all these methods have similarities and that organizations can use multiple standards for their specific needs [aziz, 2014, De Rezende and Gonçalves, 2017]. The MoP Guide is co-developed by the Office of Government Commerce (OGC) which was a UK government office for improvement of government procurement[aziz, 2014, De Rezende and Gonçalves, 2017]. To explain innovation portfolio management it is important to first understand the difference between project, program, and portfolio management.

Cooper et al. (2000) elucidated a fundamental distinction between portfolio management and project management by framing two distinct questions: *"Are we doing the right things?"*and *"Are we doing the things right?"* [Cooper et al., 2000]. The former pertains to portfolio management, while the latter aligns more with the domain of project and program management. Notably, industry standards, exemplified by the MOP stan-

dards, articulate project management as *"The planning, monitoring, and control of all aspects of the project and the motivation of all those involved to achieve project objectives within predefined parameters of time, cost, quality, and performance"*[Axelos, 2011], in contrast, program management is defined as *"the coordinated organization, direction, and implementation of a portfolio of projects and the subsequent transformation (i.e., the program) to attain outcomes and realize strategic business benefits"*[Axelos, 2011] [De Rezende and Gonçalves, 2017]. These definitions notably deviate from Cooper's (2000) conception of portfolio management, which accentuates the vital role of strategic considerations in achieving balance through the prioritization and deprioritization of initiatives [Cooper et al., 2000].

This study maintains a specific focus on the domain of innovation portfolio management while acknowledging the existence of various other portfolio management disciplines such as financial portfolio management as elucidated by Roberts et al (2023) as well as scholars such Cooper et al (2000) [Roberts and Hamilton Edwards, 2023, Cooper et al., 2000]. The conceptualization of innovation portfolio management necessitates further examination within the context of this study.

Presently, in existing literature, terms such as innovation portfolio management, portfolio management, and R&D portfolio management are employed interchangeably. In this investigation, the main terminologies will be "innovation portfolio management" and "portfolio management" when addressing R&D portfolio management. Additionally, the term "innovation portfolio management" will be utilized, with due recognition of the nuanced distinction between innovation and R&D. Notably, "innovation portfolio management" is the more frequently encountered term within the literature, as evidenced by Google Scholar, Web of Science and Scopus citations, establishing its predominance as the primary designation in this research.

2.2. INNOVATION PORTFOLIO MANAGEMENT

Now that the key terminologies are discussed the rest of this chapter will focus on elaborating the understanding of innovation portfolio management in the private and public sectors. Organizing for portfolio management includes appointing a portfolio board, portfolio managers and project/program managers all with their distinct roles. 2.1 gives insight into how an organization its strategy is supposed to be translated down to the project level and vice versa how projects should realize the strategy [Axelos, 2011, Cooper, 2017b] [Koen, 2016]. A portfolio board usually exists out of senior management that deals with strategy formulation and is involved in the decision-making of larger R&D investments and vision of where to invest organizational resources. Portfolio management breaks this strategy down into programs and projects, divides tasks, and delivers important feedback to the senior management of the portfolio board[Cooper, 2017b].

Project and program managers contribute by undertaking projects with an informational feedback structure to the portfolio managers. Depending on the investments required, project risks, where a project is in its process, and project and program-related

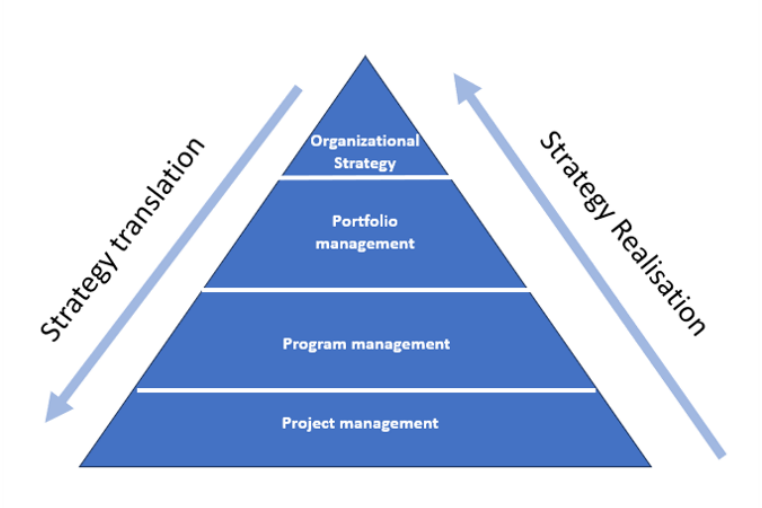

Figure 2.1: Portfolio strategy translation and realisation
[Koen, 2016]

evaluations a choice can be made on which level a decision is required [Cooper, 2017b, Koen, 2016]. When feedback or evaluation should be done at senior levels this needs to be specified in the process. Often new evaluations are required when extra funding is needed, when the outcome of a project is foreseen to be significantly different, or when a project or program is finished or started [Cooper, 2017b, Axelos, 2011, Koen, 2016]. The decision-makers are at different moments responsible for resource information, risk evaluation, strategy analysis, financial foresight, stakeholder relationship management, data management, change management, and quality assurance management [Cooper, 2017b].

Cooper (2017) delineates a three-section structure within portfolio management, encompassing business strategy and product-innovation strategy formulation, and strategic and tactical decision-making realms[Cooper, 2017b]. Business strategy and product-innovation strategy consider the overall strategy of a business and how it aims to develop itself in what sectors specifically.

Strategic decision-making is interlinked with the previous strategy-making and is more of a facet of portfolio management that centers on the allocation of developmental resources, personnel, and funds across diverse project types, markets, technologies, or product categories[Cooper, 2017b]. It addresses paramount questions such as resource distribution, the concentration of efforts on pivotal initiatives or novel platforms, and the formulation of strategic product and technology roadmaps. This level is characterized by prioritization and the delineation of overarching directions which is often done through the use of strategic buckets and strategic product and technology roadmaps [Cooper, 2017b].

The tactical decision-making level involves the operationalization of strategic roadmaps and thematic buckets. It entails the selection of suitable projects and programs from the portfolio, thus facilitating the realization of the overarching layers above. Tactical portfolio management is often done through stage-gate systems together with periodic portfolio reviews. It represents the downstream implication of strategic determinations. Tactical portfolio decisions revolve around the identification of specific new-product projects, their relative priorities, and the allocation of resources to each endeavor. In essence, while strategic portfolio management establishes the overarching guidelines and resource distribution principles, the tactical level executes the finer selection and resource allocation processes [Cooper, 2017b].

Figure 2.2 shows the three different levels as described by Coopers (2017) model [Cooper, 2017b]. The focus of this report lies on the difference between private and public innovation portfolio management and is therefore a strategic as well as tactical question.

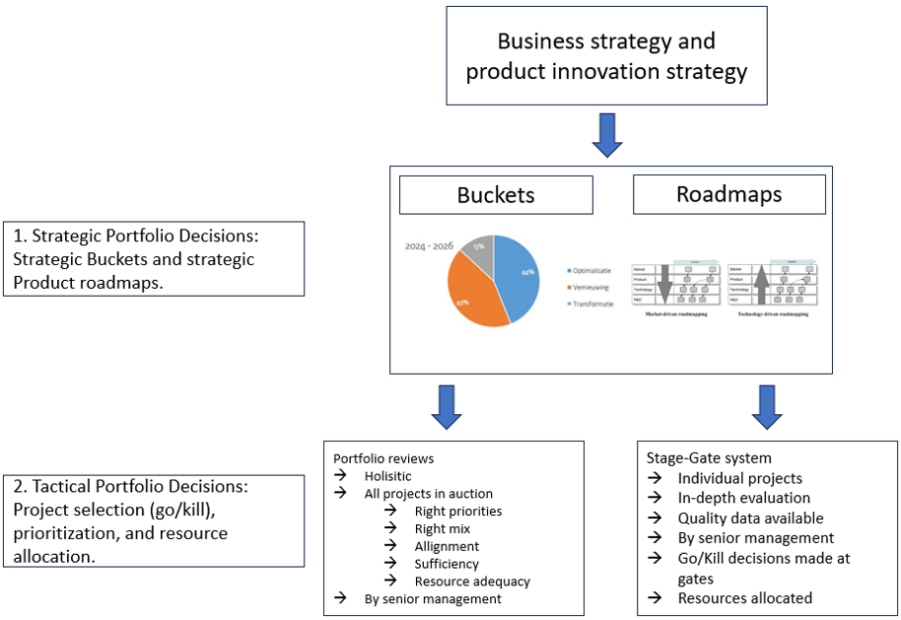

Figure 2.2: IPM framework [Cooper, 2017b]

The next sections delve deeper into innovation portfolio management in the private sector where the tree layers within the IPM model are further explained as well and prioritization methodologies are discussed. The last section describes the literature found on innovation portfolio management in the public sector.

2.3. INNOVATION PORTFOLIO MANAGEMENT IN THE PRIVATE SECTOR

As the definition stated previously portfolio management has a focus on creating a portfolio of strategically aligned projects where resources are divided to achieve the strategic goals. This, however, does not represent how the portfolio is sometimes viewed within the market. In a survey by [Morris and Pinto, 2007], portfolio management was mistakenly mixed up with program management where several projects are managed around a common theme[Morris and Pinto, 2007]. In the realm of innovation portfolio management (IPM), various studies have approached the subject from different angles, encompassing optimization, strategic considerations, decision-making processes, and organizational perspectives [Meifort, 2016]. These diverse aspects collectively contribute to the intricate nature of IPM, rendering it a multifaceted and multi-objective decision-making process.

Within this complex landscape, three overarching macro-organizational objectives consistently emerge as focal points in IPM: the maximization of value, the preservation of balance (often associated with risk reduction), and the alignment with strategic imperatives [Cooper et al., 2000]. These objectives, while interconnected, often present competing perspectives when it comes to making decisions regarding project investments.

To gain a deeper understanding of how these various objectives interact, where they fit within the decision-making process, and how they are applied, Cooper's (2017) framework provides valuable insights. In the context of portfolio management, formalizing technology strategies becomes essential to determine the allocation of resources and achieve organizational goals effectively. Figure 2.2 shows how strategy can be divided into three levels. The first level is sometimes considered to be incorporated in the subsequent two levels but is similarly seen as a separate input for the subsequent two levels and therefore taken separately in this research. This top level is business strategy and product-innovation strategy which delineates which technological capabilities the organization needs and how it aims to gain these capabilities.

2.3.1. BUSINESS STRATEGY AND PRODUCT-INNOVATION STRATEGY

Notably, innovation must be closely integrated with and aligned with the overall strategic objectives of the organization, which plays a critical role in facilitating the successful integration of innovation projects into the core product portfolio. For a strong organizational strategy, it is important to consider impacting forces on your strategy such as market, macroeconomic, and industry changes as well as key trends in the innovation landscape [Osterwalder and Pigneur, 2010].

Moreover, a strategy should possess an emergent nature, allowing for adaptability in response to dynamic market changes[Morris and Pinto, 2007, Meskendahl, 2010]. By embracing such a comprehensive and dynamic approach to innovation management, organizations can effectively align their innovation efforts with broader strategic goals

and navigate the evolving landscape of opportunities and challenges in the markets. Once the technology strategy is well-formulated, methods such as strategic buckets, spending targets, scoring schemes, strategic checks, product innovation charters, and technology road mapping can be used to develop technologies in line with the strategic vision [Cooper et al., 2000, Chao and Kavadias, 2008, Bart and Pujari, 2007].

To this end, every organization is required to develop an "innovation thesis," as outlined by Viki et al (2018), which provides a clear vision of the future and strategic objectives for innovation and R&D initiatives[Viki et al., 2018]. An innovation thesis requires you to think of what you would like to invest your resources in for the next 10 years and even more so what you don't like to invest your valuable resources on. When an organization is split up into different departments it is wise to explicitly differentiate strategies specific to the different departments or sub-units, markets, products, and technologies [Viki et al., 2018, Cooper, 2017a].

Investing based on department, market, product, or technology expertise is related to thematic investing and knowledge sharing within an organization[Viki et al., 2018]. Thematic investing is a VC term based on investing your resources in the related areas you are skilled and knowledgeable in or the themes you find most relevant[Bérubé et al., 2014]. This is inherently different from thesis-driven investing discussed previously which is meant to create a strategy with a more specific area of focus. These two approaches can complement each other, where a thematic approach is enriched by a thesis innovation approach, emphasizing expertise in a specific theme [Bérubé et al., 2014, MKinsey Quarterly, 2009].

Essential however is that the innovation ambitions are made explicit so that a consistent balanced portfolio can be made. By defining organizational innovation and technology strategy and establishing a strategy for IPM within the organization, increased portfolio performance can be achieved [Cooper et al., 2000, Chao and Kavadias, 2008]. Innovation portfolio management can help organize from strategy formulation to strategy implementation and business success [Meskendahl, 2010]. The second layer of portfolio management is strategic portfolio management including buckets and roadmaps.

2.3.2. STRATEGIC PORTFOLIO DECISIONS

Strategic portfolio management serves as a crucial bridge between strategic planning and operational execution, transforming strategic objectives into actionable plans [Cooper et al., 2002a]. This is achieved through the meticulous construction of technology roadmaps and resource allocation buckets, both of which play pivotal roles in shaping the organization's project portfolio. The strategic allocation of resources across these buckets and roadmaps is aimed at achieving a harmonious blend of projects, aligning with the organization's overarching strategy [Cooper, 2017a, Cooper, 2017b, Vishnevskiy et al., 2016].

STRATEGIC BUCKETS:

The concept of strategic buckets starts with a business innovation strategy and is the further translation that requires senior management to decide how they want to allocate their limited resources across different dimensions. The existing projects are sorted into these buckets, and senior management decides if this allocation aligns with the intended spending for each bucket. Finally, prioritization is done within each bucket to create a portfolio of projects[Cooper, 2017b].

Organizing projects into these buckets helps organizations understand their typical business operations and offers insights into the desired balance they want to achieve. Several key dimensions of balance can come to the fore, each imparting its unique influence on the allocation process. These dimensions include alignment with strategic goals, classification based on project types (ranging from radical innovations to incremental improvements), distribution across strategic arenas, considerations within product lines, allocation towards specific technologies or technology platforms, examination of familiarity within the business matrix, geographical considerations, and assessment of the stage of development of each project [Cooper, 2017b, Chao and Kavadias, 2008, Kester et al., 2014, Nagji and Tuff, 2012]. Collectively, these dimensions contribute to organizing and optimizing resource allocation, allowing organizations to create distinct "envelopes of resources" or "buckets" tailored to different facets of their portfolio.

Nagji and Tuff (2012) suggest the use of a matrix, balancing markets (existing, adjacent, new), against products (existing, incremental, new) which created three main types of innovations: core, adjacent, and transformation innovations[Nagji and Tuff, 2012]. This is a combination of the dimension of project type and familiarity matrix. They propose a 70/20/10 division in core, incremental, and new products, respectively, as an ideal way to balance the portfolio [Nagji and Tuff, 2012]. Viki et al (2018) link such a matrix as proposed by Nagji et al (2012) to McKinsey its three horizons with core, emerging, and new business models [Viki et al., 2018, MKinsey Quarterly, 2009]. The idea is that organizations manage all three horizons and thereby create a sustainable future by investing resources in current and future business. This is linked with the idea of an ambidextrous organization where the exploration of completely new ideas and exploitation of the core business happen simultaneously and are managed separately and appropriately [Tushman and O'Reilly, 1996].

Cooper (2016) its findings suggest that leading innovators typically allocate their resources in a ratio of 35/25/25/15, prioritizing incremental developments, significant product improvements, entirely new products, and innovations that are novel to both markets and businesses, respectively [Cooper et al., 2016]. Nevertheless, it's important to note that this allocation can vary significantly depending on factors such as the nature of the business, industry standards, strategic objectives, and the organization's innovation philosophy. Therefore, senior management should engage in deliberate discussions and make informed decisions regarding the specific distribution balance that best aligns with their circumstances [Cooper et al., 2016, Cooper, 2017b].

Within each bucket, projects are ranked, and when resources are depleted, lower-ranked projects are cut. High-performing commercial enterprises often rely on a strategic approach to IPM, employing a plethora of IPM evaluation methodologies that encompass financial models, scoring methodologies, checklists, and bubble diagrams [Cooper et al., 2000]. These tools, interacting in a complex web, introduce a multitude of factors that influence innovation portfolio decision-making.

Using buckets allows firms to compare projects within similar categories, rather than trying to compare all projects at once[Chao and Kavadias, 2008, Cooper, 2017b]. Balancing projects can be visually represented using tools like matrices, pie charts, and different diagrams. The evaluation tools offer information to be used as input for the visual representation. The subsequent section on tactical innovation portfolio management and the "right-mix" further explores how to achieve a suitable mix within each bucket.

STRATEGIC PRODUCT INNOVATION AND TECHNOLOGY ROADMAPS:

The importance of having a clear strategy for product innovation and technology is widely recognized as a key factor in achieving positive performance outcomes in the field of product innovation [Page, 1993, Meskendahl, 2010, Cooper, 2017a]. An effective strategy in this context necessitates a clear alignment of product innovation goals with organizational objectives. Organizations can lack well-defined product innovation goals or face challenges in effectively communicating these goals. To address this, the implementation of a strategic product or technology roadmap emerges as a valuable method to link initiatives to strategy. Vishnevskiy et al (2016) emphasized the applicability of roadmaps for the private as well as public sectors, and the use of technical as well as market demands to ensure a successful technology strategy for organizations [Vishnevskiy et al., 2016].

Cooper, Edget and Kleinschmidt (2015) found that the adoption of roadmaps remains relatively uncommon, with merely 27.6% of businesses employing them in research conducted in 2010[Cooper and Edgett, 2015]. The same research also showed that roadmaps were more often seen to be employed by businesses that achieved better innovation results. A roadmap serves as a comprehensive visual representation that delineates significant projects and essential strategic objectives extending over an extended temporal horizon. Unlike a nebulous letter of intent, a roadmap embodies a well-crafted and action-oriented strategy, offering precise guidance for achieving predetermined goals and milestones[Vishnevskiy et al., 2016, Cooper, 2017b].

Comprehensive strategic decision-making necessitates the incorporation of several key components. These components encompass organizational goals and objectives relevant to the entirety of the product innovation endeavor, a clear delineation of the role of product innovation within the organizational framework, strategic arenas or focus domains that encompass markets, technologies, and product categories targeted for new product innovation efforts, the allocation of financial resources to these strategic arenas, and the formulation of a coherent attack plan for each strategic arena[Chao and Kavadias, 2008, Cooper, 2017a, Cooper, 2017b]. This attack plan delineates the organization's strategic positioning as an innovator, a fast follower, or a low-cost provider within each respective

arena [Cooper and Edgett, 2015]. The concepts of being an innovator, a fast follower, or a low-cost provider can be likened to the strategies of "market pull" and "technology push" within an organization. "Market pull" entails letting the market drive technology development, while "technology push" involves actively engaging in and striving to be among the pioneers in the development of specific technologies [Vishnevskiy et al., 2016]. It helps an organization to understand how top leaders can turn their strategic plans into real commitments and actions. Additionally, a technology roadmap makes it easier to plan when to work on new technologies and shows when to invest in various resources [Cooper and Edgett, 2015, Vishnevskiy et al., 2016, Cooper, 2017a].

2.3.3. TACTICAL PORTFOLIO DECISIONS

While strategic portfolio decision-making sheds light on the overarching strategic goals of an organization, tactical portfolio decisions delve into the process of selecting and executing suitable projects within these diverse strategic objectives.

In order to effectively perform tactical portfolio management, a structured approach involving Stage-Gate systems and periodic portfolio reviews is imperative[Cooper, 2017c]. Stage-Gate systems operate as pivotal checkpoints within the project lifecycle, serving as decision-making junctures for project prioritization, continuation, or cessation (Go/Kill decisions), as well as resource allocation determinations for individual projects[Cooper, 2008, Cooper, 2017c]. As the name suggests, portfolio reviews constitute a decision-making process overseen by senior management, where all projects are collectively scrutinized, prioritized, and subject to Go/Kill decisions. Gates offers specificity, while reviews provide a holistic outlook. Crucial considerations during portfolio reviews encompass strategic alignment, the suitability of project selections, potential termination or acceleration of projects, the equilibrium within the portfolio, resource adequacy, and the alignment of projects with overarching goals [Cooper, 2017c, Cooper et al., 2002a, Cooper and Edgett, 2015].

To ensure the buckets discussed in section 2.3.2 are allocated funding, prioritization methods are often employed within both gates and portfolio reviews. These methods and tools mostly revolve around financial aspects such as net present value (NPV), discount rates, risk-return ratios, productivity metrics, financial success criteria, options analysis, and expected commercial value. These methods predominantly cater to the private sector's objectives of maximizing stakeholder value, financial returns, and risk mitigation [Cooper, 2017b, Cooper et al., 2002a]. Some of the prioritization methods will be further discussed in section 2.3.4.

To facilitate effective gate and portfolio review processes, data plays a pivotal role. Establishing clear data expectations, defining what should be assessed at each gate, and delineating information to be shared with senior management are critical prerequisites for data integrity [Cooper, 2017b, Cooper, 2008, Cooper, 2017c].

Project team accountability can further bolster data accuracy by mandating the description of project rewards and milestones, which can then be used as scoring criteria in subsequent senior management reviews [Cooper, 2008, Cooper, 2017b]. Additionally, implementing iterative spirals that test project concepts and validate underlying assumptions can enhance the overall robustness of the project portfolio [Cooper et al., 2000, Cooper et al., 2002a, Cooper, 2017c].

Ideally, gates, portfolio reviews, and strategic roadmaps should operate in a synergistic triangular fashion. The outcomes of one component should feed into the other two, creating a dynamic feedback loop that continually refines and improves the portfolio management process[Cooper, 2017c]. This iterative approach ensures that the organization maintains alignment with its strategic objectives and adapts to evolving circumstances effectively [Cooper, 2017c].

The subsequent section will delve deeper into the nuances of project prioritization and selection methodologies.

2.3.4. PRIORITIZATION AND SELECTION METHODOLOGIES

When discussing strategic and tactical innovation portfolio decision practices, one should consider the varying levels of maturity within strategic management across different sectors [Morris and Jamieson, 2005]. Industries can have contrasting views on strategic outcomes and whether it is progressing towards achieving its strategic objectives. This ambiguity stems from the fact that strategy is frequently not expressed in quantifiable terms, as noted by [Kaplan, 2001]. In order to make strategic trade-off decisions, such as prioritizing new initiatives over existing projects, it is important to have a method that quantifies organizational strategy[Cooper, 2017a, Kaplan, 2001, Morris and Pinto, 2007]. This allows executives to reach a consensus and avoid subjective decision-making based solely on personal opinions. Without a robust method, decision-making can become chaotic and driven by individual interests, leading to conflicts among executives.

The pursuit of balance can be achieved in numerous ways with multiple parameters, variables, and dimensions that can be considered. Cooper identified 6 predictors of success in its 2017 book [Cooper, 2017b]:

- Alignment with the organization's strategy.
- Product advantage.
- Leverage core competencies.
- Market attractiveness.
- Technical feasibility.
- Risk and return.

These parameters have proven to be useful with the best-performing innovators in the industry especially in combination with financial methods [Cooper et al., 2000] [Cooper and Edgett, 2015, Cooper, 2017b]. The parameters stem from research in the private sector. It was noted that at different stages or project types (high risk vs. lower risk), different parameters might be required to evaluate a project. Projects with higher uncertainty such as low Technology readiness level (TRL) projects often emphasize more on strategic benefits, as financial rewards can barely be taken into account in lower TRL projects [Cooper and Edgett, 2015, Cooper, 2017b].

A bubble plot is a common method to show the risk-reward for projects [Cooper, 2017a, Chao and Kavadias, 2008]. where one axis represents the organization's reward measure, and the other axis shows the probability of success. These measures can be both qualitative and quantitative. Bubble size can denote resource utilization, such as project cost or workforce allocation. Additionally, product lines and launch horizons can be considered within the bubbles, facilitating informed resource allocation decisions. Ultimately, this approach aids in selecting projects that strike a balance between competing priorities.

The parameters provided by Cooper (2017) are relatively comprehensive however some important parameters or defining features of the parameters identified in other papers by Cooper et al as well as other papers seem not to be mentioned as explicit, these are:

- Ease of implementation, implicit included in technical feasibility.
- Timing of projects, implicit in market attractiveness.
- Cash flows required, this is more of a further elaboration on risk and return. [Cooper et al., 2002a, Cooper and Edgett, 2015, Cooper, 2008]

Organizing for portfolio management and balance is unique for every organization and depends on the organization its structure however several rules come forward as general rules applicable in most situations [Cooper et al., 2002a, Meskendahl, 2010] [Morris and Pinto, 2007].

Companies implementing portfolio management practices should develop their own customized models to achieve an optimal balance of projects tailored to their specific needs and objectives [Archer and Ghasemzadeh, 1999, Cooper, 2017b]. When qualitative as well as quantitative parameters are used the axis can exist out of multiple parameters scored on one axis e.g. rating the cash flows required and the R&D cost for implementation. Scoring models can additionally provide input for bubble diagrams linking scoring models to go/kill decision-making moments and links portfolios closer to go/kill decision-making moments [Cooper et al., 2002a].

The flaws in finding a balance in portfolios are still many with uncertain data, information overload, lack of decisive power through a mere balance, unclear strategy on what the "right" balance pertains, and uncertainty about what should be done with the results of balance maps [Cooper et al., 2002a, Cooper et al., 2002b]. As described in the parameters and literature there are however key indicators on which a project/program or portfolio can be scored within a portfolio to predict success.

The previous section delved into innovation portfolio management from a private sector view. The next section aims to provide insights into innovation portfolio management literature found in the public sector and the evaluation methodologies found for portfolio evaluation. Most of these papers are not well referenced and therefore the interest lies mostly in the description, to learn what parameters and forms of strategic and tactical IPM could be recognized.

2.4. IPM IN THE PUBLIC SECTOR

Where the private sector suggests that innovation portfolio management is done through a strategic, portfolio-wide perspective, government policymakers often prioritize the individual merits of projects, overlooking potential portfolio effects [litvinchev et al., 2010]. The complexity of public portfolio management is exemplified in Peerenboom, Beuhring, and Joseph's (1989) paper which attempts to hand tools for project selection through a decision analysis procedure in the environmental programs for the energy department in the US [Peerenboom et al., 1989]. The paper is the first clear insight found on innovation portfolio management in the public sector and provides a practical example with similarities to Cooper's 2017 framework[Peerenboom et al., 1989, Cooper, 2017b].

The public sector faces challenges in quantifying project value purely in terms of financial benefits [Roberts and Hamilton Edwards, 2023, Moore, 2013]. An approach to creating a measurable formulation for strategy is found in Moore's (2000) work, where strategic value is represented in a triangle of legitimacy and support, value, and operational capacity[Moore, 2013, Moore, 2021]. "Value" focuses on the value proposition guiding the organization, while "legitimacy and support" emphasizes the sources of support needed to pursue the value proposition. "Operational capacity" highlights the organization's capability to achieve desired outcomes, which may sometimes require external partnerships and collaborations[Moore, 2013]. By considering these points - value, legitimacy and support, and operational capacity - managers can navigate the complexities of strategy in the public sector effectively. This strategic approach ensures alignment between organizational objectives, stakeholder support, and operational capabilities, ultimately driving successful outcomes and value creation[Moore, 2013].

Applying this to Cooper's IPM model involves establishing legitimacy and gaining support through portfolio reviews and technical roadmaps. The value is expected to be recognized through scoring methods in the evaluation rounds during portfolio reviews and at the various gates in the process. Operational capacity is closely tied to the available resources and how they are allocated within the framework. The tools used in IPM are designed to optimize value by ensuring a balanced selection of projects that align

with available resources and strategic objectives. All three aspects – legitimacy, value, and operational capacity – are essential components of this process. These theories match portfolio management to strategic management in the public sector where it is recognized that being strategic in IPM extends beyond purely financial considerations [Weill and Broadbent, 1998, Cooper and Edgett, 2015, Moore, 2013, Cooper, 2017b].

Portfolio management examples within the public sector mainly focus on evaluation methods. Davis and Owens(2003) used an options-based portfolio method, primarily employed in the financial sector, to maximize financial returns and minimize project risk in the US federal renewable electric R&D program [Davis and Owens, 2003]. The real-options method proposed gives good insights into the financial reward of strategic investments based on the future value of technologies. This is however less relevant when considering the application in a public domain such as the military.

Vonortas and Herzfeld (1998) show that a financial tool is used by NASA when projects are undertaken in cooperation with a private party[Vonortas and Hertzfeld, 1998]. The paper suggests that most projects are split up into Research, technology development, and testing stages where each stage gives better insights into the costs and rewards. Here the parameter of R&D costs is weighed up against the benefit to the public by allowing technical experts to value the risks and rewards. Although all public organizations should have a strategy related to benefiting the public, this parameter for balance is made more explicit [Vonortas and Hertzfeld, 1998].

Moreover, the paper by Vonortas and Herzfeld (1998) shows that future costs of a project or program for implementation of a technology could be considered via ex-ante valuation methodologies such as the NPV method proposed in their paper [Vonortas and Hertzfeld, 1998]. Important to note here is that it considers the possibility of competition of private parties to develop a similar technology once it is proven to build. Private parties use such methodologies to deliver a quantified approach instead of the use of qualitative methodologies to evaluate projects and programs over the whole cost of a project. The idea of valuing projects on the public's interest, the value it brings to private companies, and quantifying projects can help prioritize, especially when comparing projects requiring larger investments. This form of evaluation also gives insights into whether the public party should help in the development or let the private parties develop it without public money[Vonortas and Hertzfeld, 1998].

Vonortas and Herzfeld (1998) discuss how a project phase impacts uncertainty and that a new phase delivers informational input that should reduce project uncertainty. The uncertainty here can lie in many things and could be distinguished in technical, market, and external risks which should be considered in the project as well as portfolio parameters [Vonortas and Hertzfeld, 1998]. This is similar to private sector literature which mentioned that lower TRL projects are often valued more on their strategic merit and higher TRL projects more dominantly on their financial benefits [Cooper, 2017b, Chao and Kavadias, 2008].

Papers such as the paper by Vonortas and Herzfeld (1998) with clear examples of how to prioritize and do project selection through portfolio decision-making methods are rare within the public sector [Vonortas and Hertzfeld, 1998, Linquiti, 2015].

Specific to military innovation is that it may become hard to evaluate projects on their public impact since most of the innovation impact is on its operations and does not directly impact public lives which makes the military different from health or transport innovations [Grissom, 2006, Chesbrough and Vanhaverbeke, 2018]. Since valuation based on public interest can be difficult within the military the following paragraph discusses research done on portfolio management practices found within the US military. Two papers were found discussing the Office of Naval Research (ONR) and the US army its portfolio management tool called Portman [Silberglift et al., 2004, Chow et al., 2012]. The ONR holds the critical responsibility of defining and sponsoring research and development (R&D) endeavors necessary to fulfill the present and future needs of the Navy and Marine Corps. In pursuit of this mission, ONR must explore a wide spectrum of research, spanning from fundamental investigations that unlock new possibilities for the long term, to advanced technology development aimed at bolstering the current fleet in the near term. ONR acknowledges the challenge of making funding decisions amidst various uncertainties, including uncertainties regarding required capabilities, performance requirements, and the feasibility of technologies or R&D approaches [Silberglift et al., 2004, Chow et al., 2012].

The R&D decision framework as well as the PORTMAN model described calculate the expected Value of an R&D project [Silberglift et al., 2004, Chow et al., 2012]. The ONR considers three factors: the value of the desired military capability, how well the project's performance potential matches the required level of performance, and the probability of successfully transitioning the project [Silberglift et al., 2004]. This scaled capability is then adjusted based on the likelihood of the project's success, taking into account subsequent stages of research and development and the implementation of the resulting product, component, or system.

The research paper concerning the enhancements made to the Army's model represents a substantial refinement, taking into account the intricate inter-dependencies among strategic imperatives, product functionalities, financial considerations, and inherent uncertainties in a manner that transcends the reproducible of any singular set of criteria [Chow et al., 2012]. The evaluation of product systems on their strategic implication, and product functionality to the strategy and weighing that against costs and uncertainties shows a clear form of portfolio management. The expected value is not defined by the financial reward but by the importance of the strategy, the impact of the technology and or concept attractiveness, and the probability of technical and commercial success. The 2012 paper by Chow et al found that uncertainty of budgets and implementation cost increased the R&D costs by 43% for the US Army large equipment projects [Chow et al., 2012].

Kerzner its project management approach underscored the importance of considering costs throughout a whole innovation project lifecycle [Kerzner, 2017]. The program additionally mentioned that too much money reduced project success rates, which was also mentioned in the PORTMAN model by Chow et al (2012) [Kerzner, 2017, Chow et al., 2012].

Therefore the focus here lies on balance between projects evaluating a project and prioritizing projects on the expected value it produces. Linquitti (2015) offers more insights into how the evaluation of projects within a portfolio can benefit decision-making and offers some methodological examples of how this could be done and common shortcomings [Linquiti, 2015]. Linquitti denotes the importance of including the probability of success to reward, that not all public rewards can be put in monetary reward, that interdependencies within projects should be considered in portfolio evaluation and benefit-cost analysis could be done through real-option methods[Linquiti, 2015]. Another example provided by linquiti (2015) is the portfolio management idea of the US Army Corps of Engineers Research and Development Centre (ERDC)[Linquiti, 2015]. It describes how R&D projects are evaluated within a portfolio on four criteria. These criteria encompass:

1. The project's alignment with the overarching military or civil works objectives of the Corps.
2. Its association with emerging or aging technologies.
3. Its relevance to either declining or high-priority business areas.
4. And the level of technical risk it entails.

After evaluating projects, they are categorized into four distinct "buckets" depending on their scores in two key dimensions:

- Mission relevance.
- And momentum.

The objective is to remove projects with low momentum and mission relevance from the portfolio, as discussed in Linquiti's (2015) work [Linquiti, 2015]. The evaluation criteria are outlined and can be matched with certain parameters and methods by Cooper such as alignment with strategy, maturity matrix, "market" attractiveness, and risk and return[Cooper, 2017b]. "Market" is in brackets since the military does not look at the outside market but at the attractiveness of the organization. What the four buckets are is not described in the paper nor is it described how these parameters are used.

Mission relevance and momentum seem to be key scoring indicators for a project. Momentum can be linked to project timing, and mission relevance directly relates to the project's importance for the military and strategic considerations. These indicators are far more explicit to the nature of the public value the army aims to deliver than the generalized parameters offered by [Cooper, 2017b].

Linquiti's (2015) highlights the complexity of risks within the public sector, urging policymakers to address factors at macro, meso, and micro levels to effectively manage R&D portfolios. Risk assessment at different levels is crucial in portfolio management practices [Linquiti, 2015]. Some approaches discussed in Linquiti's (2015) work, like the "bucket" method, quantitative multi-objective methods, static choice methods, and dynamic management methods, are relevant for portfolio evaluation in the public sector. However, the book lacks clarity on adapting these methods[Linquiti, 2015].

In contrast, Peerenboom et al. (1989) offer more practical insights into how IPM can be performed in an energy funding program[Peerenboom et al., 1989]. Further research is needed to bridge the gap between private-sector approaches and their application in the public sector, particularly in the conduction of IPM in a public organization [Peerenboom et al., 1989, Linquiti, 2015, Roberts and Hamilton Edwards, 2023].

3

RESEARCH METHODS

The preceding chapters have delineated the study's scope and have provided an overview of the existing literature. This chapter will delve into the research methodology employed to scrutinize public sector IPM. Specifically, the research takes the form of a case study conducted within the Ministry of Defense, involving multiple instances within the Ministry to gain comprehensive insights into the organization's current IPM processes.

3.1. QUICK SCAN OF THE PROBLEM

The research question *"How does innovation portfolio management in the public sector, as exemplified by a case study within the Ministry of Defense, differ from private sector innovation portfolio management literature?"* needs additional information to be able to fully answer the question. The sub-questions give guidance to answer the research question. Kester et al (2014) as well Meifort (2016) emphasize that there is a need for specific case studies to enhance the understanding of IPM in real-world examples [Kester et al., 2014, Meifort, 2016]. Chapter 2 delved into the theoretical underpinnings of IPM and explored literature from both the private as well as public sectors. Although methods for assessing projects in the public sector are available, there is a lack of understanding about how to actually apply and customize IPM theory in real-world public sector scenarios [Roberts and Hamilton Edwards, 2023]. The three-tiered theoretical framework presented by Cooper in 2017 provided valuable insights into the literature on organizing for portfolio management and will therefore serve as a foundational basis for the case study investigation[Cooper, 2017b].

3.2. RESEARCH SET-UP

As delineated in Chapter 1, this study focuses on the understanding of the IPM process in the public sector, specifically within the Ministry of Defence (MoD). The research is set up by investigating the organization based on its specific organizational structure. It aims to gain insights by thoroughly examining all four operational departments within the MoD on the two distinct R&D tracks described in the introduction. The research is divided into two main phases: the first phase aims to improve our understanding of the MoD's organization and valuation methods, while the second phase seeks to provide a comprehensive overview of IPM practices throughout the entire MoD.

PHASE ONE:

In the initial phase, the decision-making processes and evaluation methodologies used by project and program managers are examined. This first phase helps to understand the informational flow to portfolio managers and grasp a first understanding of what decision-making processes are in place. This research is done by conducting interviews with project, program, and portfolio managers on both short-trajectory projects (KCI) as well as two long-term trajectory projects (S and T).

PHASE TWO:

The subsequent phase encompasses the comprehensive examination of the IPM framework. It extends beyond the tactical level to encompass the broader spectrum of IPM, encompassing strategy, strategic decision-making, tactical decision-making, data clarity, and evaluation methodologies. This phase is conducted across all operational departments and on both short trajectory (KCI) as well as long-trajectory R&D portfolio management, relying on interviews with R&D strategy advisors and key personnel involved in portfolio decision-making. Iterative interviews with select respondents are conducted to deepen insights into specific cases. additionally, support from portfolio managers, subject matter experts (SME's), and innovation managers within the MoD was used to validate the results.

The ensuing sections provide an exhaustive elaboration of the research set-up within the respective phases.

3.3. CASE STUDY SELECTION

For this study, an embedded (multiple units of analysis) single case design will be used to answer the research question in place [Yin, 2015]. Sekeran and Bougie (2016) suggest that the right sampling size is determined by population, sample frame, sample design, sample size, and sampling process [Sekaran and Bougie, 2016]. In order to ensure the robustness of the multiple-case design, a thorough selection process will be undertaken. According to Yin (2015), it's advisable to examine a minimum of six project cases [Yin, 2015].

In this study, initially, four project cases were analyzed. In the initial phase of this research however was not proficient to answer the research question in place. Therefore, a second improved research was set up. The secondary research focuses on two distinct R&D pathways unique to the MoD organization. Within this second research phase, the four operational departments are selected as individual cases, resulting in a total of eight distinctive case studies.[Yin, 2015]. An entire list of the interviews with interviewee profiles can be found in section 3.4.

Phase one helps to give a better insight into what evaluation methodologies are employed at project, program, and portfolio levels and how this differs between projects, programs, and portfolios. This phase is primarily focused on how the selection and execution of projects take place and therefore mainly focuses on the tactical decision-making process. The programs picked for this part of the research have been picked on the following distinctions:

- Innovative character: this refers to the three horizons where the programs were sought to have been in a different place in the innovative matrix as discussed in the theoretical framework. programs had to deal with either incremental, disruptive, or radical innovation and;
- Be in existing, adjacent, or new markets for the MoD.
- Strategic objectives: programs were picked on their distinct difference in strategic objectives. The MoD its strategic papers and roadmaps were used to pick programs from different roadmaps.
- Project status: within programs, projects were discussed that were either stopped, not on track, on-track, or finished. this was done to see what decision-making led to the choice to start, stop, and continue a project.

Table 3.1: Projects investigated for research 1

Theme	Innovative character	Market	strategic goal	Project status
ET	incremental	Existing	Roadmap logistics	stopped & started
AM	Radical	Adjacent	Roadmap AM	not on track
Unmanned	disruptive	new	Roadmap Unmanned	On-Track
Exoskeleton	incremental	existing	Unforeseen opportunity	Finished

In the second phase of the research, the four operational departments of the MoD are selected as case studies. Given the MoD's clear differentiation between long-trajectory and short-trajectory R&D projects, a thorough investigation will be performed on these two distinctions within the four departments and the organization itself. Table 3.2 provides an overview of the various departments and the specific units investigated, categorized into long-trajectory (referred to as science and technology or S&T) and short trajectory (KCI).

Notably, "Bestuurstaf" (BS) denotes the centralized authority within the MoD responsible for R&D project funding, playing a pivotal role in the IPM process. The subsequent sections of this research will consistently employ the Dutch abbreviations for the four departments as indicated in the brackets in the table. Important to note is that large-scale projects such as the new submarine acquisition follow a different acquisition pattern and are not discussed or investigated in this research. The operational departments as well as the entire MoD are investigated through the use of Cooper's three-tiered framework as described in figure 2.2. This means the MoD as a whole, as well as the four departments, are investigated on their business strategy and product innovation strategy, strategic portfolio decision-making ,and tactical portfolio decision-making process.

Table 3.2: Departments investigated for research 2

Departments	**Long-trajectory (S&T)**	**Short-trajectory (KCI)**
Bestuurstaf (BS)	S&T	FRONT
Marine (CZSK)	KNZ	V&I
Army (CLAS)	DWS&B and strategy	Innovation unit CLAS
Air force (CLSK)	S&T CLSK	AIR
Military police (KMAR)	S&T KMAR	Innovation unit KMAR

The second phase of research is more of an iterative process with continued contact with people within the MoD validating results and testing outcomes. Additionally, the findings from this research are presented and deliberated upon with subject matter experts (SME) from the Ministry of Defense, including portfolio managers who possess extensive experience both within and outside the organization in portfolio management. These SMEs are used to test and validate the results and conclusions as well as give insights into the generalizability of the results to project portfolio management within the MoD.

3.4. DATA COLLECTION, INTERVIEWS AND RESPONDENTS

The predominant nature of the data in this study is qualitative, primarily consisting of textual information. Data is procured from diverse sources, encompassing online scientific repositories such as Web of Science and Scopus, as well as various archives within the Ministry of Defense (MoD). Further data is collected through semi-structured interviews and desk research. Semi-structured interviews are conducted to gather in-depth insights and perspectives from relevant stakeholders such as project owners, portfolio managers, innovation directors, and strategy advisor, which was previously described as those involved in strategy and portfolio review decision-making, within the MoD. The interviews conducted for phase one followed a different interview guide than the interviews conducted for the second part of the research. The interview guides are provided in Appendix Band C.

The interview guide for the first phase primarily draws upon the theory of prioritization and selection methodologies found in section 2.3.4. It additionally gives an understanding of the information shared for the triangle of constant evaluation between roadmaps, gates, and portfolio reviews as described in 2.3.3. The interviews with project and program managers help to understand what valuation methods for projects are used and what parameters are used to create the right mix. How, when, and why questions help to give an understanding of the difference in IPM for the MoD compared to the private sector and thereby help to give an understanding of sub-question four. After the first interview of phase one, more emphasis was put on phrasing in words like prioritizing and triage since these terms were more common in the MoD than the term "portfolio management". The interview guide is based on interview guides found in Cooper et al their 2000 and 2002 research [Cooper et al., 2002b, Cooper et al., 2000]. Since there is an overlap in questions and answers it was possible to go over all the questions and skip questions that were already answered. The interview guide was adjusted during the interviews to be more specific and reduce the number of questions in the guide. During the first phase of the research, it became apparent that investigation into portfolio management required a more holistic view. Theory underscored this and provided the many different aspects of portfolio management that could be investigated. This insight was the start of the second phase of the research using Cooper's 2017 framework.

The interview guide for phase two is much more specific and aimed at providing insights into the three-tiered layers of Cooper's 2017 framework. The questions are based on the different layers and their characteristics as well as insights from the first interview guide which provided necessary input on the tactical portfolio decision-making process. This second phase provides more insights into the first two layers of Cooper's framework of strategy and strategic decision-making processes used within decision-making.

Flexibility within the interviews is maintained to allow for probing questions and exploration of specific topics while maintaining a consistent focus on portfolio management. The final sources used yielded data in multiple formats, including articles, scientific papers, interview notes, transcripts from focus groups, responses to open-ended questions, audio recording transcriptions, strategic papers, government notes, and articles.

MoD articles were primarily shared by interviewees, specifically the articles indicated to be used by the interviewees in their portfolio decision-making processes. The relevance of these articles was assessed based on factors like their publication date and their significance as emphasized by the interviewees about IPM decision-making research. Several strategic documents were not available to the public, these are elaborated on in the text in terms of their specificity to IPM and referenced as "internal documents". To ensure non-biased results a broad range of interviewees was considered and multiple people were interviewed per operational department as well as per program. For all departments portfolio managers of the short-cycle innovation unit, portfolio managers involved in the long-trajectory R&D as well as strategic innovation advisors are

interviewed. Additionally, innovation portfolio managers responsible for the funding of innovation projects were interviewed. All the respondents provided the necessary input to answer sub-questions one, two, and three.

Appendix A provides the interview guides, data management plan, and ethics report. At first, the idea for phase one was to do process tracing on each project under investigation, however, most projects did not have clear decision-making points, making process tracing hard. The impact of portfolio management on decision-making moments during projects was vague since project and program managers were not always aware of the process of decision-making on a senior management level where decisions on the wider portfolio are often taken. The questions related to process tracing were maintained to attempt to define clear moments where, why, and how the decisions were made. Additionally, extra emphasis was put on why there were no clear decision-making moments if this came forward in the interviews or how decisions were made when no clear moments were identified in the project.

The interviews were recorded and for the first part of the research, all interviews were transcribed. For the second part of the research most interviews were recorded when there was consent of the participants, these recordings were used to take out information that was not clear during the interviews. Additionally, extra information was sometimes asked, when necessary, during subsequent mail or telephone contact. Table 3.3 and table 3.4 show the list of respondents that participated in this research.

Table 3.3: Respondents research 1

#	Department	function
R1	CLAS	Project manager
R2	CLAS	Project manager
R3	MIND	Project manager
R4	CLAS	Programma/SME
R5	CLAS	Program Manager
R6	CLAS	Program Manager/SME
R7	CLAS	Portfolio Manager
R8	CZSK	Program CZSK/SME
R9	CZSK	Portfolio Manager
R10	FRONT	Project/Portfolio Manager

The nomenclature of "project", and "program" manager was known within the MoD however the nomenclature for "Portfolio" manager was less common. People who were involved in portfolio reviews, technology roadmapping, and prioritization were for the ease of this thesis branded portfolio managers. The range of interviewees was used to get a broad overview of the decision-making within the portfolios and programs.

Table 3.4: Respondents research 2

#	Deparment	KCI vs long-trajectory	Function
R11	CLAS	Both	Strategic advisor
R12	CLAS	Long-trajectory	Portfolio manager
R13	CLAS	Both	Portfolio manager
R14	CZSK	Both	Strategic advisor
R15	CZSK	Long-trajectory	Portfolio manager
R16	CZSK	KCI	Portfolio manager
R17	CLSK	Long-trajectory	Portfolio manager
R18	CLSK	Both	Portfolio manager/strategic advisor
R19	KMAR	KCI	Project/program manager
R20	KMAR	Both	Portfolio manager
R21	KMAR	Both	Strategic advisor
R22	COMMIT	Long-trajectory	Project&Program manager
R23	COMMIT	Both	Portfolio manager
R24	S&T	Long-trajectory	Strategic advisor
R25	S&T	Long-trajectory	Portfolio manager
R26	FRONT	KCI	Accounting expert
R27	FRONT	KCI	Strategic advisor
R28	FRONT	KCI	Portfolio manager

Table 3.5 shows respondents who were contacted more frequently to test and validate outcomes. R29 is a focus group session with portfolio management experts who helped to discuss the validity as well as the implications for my results. The approach helped to prevent biased results and provided a broader perspective on the subject matter.

Table 3.5: Respondents used for iterative feedback

#	Department	function
R18	CLSK	Portfolio manager
R24	COMMIT	Portfolio manager
R28	FRONT	Portfolio manager
R29	CLAS/FRONT/BS/S&T	Portfolio experts

Some conversations and meetings that have contributed to a better understanding of the organization are not included in the research set-up or respondents list. However, all information that is included in this research was with consent and the outcomes of the research were double-checked for validation. Team members of FRONT, the team where I conducted my research, as well as contact with my TU Delft supervisor ensured a sufficient group of people was interviewed.

During interviews sometimes new names came up that could add to the topic, these people were contacted when felt necessary to complete a better understanding of a case. Further information was gathered via email and sometimes new meetings were planned to include input or validate results. Sometimes follow-up contact was necessary to get a better understanding of the whole process. When respondents provided crucial information that was not found in any documents, this information was double-checked with someone in the group of table 3.5. The respondents will be referenced by their number as such R#, to share the relevant information provided by the respondent.

3.5. ANALYSIS

The interviews conducted with the project and program managers were transcribed and then an attempt was made to analyze the data using the Atlas.Ti software. Initially, the plan was to code the data based on the six success factors and additional parameters outlined in section 2.3.4. However, it became apparent that this approach offered limited added value to the comprehensive study of the IPM system as a whole.

Furthermore, the initial findings indicated a lack of discernible patterns which can be attributed to the research setup and the current lack of consistent methodologies used within the MoD. The inclusion of this information in the methods section serves to highlight the sub-optimal choice of methodology for this research, potentially guiding future researchers away from similar pitfalls. A more detailed discussion on this matter is provided in the reflection section in chapter 7. The transcription and coding were eventually used to support the use of quotes provided in the results section. The quotes will be translated for clarity conveying the core message without adhering strictly to verbatim translation.

The second phase of this research endeavors to offer a comprehensive depiction of IPM at the MoD. This will be achieved by conducting an in-depth analysis of the interview findings and collected data. The analysis process involves identifying both shared practices and distinctions in IPM within the MoD. Subsequently, the outcomes of the MoD case study will be compared with existing literature and empirical data available in the literature.

Furthermore, when disparities are identified, efforts will be made to seek explanations that shed light on why and how portfolio management is executed in a particular manner. In cases where conflicting explanations arise regarding the rationale behind the chosen portfolio management approach, these alternative perspectives will be explicitly acknowledged and subject to thorough discussion and analysis. Discussing rival theories and explanations adds to case study research as mentioned by Yin [Yin, 2015].

3.6. ADVANTAGES AND DISADVANTAGES OF INTERVIEWS

As previously discussed semi-structured interviews have their merits and defaults. The advantages lie in its flexibility, rich and detailed data, participant engagement, and participant comfort. However, the disadvantages are the consumption of time, potential

bias, limited standardization, and skill dependency [Yin, 2015]. For this research, rich and detailed data is a necessity, and therefore the technique is most valuable. However, consideration with regard to the potential limitations should be done when creating a final conclusion. Additionally, the execution plan should be followed appropriately to ensure the reliability and validity of the collected data.

4

RESULTS

The previous chapter discussed the research methods of this thesis. This chapter will provide the results of the conducted research in four sections. First, the MoD its innovation process and strategy is described. Secondly, the portfolio management structure within the MoD is explained. Third, a cross-case analysis is presented after which the interpretation of the results take place.

4.1. CASE STUDY DESCRIPTION

As discussed throughout the beginning of this study IPM within the public sector is researched by an in-depth analysis of the Dutch MoD. The case focuses on the entire innovation chain from low TRL to implementation. The four cases that were researched are the operational commands of the MoD. To understand how IPM is used in the decision-making within the operational commands, the organization as a whole will be described including its strategy formulation and distribution of money.

4.1.1. INNOVATION AND STRATEGY WITHIN THE MOD

A fundamental aspect of comprehending IPM involves gaining clarity regarding the definition and process of innovation within an organization [Cooper, 2017b]. The absence of well-defined boundaries surrounding innovation can introduce ambiguity into the portfolio [Cooper, 2017b, Cooper and Edgett, 2015]. This subsection will briefly discuss the definition of innovation used in this study as well as how innovation and innovation projects are defined by the MoD. The two most recently published innovation strategies by the MoD, namely the *SKIA* and *innovatie strategie Defensie* (innovation strategy MoD), are discussed to understand how innovation is defined within the MoD. Since, these are the best papers for understanding the MoD's innovation definition and innovation process [Ministerie van Defensie, 2020b, Ministerie van Defensie, 2018]. The subsequent section will delve into how strategies are formulated and how these relate to the IPM framework.

INNOVATION DEFINITION WITHIN THE MOD

In the 2018 innovation strategy, the definition of innovation was adopted from the Advisory Council for Science, Technology, and Innovation (AWTI), which defines innovation as "The implementation of a new or significantly updated product or service, process, new marketing method, or a new organizational model"[AWTI,]. It is worth noting that they do not categorize minor, ongoing changes as innovation but reserve the term for initiatives that are novel to the organization, substantial in nature, and enduring enough to alter the organization's mode of operation or character significantly [Ministerie van Defensie, 2018, AWTI,].

The product for the MoD would be "security" where the MoD continuously aims to improve its business processes to guard that security as well as to produce new products to maintain security in changing environments
[Ministerie van Defensie, 2020b].

The strategic knowledge and innovation agenda (SKIA) 2020-2025, described knowledge development, technology development, and innovation as instrumental tools in aiding the MoD's overarching mission of "maintaining security" for the Kingdom
[Ministerie van Defensie, 2020b]. Therefore, the definition of innovation seems to only be applied to technologies. However, the SKIA also describes the innovating capacity of the MoD on the one hand, as the development and applicability of technologies through Research and Technology development, and on the other hand, on the successful implementation of these technologies[Ministerie van Defensie, 2020b].

Moreover, the SKIA distinguishes between two tracks of innovation, one is the introduction of platforms and weapon systems resulting from long-term innovation trajectories; the second trajectory identified is within relevant and available civilian technologies that can be made militarily applicable in a relatively short period. Comparing the description with actual findings, these two different trajectories are split up into seven project types used within the MoD to distinguish the innovation process. The seven project types are:

- Knowledge Development (KD)
- Applied Research
- Technology Development (TD)
- Technology testing and further development
- Product development
- Concept development and experimentation (CD&E)
- Pilot implementation

Projects on knowledge development up to product development were primarily found to fall within the first trajectory and mainly regard lower TRL levels up to TRL 7. The first and second trajectories come together in "concept development and experimentation", and pilot implementation, which should be referred to as "innovation" according to the SKIA [Ministerie van Defensie, 2020b]. What was found from primary research was that even though a project can start in any of the seven project "stages", funding within the MoD is split up into three stages which are named almost similar to the three facets, namely: Knowledge Development, Technology Development,Concept Development and Experimentation otherwise referred to as Kort-cyclische innovatie (KCI). Knowledge development projects fall in the lower segment of technology readiness levels; Technology development projects fall between TRL four up to six; And CD&E projects often relate to technologies in TRL seven up to nine.

This thesis will not go into the details of public procurement. Nevertheless, it is important to note that the idea of the innovation process in place is that it enables the government to become a *smart buyer* and *smart specifier* of the products they would like to procure. Splitting projects into seven project types allows the MoD to become a smart buyer or smart specifier. Certainly, going into more depth on "smart specifier" and "smart buyer" within the context of government procurement is crucial.

"Smart specifier" implies that the government possesses a deep understanding of its needs and can articulate precisely what type of product or service is required [Ministerie van Defensie, 2020b]. This clarity extends to detailed product specifications, performance standards, and any relevant technical requirements. This level of precision is essential as it minimizes ambiguity and ensures that potential suppliers have a clear understanding of the government's expectations. It also helps prevent misunderstandings, reduces the likelihood of contract disputes, and fosters competition among suppliers based on merit rather than interpretation.

On the other hand, *smart buyer* refers to a procurement process where the government has taken several strategic steps before making a purchasing decision [Ministerie van Defensie, 2020b]. Firstly, the potential suppliers have been thoroughly identified and assessed. This involves evaluating their capabilities, track records, and reliability. Secondly, there is a comprehensive understanding of the estimated costs associated with the procurement, including not only the initial purchase price but also the ongoing operational and maintenance costs.

Lastly, the government has a clear grasp of the desired benefits and outcomes expected from the procurement, both in the short and long term. This holistic approach to buying ensures that the government makes informed decisions that are not solely price-driven but consider the total cost of ownership, supplier capabilities, and the alignment of the procurement with broader strategic objectives. Ultimately, being a *smart buyer* enables the government to maximize the value it receives from its procurement activities and enhance the efficiency of public spending.

INNOVATION STRATEGY WITHIN THE MOD

Considering the *strategy* required to perform strategic and tactical innovation portfolio management as described by Cooper (2017) the MoD uses a four-year strategic cycle. The "Defensie visie 2035"(Defense vision 2035, DV35) is a starting point of this cycle where it describes how the MoD wants to develop itself; The "Defensie NOTA", is the endpoint of this strategic cycle which describes what actions are actively taken to accomplish the things mentioned in the Defensie visie [Ministerie van Defensie, 2020a]. Every four years the cycle starts again, where the DV35 is updated on a yearly basis. To facilitate this, an ongoing process based on strategic foresight and forecasting produces robust measures related to organization, concepts, and capabilities that contribute to a resilient and financially sustainable armed forces. Strategic papers that are currently in development with regards to technology and capability development are the capability plan and future operating concept that can be used to prioritize specific technological arenas. Figure 4.1 represents the four-year strategic cycle for the development of a Defense vision and operational concepts.

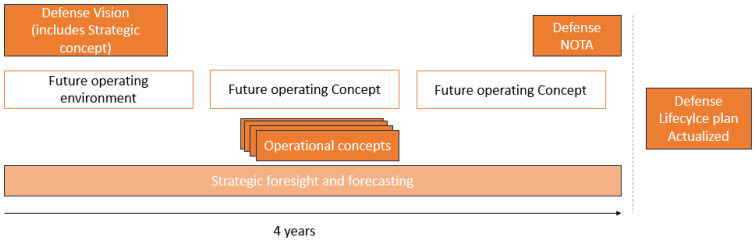

Figure 4.1: Four year cycle

Together with the "Defensie visie 2035" the SKIA is also updated every four years. The SKIA is the knowledge development, technology development, and innovation translation of the Defensie visie 2035. The SKIA describes the main concepts and strategic changes related to the innovation endeavors of the MoD. The concepts described in the SKIA can be used to produce priorities in strategic portfolio management endeavors as described in Cooper's 2017 framework. As an example figure 4.2, provided in the SKIA and taken from the "defensie industrie strategie" (Defense industry strategy, DIS), represents research to what extent the MoD aims to be involved in the development of certain technologies within industry[Ministerie van Defensie, 2020b]. This can be seen as an indication of to what extent the MoD wants to *push* a technology further or let the market develop the technology and buy it later referred to as market *pull*. This vision can support decision-makers in the prioritization of buckets and roadmaps based on the required involvement.

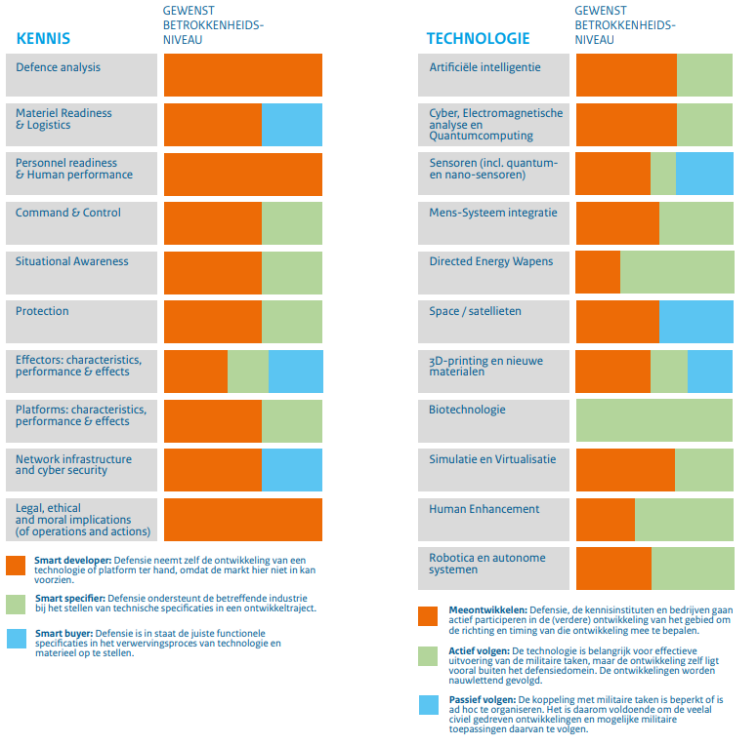

Figure 4.2: DIS Vision

Other concepts described in the SKIA such as technology push, capability pull and the R&T areas which will not be discussed further in this section, additionally provide insights for the use as buckets and prioritization within strategic portfolio management.

The SKIA aims to give direction to the innovation endeavors of the different departments. Nevertheless it is up to the individual departments within the MoD to translate the SKIA into strategic concepts relevant to the individual department incorporating its inherently different strategic partners, organizational tasks, and required technologies.

4.2. THE MOD ITS INNOVATION STRUCTURE AND NETWORK

To understand where decision-making takes place and how IPM is considered in the decision-making process it is crucial to have an understanding of the organizational structure, governance model, and innovation network of the MoD. Figure 4.3 gives an overview of the organizational structure with specific emphasis on Future Relevant Operations of New Technologies(FRONT), S&T (S and T), and DSK/K&I which are presented in **BOLD**. FRONT is responsible for the support of short-cyle- mainly CD and E- innovation projects and is involved in the decision-making process for funding these projects. S&T supports R&T projects and is involved in the decision-making process for funding

these projects. The organizational chart in figure 4.3 shows how the two teams are placed within the MoD's organizational structure. Both need to be close to operations and be in contact with the departments to understand their needs and requirements. However, both also support the development of policy for innovation, and have a responsibility for advising how the budget is distributed between innovative projects and the different departments. Regarding policy for innovation, both FRONT and S&T work closely together with the "Directie Strategie en Kennis/ Kennis en Innovatie" (Directorate for Strategy and Knowledge/ Knowledge and Innovation, DSK/K&I), which is solely responsible for the knowledge and innovation strategy for the entire organization and for the third entity in bold in the organizational structure depicted on figure 4.3. The differences between FRONT, S&T and DSK/K&I is found in table 4.1.

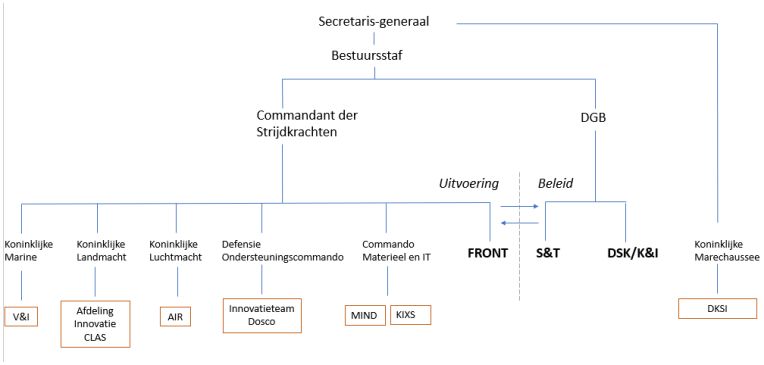

Figure 4.3: Organizational structure - innovation specific

FRONT	**S&T**	**DSK\K&I**
Higher TRL	Lower TRL	Strategy entire innovation chain
Low initial investment	High initial investment	No investment
Experimentation phase	KD and TD phase	Policy and strategy
short project time (<5y)	Long proj time (>5y)	Strategy creation
Operational and policy	Operational and policy	Policy
>700 active projects	<50 active Projects	No projects
Money received within Defense	Money received from EZK	No money

Table 4.1: Table differences FRONT, S&T, DSK/K&I

DSK/K&I, FRONT and S&T all fall under the "Bestuursstaf"(Administrative staff). The Bestuursstaf assumes the responsibility of formulating policies within the Ministry of Defense and is the commissioner for the acquisition of products on behalf of the minister. This entity provides overarching direction to the department, allocates the Defense budget, and exercises oversight over expenditures. The operational Departments of the armed forces are tasked with executing the policy devised by the Administrative Staff, thereby translating the strategic directives into practical actions on the ground, and are the needs assessors in the acquisition of material projects. There also is an executor for the acquisition of large-scale projects which is called COMMIT which is "Commando Materieel en IT". These three partners of the Bestuursstaf, Operational departments and COMMIT each have a distinct role, and play an integral role in the development of KD, TD,CD and E projects, which will become clearer in the following sections on the case descriptions.

S&T, and FRONT work in close collaboration with the entire innovation network of the MoD. Figure4.4 represents the innovation network with the different innovation teams and partners within the MoD. The main focus of this study is on the four operational departments depicted on the right side. It is important to note that the network has been in transition in the past two years, especially in the branding of specific departments mentioned in the network[Ministerie van Defensie, 2020b]. The changes will be discussed in the case study analysis when this is applicable.

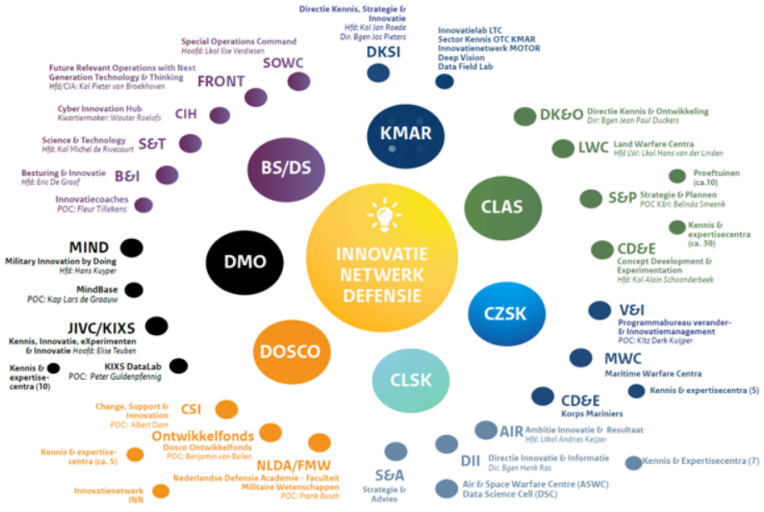

Figure 4.4: Innovation network Defense

As mentioned one of the main differences between S&T and FRONT is its involvement in different project stages. S&T collaborates closely with the knowledge centers operating within the Ministry of Defenc se (MoD), depicted in figure 4.4, and its strong strategic partnerships with key R&D entities TNO, MARIN, and NLR. The initiatives falling under the purview of S&T typically necessitate substantial financial investments and encompass projects with extended duration, occasionally spanning over a period of fifteen years or more [Ministerie van Defensie, 2020b].

FRONT on the other hand works more closely with the different innovation teams depicted in the orange rectangles in figure 4.3. FRONT its initiatives are often lower in cost and most of the time they require more involvement of the operational units and innovation teams. The projects also share characteristics of shorter duration cycles, hence the name short cycle innovations (KCI) has emerged.

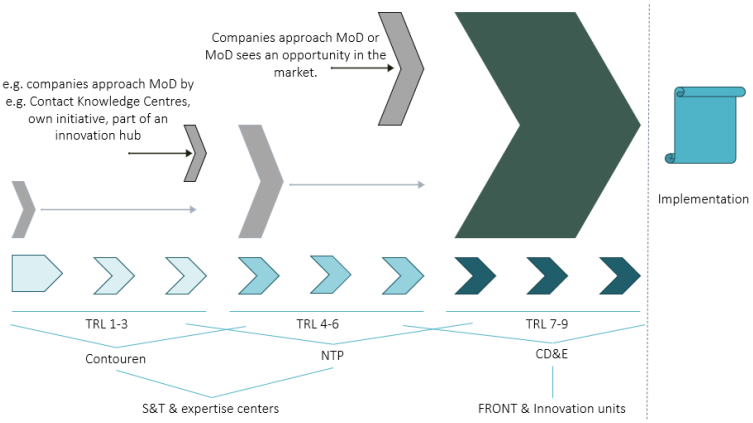

Figure 4.5: S&T vs short-cycle innovation units

Figure 4.5 depicts the decision-making points within the MoD regarding starting projects. The figure is a simplification of the real-world situation where the grey arrows represent projects that can start in either TRL 1-3 or within TRL 4-6 and the green arrow for projects from TRL 7 up to 9. However, due to the fact that indicating which stage an innovation is at is experienced to be difficult, projects can be perceived differently in reality. Moreover, objectives of the projects pursued are rarely put down by defining their TRL stages. The darker grey arrows represent ideations of projects that come from outside the organization.

FRONT and S&T have distinct roles as they are responsible or partly responsible for the collection of project proposal plans and distribution and allocation of budgets to the different departments their innovation teams and knowledge centers. The reason why the section has delved into the differences between FRONT, S&T, and DSK/K&I is that some of their pursuits are interlinked and it shows a first form of portfolio management done on an upper-management level separating three integral parts of portfolio and innovation management, with the choice to separate FRONT and S&T creating a clear separation of two innovation parts based on the characteristics of a project. A second organizational decision that hints at portfolio management is the governance model within the MoD. Where the decision-making for acquisition is done at different layers of the Bestuursstaf, Operational departments and COMMIT.

Before delving into the operational department cases the collection of project proposal plans and distribution of KCI as well as KD and TD budgets are described. This contributes to understanding which party is responsible for budget allocations and how budget allocation takes place. This gives insight into both strategic as well as tactical innovation portfolio management as described by the Cooper 2017 framework.

COLLECTION, SELECTION AND EXECUTION OF KCI BUDGETS

Since 2022 FRONT has been responsible for the collection of the (CD&E) innovation plans within the MoD. The budget allocation for short-cycle innovation has since then been put under the management of the members of the so called "Periodiek overleg innovatie Directeuren" (periodic innovation consultation Directors), also known as POIND. POIND is composed of the innovation directors from the operational departments, plus COMMIT, DOSCO, and the Bestuursstaf. These directors convene every two months to engage in discussions about innovation, its focal points, and the allocation of the short-cycle innovation budget.

The budget for the following year is allocated the summer before, which means in the summer of 2023, the budget for projects in 2024 is allocated. There is a threefold budget available. The fixed spending budget is equally divided between the different departments, plans in this category may assume funding from the 1st of January 2024. The operational departments can decide which of the projects that it submit fall under this budget. The plans that fall under the flexible budget have no certainty of funding from 1 January 2024. Each department may submit plans for an X amount after which the POIND can steer on projects it deems more relevant. Additionally, POIND holds an agility budget to fund unforeseen opportunities during the year. FRONT receives the project plan proposals from the innovation units within the MoD. The innovation units can select projects before they send them to FRONT. How this is done will be discussed in the case study descriptions. Before the POIND meetings, FRONT evaluates every project plan proposal otherwise called need-requests on the dimension of required and value aspects of a project.

Required relates to the completeness of the proposed project plan where the plan needs to meet the criteria of a minimum TRL of 6 or higher, an identified project owner available, financial viability, and fit with one of the MoD its strategies (Defensie NOTA, Defensie visie or SKIA) or roadmaps[Ministerie van Defensie, 2020b].

Valued is based on a multi-criteria analysis in which plan proposals are valued on their:

- Innovation area
- Horizon
- Concept Maturity Level (CML)
- Implementation
- Relationship with previous proposals
- Financial volume required for the year considered
- Total required financial volume
- Coordination with stakeholders

The innovation area refers to nine innovation areas that the MoD identified as relevant within the MoD's operational domain. Without going into too much depth these areas are deliberately broad to ensure that all innovative projects can be included. Horizons used are similar to the described horizons in section 2.3.2. Concept Maturity level refers to a process developed by TNO offering insight into the maturity of CD&E projects [Van der Wiel et al., 2010]. Implementation refers to the foresight for the implementation opportunities. The other criteria are relatively straightforward and will be discussed in the case studies if and when applicable. For all project proposals, the values are given to the criteria where a project can score either all, some, or no points. With the MCA, POIND members receive insight into project proposals' value, with the aim of picking higher-valued innovative proposals. For example, projects that have a transformative or new character score higher than projects with a core, existing product business case.

The process for funding allocation is shown in figure 4.6. Before this process starts it is important to note that the innovation units are responsible for collecting all ideas and proposals from people within the organization which can be individuals within the innovation domain of the MoD, industry, operational unit or the innovation unit's own personnel. The innovation unit is responsible for submitting a project proposal plan to FRONT which evaluated a proposal on the dimensions previously mentioned.

These valuations are sent to POIND which is responsible for the eventual prioritization and allocation of budgets. To complete the process the called "portfolioberaad" (portfolio consultation board) is added to this description. The portfolio consultation board is responsible for the eventual decision to execute the project plans. However, it is a formality that takes up the plans in the correspondence of the entire MoD and its project plan executions.

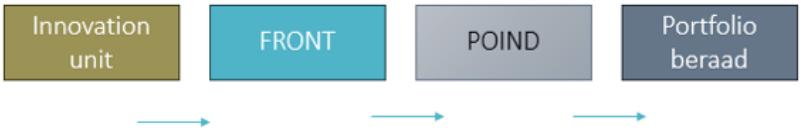

Figure 4.6: Portfolio funding decision-making process

The execution of the project proposal plan is often done by close cooperation of innovation units, operational units that can experiment with the technology, and the business that develops the technology.

COLLECTION, SELECTION AND EXECUTION OF KD AND TD BUDGETS

S&T is responsible for overseeing the project plans concerning KD and TD efforts. Under the purview of Knowledge Development, S&T distinguishes between two categories: primary knowledge development and secondary knowledge development. Primary knowledge development involves collaborations with external knowledge institutes such as TNO, MARIN, and NLR, typically governed by contracts specifying financial arrangements, program plans, and cooperation agreements spanning several years. Some of these contracts are of a continuous nature, especially for critical knowledge domains vital to the MoD.

On the other hand, secondary knowledge development focuses on recognizing and leveraging knowledge available within the Dutch market. This is managed through a separate process called Research & Technology and Innovation Cooperation (RT&I). It centers on collaborations with universities, colleges, civil research institutes, and industry partners. Contracts in this category also encompass financial aspects, program planning, and cooperation agreements, typically with a general duration of four years.

KD proposals are demand-driven, meaning the proposals come from inside the organization and are then articulated as proposals to the three knowledge institutes or in the case of RT&I to the partners within that network. Project proposals can come from anyone within the organization. However, most of the proposals come from the knowledge centers, centers of excellence, or knowledge groups within the individual departments. This process is depicted in figure4.7 where Defense employees can be anyone within the organization but are often someone involved in the process.

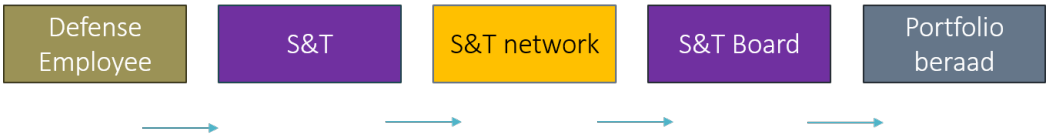

Figure 4.7: S&T KD

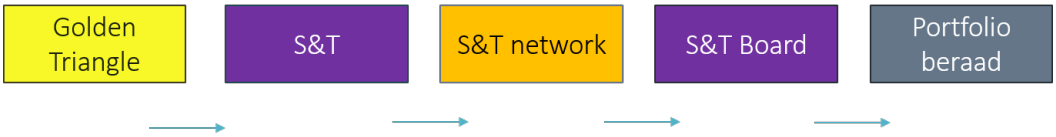

Figure 4.8: S&T TD

TD proposals on the other hand are supply or market-driven, meaning a partner within the industry, the knowledge institutes, and the MoD itself can send in proposals. The three different domains are referred to as the "golden triangle" within the MoD, similar to the triple helix idea. This process is depicted in figure4.8. RT&I follows the same process where the first block can be any of the partners described or international partners of the MoD.

The KD project proposals by TNO, MARIN and NLR are collected once a year in a similar rhythm as the KCI, the proposals by RT&I and TD proposals are both collected three times a year. The budgets S&T is responsible for in the upcoming years are split up into reparation and emphasis on the Defensie visie 2035(DV35). Reparation relates to KD areas that have been neglected due to the limited available budget over the previous years and DV-specific investment is higher in funding and based on strategic consideration of where the MoD wants to be in 2035. The head of S&T is the portfolio manager responsible for the selection procedure of the KD and TD projects and does this in close collaboration with partners within the MoD. Again the head of S&T prepares the selection choice where the eventual decision-making for execution is done within the “portfolio beraad” as described in the KCI process.

In a similar fashion as the KCI cycle, the selection of KD and TD projects is done based on two dimensions. First, all projects are reviewed on their completeness where proposals need to fulfill the requirements to fit into either TRL 1-4 for KD or 4-6 for TD, the extent of overlap in relation to other research areas, and the need for continuation of projects within the Knowledge institutes. Additionally, proposals are examined whether they focus on building up defense-specific knowledge or knowledge that is not available in the market. The proposals meeting the assessment criteria are then assessed on *relevance* and *urgency*. Relevance refers to the relevance a proposal has to the MoD; urgency is defined as the urgency a proposal has in the current market and strategy of the MoD. These criteria are inherently normative evaluations based on the assessment of the decision-makers.

The valuation assessment is done by the S&T network including R&D and acquisition partners within the MoD by circulating the proposals with the request to appreciate and prioritize projects based on *relevance* and *urgency*. Once appreciation is performed projects are sent back to S&T projects which is then responsible for the eventual decision-making and balance within the portfolio. The S&T board currently creates balance on the different departments, R&T areas provided in the SKIA, and the focus areas provided by the State secretary (R25, Internal document 2023). Additionally to arrive at a consideration to honor proposals projects are balanced on current and expiring programs and distribution of the DV-specific goals and repair areas as previously described.

KD, RT&I, and TD all have their own budget and time for funding therefore appreciation happens at seven moments throughout the year. How appreciation is done, is different within every department, which is discussed in the next section.

The project proposal plans are executed by operational departments, while external knowledge partners, such as knowledge institutes and industry, provide program or project leadership. How selection and execution are done within the departments is described in more detail in section 4.3.3. As the primary funding source, S&T retains responsibility as the Research and Technology (R&T) portfolio manager for the execution of these projects and programs. S&T conducts random evaluations of project proposal execution at the conclusion of each project's execution period to ensure compliance and effectiveness.

Furthermore, the operational departments that oversaw project execution are accountable for advancing the knowledge and technology products through innovation within a program or current organization. They are also responsible for facilitating knowledge utilization in various contexts, including policy development, capability development, investment projects, and operational deployments.

In the next section, the four operational departments' selection and execution processes are described through the IPM framework as described by Cooper (2017). First, the strategy of the department is described, then the strategic portfolio decision-making in place is discussed after which the tactical portfolio decision-making is described which results in the selection and execution of proposals.

4.3. CROSS-CASE ANALYSIS

The previous section described the funding process for KD, TD, and KCI project proposals. The section described that before project proposals are evaluated by POIND or S&T the operational departments with their knowledge centers and innovation units have their own selection procedures, moreover the departments are responsible for the execution of the proposals. Therefore it is essential to understand the departments their innovation portfolio management to get a grasp on how the entire MoD performs IPM. This is similar to the suggested method by Peerenboom et al (1989) where each subcommittee was responsible for selecting and prioritizing within its domain[Peerenboom et al., 1989]. This section does not aim to delineate the varying maturity levels of each department,

as such a comparison holds limited scientific relevance. The section will provide a cross-case analysis of the MoD's IPM structure based on the three layers provided by Cooper (2017). The three tables 4.2, 4.3,4.4 provide an initial glimpse of the results.

The subsequent sections further examine these results in the context of the existing literature, with the primary aim of establishing connections between these findings and the research questions. The resemblances observed in this cross-case analysis offer insights into the MoD's execution of IPM, while the distinctions shed light on the extent to which the findings can be generalized for MoD IPM as a whole.

Notably, there is no singular answer to the sub-question regarding how IPM, strategic IPM, and tactical IPM are executed within the MoD. The results indicate that both long-cycle and short-cycle IPM exhibit diversity in their approaches within the MoD.

4.3.1. BUSINESS STRATEGY&PRODUCT INNOVATION STRATEGY

Table 4.2: Business strategy and product innovation strategy

Departments	**S&T \ POIND Funding**	**Business Strategy and Product Innovation Strategy**
CZSK	KD & TD	Sailplan & Maritieme Kennis Opbouw (MKO)
CZSK	KCI	Sailplan
CLAS	KD & TD	Landmacht Vandaag, Morgen, Overmorgen, Toekomst; Marsroutes (12 capability Roadmaps); vision CLAS
CLAS	KCI	Landmacht Vandaag, Morgen, Overmorgen, Toekomst "mogelijk toekomstig optreden"(MTO). Marsroutes (capability Roadmaps)
CLSK	KD & TD	Commanders Intent (at the moment CLSK is developing "flightplans" that should provide more information on its required capabilities and innovation)
CLSK	KCI	Commanders Intent (at the moment CLSK is developing "flightplans" that should provide more information on its required capabilities and innovation)
KMAR	KD & TD	Commanders Intent And Multi-Annual Strategic Plan
KMAR	KCI	Commanders Intent And Multi-Annual Strategic Plan

As table 4.2 reveals there are several business strategies used within the MoD and its innovation network. The main documents referred to within the MoD are the "in-

novatie strategie Defensie, 2018", "SKIA 2021-2025", "Defensie visie 2035", "Sterker Nederland, Veiliger Europa, Defensie nota 2022""Nota Defensie industrie Strategie, 2018" and an internal document on focus areas for the MoD [Ministerie van Defensie, 2020b, Ministerie van Defensie, 2020a, Ministerie van Defensie, 2018, Ministerie van Defensie, 2022b, Ministerie van Defensie, 2022a].

Moreover, within the innovation network, people refer to the "Defensie lifecycle Plan"(DLP), "capability plan", and "future operating concept" which have yet to become available and should offer essential guidance into the strategic translation from a business strategy into a specific product innovation strategy. The Defensie visie 2035 document which is updated on a yearly basis is leading with regard to the MoD its vision for the future.

Within each department, it was found that the departments vary in the specificity of their business and product innovation strategy. The CZSK and CLAS have specified their strategic needs. The CZSK has a specific business innovation strategy written for its KD and partly TD requirements within one strategic paper called the "Maritieme Kennis Opbouw"(MKO), maritime knowledge build-up. For the CLAS the innovation strategy is split up into different technology Roadmaps. The reason for the CLAS to split up its innovation strategy was offered by a respondent who mentioned that the CZSK has a better understanding of its timeline with regard to the implementation of new products into its service since it's bound to the updates of its ships (R12).

The CLSK and KMAR both lack specific strategic papers and mainly use the commander's intent and the MoD its wider strategic papers such as DV2035 and the SKIA as guidelines for its strategic direction for R&D endeavors.

4.3.2. STRATEGIC PORTFOLIO DECISIONS

Strategic portfolio decisions involve translating overarching strategic objectives and goals into concrete resource allocations. In the context of a military analogy, this transformation mirrors the transition from strategic planning to operational deployment. It encompasses the challenging task of determining whether to concentrate all development resources on existing, low-risk projects, akin to a strategy of "defending the base," or to allocate a portion of these resources to invest in emerging technologies [Cooper, 2017b, Cooper and Edgett, 2015].

Table 4.3 shows the strategic portfolio decisions per department split into "buckets" and "roadmaps". The table describes the strategies used as buckets and roadmaps that are developed. These will be further elaborated on in the text. The first thing that becomes clear and was already identified in sections 4.2,4.2 was that the MoD divides its resources regarding project types. Whereas KD, TD, and KCI projects all have their budget. These are the main budgets available for R&D projects within the MoD. However, there are more budgets that the innovation unit uses for its endeavors. This will be further discussed in section 4.3.3.

An interesting to note is that the division of money resources is more invested in KD

Table 4.3: Buckets and technology roadmaps

Departments S&T \ POIND funding	**Buckets**	**Product innovation and technology roadmaps**
CZSK KD & TD	9 R&T areas provided in the SKIA, project types described in the strategic product roadmaps and MKO	Technology roadmaps developed by COMMIT
CZSK KCI	9 Innovation areas by FRONT.	does not make use of technology roadmaps
CLAS KD & TD	CLAS its own developed 9 technology roadmaps and the MTO	Technology roadmaps developed by COMMIT
CLAS KCI	12 capability roadmaps developed by CLAS based on MTO and strategic papers; Horizon; within roadmaps subdivision of buckets can exist	currently in the process of including the nine technology roadmaps
CLSK KD & TD	9 R&T areas provided in the SKIA	Letter of intent and description on some technologies in the technology roadmaps. Currently in the process of developing "Flightplans" related to technology roadmaps
CLSK KCI	9 Innovation areas by FRONT; Horizon	Letter of intent and description on some technologies in the technology roadmaps; Flightplan should support KCI decision-making as well.
KMAR KD & TD	9 R&T roadmaps provided in the SKIA	No clear technology roadmap discovered.
KMAR KCI	9 Innovation areas by FRONT.	does not make use of technology roadmaps.

and TD whereas the KCI projects are often more human resource-heavy. The interpretation of these results should be treated with care cause only the R&D budgets divided by S&T and POIND were considered even though there are more budgets used within the innovation R&D chain that could influence these numbers.

Another bucket that is visible straight away is the different departments. As described in section 4.2 POIND divides money per department with fixed, flexible, and agile budgets. The fixed budget is available for each department regardless. For KD and TD within S&T, there are no clear budgets allocated within KD or TD. Proposals regarding KD and TD are sent to each department for evaluation on urgency and relevance and ranked on that basis. Even though all project proposals are sent to every stakeholder involved in the evaluation process within S&T, in practice, only those who have an affiliation with the technology or those who specifically oppose a specific topic reply to the appreciation request. When all requests are appreciated and S&T collects the results of the proposal appreciation, S&T aims to balance the proposals, where division per department is considered before funding is allocated.

Other buckets that were identified are thematic. The MoD and departments have certain technologies that they have deemed essential which have gained a special budget and personnel allocated to the these technological areas. This is either done by the department or goes all the way up to the minister who decides that certain domains need extra attention. Examples of this are the "space domain" which has received a special budget specifically allocated to the development of space knowledge for the MoD. Another example is the Remote automated systems (RAS) unit of the CLAS which has received separate funding from the department for further development. After initial funding as with the RAS unit further investment is required to come from the allocated R&D budgets of S&T and POIND. Within these budgets, it was found that no specific resources were dedicated to any themes as of yet.

Reasons given for the lack of resource allocation towards specific thematic buckets differed. Respondent 28 mentioned that it was currently hard to allocate resources to innovation areas for POIND since clear guidance was lacking as the capability gap and future operating concepts required for guidance were not available yet (R28). Respondent 24 mentioned that specific allocation toward R&T areas or focus areas is done during balancing. For both S&T and POIND the research proposals are either demand-driven, by the departments, or supply-driven by the "golden triangle" of either the MoD, industry, or knowledge institutions, but never allocation-driven. Therefore it is not done by allocating a sum of money or more people to an R&T area or focus area but it is done after the valuation of either demand-driven or supply-driven proposals by balancing the projects to ensure that enough projects are put in certain areas. Enough is however not defined neither is there a clear understanding of what areas should be allocated more or fewer resources.

The decision-making process on these priorities is first decided within departments and if there are still more proposals than available money it's decided by the members of S&T. Respondent 25 mentioned that S&T invests in its people to ensure they have a good understanding and oversight into picking the right project. Respondent 25 moreover mentioned that:

"The knowledge to evaluate projects is more prominent in the heads of the members of S&T than developed into clear decision-making processes"

When looking into the thematic buckets used within the departments there are clear distinctions between the departments and also between the thematic buckets of R&T, and KCI proposals. For KD and TD the CZSK attempts to balance proposals such that there is a balance in the roadmaps, R&T areas, and the MKO which often have great overlap and are in alignment with each other. The CLAS aims to balance proposals based on its own technology roadmaps and MTO, where it attempts to balance projects for the near future as well as farther away. The CLSK and KMAR both rely on the R&T areas provided in the MoD strategy for their balancing of projects. This will be further discussed in the tactical portfolio decision section since this is more related to how strategic portfolio decision-making is executed.

Strategic product roadmaps or technology roadmaps were found primarily to be used for KD and TD by CLAS and CZSK. The CLSK plans on formulating such roadmaps in the form of "flightplans" but does not use them as of yet. Within the Short-cycle chain, the use of technology roadmaps or product innovation roadmaps was not found to be in place. The CLAS however did mention it was looking into the inclusion of roadmaps into the decision-making for KCI projects as did the CLSK once the "Flightplans" are delivered.

4.3.3. TACTICAL PORTFOLIO DECISIONS

Tactical portfolio decision-making is described by the model of Cooper 2017 through the use of portfolio reviews and gates. Tactical portfolio decision-making is thereby the layer where the selection of projects takes place (portfolio reviews) and execution of projects is performed (gates). For portfolio decision-making in the portfolio reviews it is essential information from the gates is fed back to allow the portfolio review decision-makers to adjust their portfolio to the information provided by the projects that are in execution. Moreover as described in the theory, gates and portfolio reviews impact the technology roadmaps where new information from the executed projects can give insights into future required research[Cooper, 2017b]. The portfolio reviews are used to execute the strategic line that is set out in the strategy and strategic decision-making. As described in the previous section there are clear buckets with allocated budgets and thematic buckets without allocation of budgets. The buckets with budgets allocated have a clear decision-making process which was described in figures 4.6, 4.7, 4.8.

Table 4.4: Tactical portfolio decision

Departments S&T \ POIND funding	**Portfolio Review**	**Gates**
CZSK KD & TD	Review performed by "Kennis Netwerk Zee" and sent to partners within the MoD by Funder (S&T)	Start of a project exists out of explicit "review" gates. The projects are furthermore distinguished by their project type, which creates gates within the development. No explicit gates or milestones during a project are required.
CZSK KCI	Review performed by innovation unit and by the Funder (POIND)	Idem
CLAS KD & TD	Review performed within MDT's, and sent to partners within the MoD by Funder (S&T)	Idem
CLAS KCI	Review by program management, by the innovation unit and by the Funder (POIND)	Idem
CLSK KD & TD	Review performed within MDT's, and sent to partners within the MoD by Funder (S&T)	Idem
CLSK KCI	Review performed by innovation unit using its own MCA and by the Funder (POIND)	Idem
KMAR KD & TD	Review performed by "Intake and innovation table" and sent to partners within the MoD by Funder (S&T)	Idem
KMAR KCI	Review performed by "Intake and innovation table" and by the Funder (POIND)	Idem

The figures show that portfolio reviews are performed on multiple levels, the first for KCI is within the innovation units, and for KD and TD either in the first step or the third step in the S&T network. The next paragraphs will explain the process on where or by whom these decisions are performed which is partly described in table4.4.

As figure 4.7 depicts, the first step is "Defense Employee" which sends in a project proposal plan. In reality, these proposals are often well-elaborated and part of a bigger group of projects that are sent in by the knowledge centers. The CZSK and KMAR have a board in place where projects are one by one discussed and evaluated. Eventually, the best projects are shared with S&T after which S&T shares them with the S&T network for further evaluation. The CZSK board called "Kennis Netwerk Zee"(Knowledge Network Sea) also referred to as KNZ, evaluated projects based on the valuation parameters *urgency* and *relevance*, as proposed by S&T where each voting member is allowed to rate proposals on both parameters and proposals, are ranked from highest to lowest. Last year the thirteen highest-ranked KD proposals were submitted to S&T and eleven were eventually granted budget by S&T. For the KMAR the parameters used to rank projects were not as clear and no specific valuation method was identified. The CLAS and CLSK do not use a single board to evaluate every proposal within their domain but use multi-disciplinary teams (MDT's). The proposals are often collected in step three of the S&T process, as described in figure 4.6, and the head of the warfare center for CLSK or by S&P and COMMIT for the CLAS gathers the involved partners within the technology domain for evaluation of the projects. This is done on the same parameters as S&T prescribes. For TD this process is similar in nature.

When we consider tactical portfolio decision-making it is important to connect it with the strategic guidance given in the layers before as the departments show significant differences in the use of strategic guidance in their portfolio reviews. This is partly where the overlap in strategic decision-making with the use of a thematic bucket comes in. One could argue that since no clear resources are allocated to the thematic buckets they should not be described as buckets however since balancing is done on these thematic buckets in a similar fashion it is used to balance resources. To understand how these buckets and roadmaps are used this paragraph will describe how the departments use them within their review decision making.

The process varies across the departments, reflecting their distinct approaches to achieving focus and specialization within overarching strategies. A noteworthy example illustrating the pursuit of specialization is evident within the Royal Netherlands Army (CLAS), which has devised twelve capability roadmaps akin to "business" strategies tailored explicitly to the CLAS. Furthermore, the CLAS has established nine technology roadmaps for its Research and Technology (R&T) portfolio, and it is currently transitioning toward implementing fourteen innovation areas, aligning with the twelve capability roadmaps for its "short-cycle" innovation endeavors.

The prioritization of these technology roadmaps and the specific technologies encompassed within them is orchestrated through multi-disciplinary teams (MDTs). These teams encompass subject matter experts and stakeholders within the chain, who contribute their input regarding the selection of technologies and roadmaps deserving of project funding. It is pertinent to note that the composition of these decision-making bodies varies according to the specific roadmap and technology in question, with overarching coordination facilitated by the Strategy and Policy (S&P) departments and COMMIT General Working Staffs (GWS). The Royal Netherlands Navy (CZSK) on the other hand has a specific portfolio review body in place, KNZ, to prioritize roadmaps and technologies within the roadmaps. Respondent 14 involved in the decision-making process of the KNZ remarks that little indication is given on how to prioritize, between roadmaps, R&T domains, and technologies within roadmaps, by more senior management such as the head of the CZSK (R14).

The Royal Netherlands Air Force (CLSK) and Royal Marechaussee (KMAR) presently appear to lack clearly defined roadmaps coupled with the portfolio review processes observed in the Royal Netherlands Army (CLAS) and Royal Netherlands Navy (CZSK). Several respondents gave specific reasons for these disparities; within the CLSK, the primary technologies are predominantly developed in the United States, while the CZSK and CLAS engage significantly in the development of technologies within the Netherlands (R14, R19). Additionally, respondent 21 involved in the decision-making within the KMAR noted its limited maturity and ongoing efforts to establish a robust research and development (R&D) and innovation network that contribute to the divergence in approaches (R21). For the CLSK a similar notion on maturity was provided (R19).

Comparing the use of buckets with the available strategies it is found that the departments with more explicit strategies regarding their future operations and capability needs also rely more on their own thematic technology roadmaps, capability needs, R&T, and innovation areas for balancing. CZSK and CLAS do this significantly more in their KD and TD proposals compared to CLSK and KMAR.

For KCI proposals the CLAS deviates from the other innovation units. The CLAS is in transition to use fourteen innovation areas based on the twelve strategic capability roadmaps to balance the proposals. Furthermore, within these innovation areas, which are referred to as programs, the program manager can bring more emphasis and balance within its programs through the use of technology roadmaps and available strategies. The idea of balancing within programs was observed multiple times in the preliminary research during interviews with respondents (R4, R5, R8). The innovation units of CZSK, CLSK and KMAR use the nine innovation areas provided by FRONT as their main form of balance in the portfolio reviews. Respondent 17 mentioned that CZSK its technology roadmaps and MKO available for R&T do not provide clear guidance for balance or use of buckets in the KCI domain (R17).

All innovation units mention that proposals are also valued for their informativeness however only the innovation unit of CLSK has a specific MCA in place where proposals that have a more innovative character based on horizons, score higher. As outlined in the section 4.2 the evaluation process at FRONT also involved the utilization of a MCA.

Within the MCA, proposals were among other things assessed based on their level of innovativeness, which can be regarded as a form of balancing within innovation buckets. Important to reiterate what was already said balancing is done after proposals are submitted and therefore proposals are not allocation-driven. The use of buckets and innovation portfolio management is however based on setting spending targets and making conscious resource decisions. The MoD currently does not make use of spending targets regarding themes within the R&T and KCI domain but does use the buckets to look back and balance proposals.

Additionally, thematic buckets are used to share knowledge within the network of the specific theme by grouping the projects together. What the "balance" is based on is however not defined in any strategic paper or process but in the heads of the final decision-makers. Since it is not further elaborated in the process of the decision-making a danger exists that clear guidance is gone when employees involved in the decision-making process leave or change seats. Within the MoD, this is more prominently an issue as all military personnel, which most of the decision-makers are, are required to change into a new function after three years.

The aim of portfolio reviews is to ensure balance through the right priorities, the right mix, alignment with strategy, sufficiency, and resource adequacy[Cooper, 2017b]. From the departmental cases, it was seen that there was not one overall methodology within the departments to evaluate projects. S&T and FRONT its evaluation methods were however used throughout all the projects submitted from the departments. When a focus is put on the thematic buckets it becomes hard to find who is responsible for the decision-making process or what "the right mix" is. Moreover, when a project or program falls within multiple thematic buckets it becomes even harder to find out what the rules are with regards to prioritization of such a proposal over other proposals.

Currently, however, for KCI proposals there is no cut-off for projects since all projects that fulfill the minimum requirements are attributed money. Several respondents mentioned this created reluctance to actively steer toward certain technologies over others (R10,18,27).

Figure 4.3.3 shows that the use of gates is similar for the entire organization. The use of gates was identified in some projects but not all as it was not a requirement within project proposals. The project owners who did not use specific milestones in their projects mentioned it was difficult to put a time frame on the projects they conducted.

Even though a timeline of projects with milestones is required for the allocation of money, there is no requirement to update the progress of such a project. The book by Luc de Beer (2022) discussed this issue as a failure of good project management within the MoD [Beer, 2022].

Literature prescribes gates for use in innovation projects by updating senior management and requesting extra funds or resources. Considering the seven project types these could also be described as gates. Therefore the gates seem to be institutionalized by only allowing projects to evolve to a certain stage. In practice, it was found that the MoD evaluation project milestones were not a set process. However, project managers did describe processes that shared similar characteristics. A CLAS portfolio manager who attended the focus group described that the CLAS is currently in transition to implement PRINCE2 and fortes change cloud for its innovation projects (R29). These methods are currently in use for larger projects within the MoD but were seen as unnecessary administration by the innovation project owners (R3, R5).

Commonalities exist among the identified issues of gates, data clarity, and evaluation methods. Firstly the evaluation of a project predominantly pertains to the initial stages of a project, where roles and responsibilities are clearly defined, and necessary information sharing is established. However, as projects progress, the uniformity and clarity of information sharing tend to diminish.

Concerning scoring models, a distinct divergence emerges between short-cycle and R&T projects across different departments. Short-cycle projects lack established scoring models within departments, although such models are employed by FRONT and found within AIR of the CLSK. R&T projects feature a well-defined scoring model from the funding side of S&T focused on the parameter's relevance and urgency which is used throughout the R&T network for the evaluation of projects.

As a more general note, another similarity is that the setting-up and implementation of innovation portfolio management seems to be in development for every department where maturity levels clearly defer and each department is still looking into the right way to organize its strategic and tactical portfolio decision making. The MoD currently uses the MoP standards as a first insight into its design for portfolio management but is looking into how it can best implement a portfolio process into its decision-making.

This research along with research design studies such as Peerenboom et al 1989 and Archer and Ghasemzadeh (1999) can provide more insight for the MoD on how it can best organize for portfolio management [Peerenboom et al., 1989, Archer and Ghasemzadeh, 1999]. Appendix D shows both models with specific implementation suggestions for the MoD, and comments on the MoD its current state.

4.4. INTERPRETATION OF THE RESULTS

This chapter gives insights into how the IPM process is organized within the MoD. It shows Cooper its model is applicable to display an IPM model within the public sector. The disparities between the S&T process and POIND process as well as the disparities between the four departments indicate the changing nature of the organization. Additionally, these cases provide clear examples of how IPM is organized within the MoD. The S&T process for the CZSK and CLAS shows how innovation strategies, technology roadmaps, and portfolio reviews are leading in the MoD its current IPM practices.

The MoD its overall innovation strategy in the form of a future operating concept (FOC) and capability plan is currently in development. These documents are guiding for all the departments and decisions on priorities within these documents are developed in a political process with the Minister and state secretary of the MoD, the highest-ranked commander of the MoD, and the most senior management involved in the R&D and acquisition process. The current lack of guidance on an innovation strategy revealed that it does not necessarily have to create a lack of departmental innovation strategy since both CZSK and CLAS show innovation strategic direction in their S&T R&D strategic documents.

These strategic documents need to align with NATO requirements, emerging threats and opportunities within their respective domains, and the broader political agenda. Respondent 11 mentioned that these departmental strategies should be leading since

> "fully guiding technology development from The Hague is not possible because they don't know exactly what a specific operational unit needs"

The centralized funding bodies and strategy-making triangle of DSK/K&I, S&T, and FRONT are meant by the Hague. The centralized strategies, FOC, and capability plan will be beneficial by adding new insights and guidance for the departmental strategies formulated.

The literature emphasizes the necessity of a comprehensive product innovation strategy to guide technology investments and resource allocation. The debate within the Ministry of Defense (MoD) and politics revolves around who should be responsible for these decisions: the political realm, the wider organization, or individual departments (R11, R22, R27). Another difficulty within the strategic decision-making realm is the continuous change of military personnel as well as the inherent culture of the MoD departments to fight for a department its resources instead of following a wider MoD strategy (R11, R22,R27).

Concerning strategic portfolio decision-making, an emphasis lies on the use of strategic innovation product roadmaps. Strategic buckets are recognized by the allocation of resources to KD, TD, and KCI, and the Defense-wide resource distribution per department. Moreover, figure 4.2 shows the MoD develops strategic papers which define what

technological fields the MoD aims to concentrate on.

The MoD's choice to what extent it aims to be involved in the development of certain technologies is steered by how the Dutch innovation and R&D market develops. At the same time, the MoD itself with its large funding budgets also plays a role in the enhancement and steering of certain markets within the Netherlands. Since the MoD does not develop its technologies it becomes a political decision in which technologies the MoD and the Netherlands feel the market should develop and the MoD chooses to *push* technology advancement in the Dutch market. The definition of *technology push* in the context of the MoD involves determining which technologies should be advanced to make the Dutch market and military stand out as pioneers.

Simultaneously, the MoD faces the challenge of developing technologies that the market wouldn't naturally advance on its own, like military radar systems and adapting to technologies that evolve rapidly in the commercial sector, such as battery technology. Additionally, extra allocation into certain domains is sometimes done such as the "space domain".

However, looking into prioritization within specific technological areas by S&T and POIND decisions are not guided by a predetermined division of allocated resources. The reasons for this are multiple namely a lack of guidance with regards to the FOC and capability plan, the project being demand-driven instead of allocation-driven, the inherent nature of the organization to be operational in multiple domains and therefore have knowledge and innovate in multiple domains, and the fact that currently, the MoD has a large sum of money where it is struggling to spend the money it has been allocated in the R&D domain. Respondent 15 mentioned

"I believe that money cannot be the leading factor in portfolio management"

Multiple respondents mentioned the "lack of scarcity" as a reason not to prioritize (R10, R18, R27). A lack of prioritization however does not mean every project is justified since the MoD is responsible as a governmental organization to justify the projects it undertakes each project is always tested on the questions: is a project *legitimate?* and is a project *effective?* (R2,R3,R5,R6). Effective and legitimate are not further defined by those involved in the process. However, the respondents did refer to the innovation process in place where they mentioned to answer the questions the MoD prioritizes based on the TRL of projects and uses the strategic roadmaps available.

The roadmaps available are based on strategies such as the DIS with specific technology priorities. Moreover, it balances and picks projects based on the parameters of *urgency* and *relevance*, the division between different departments, thematic areas, and focus areas. This balancing is not done by explicit numbers or targets or within written statements but is mostly based on the knowledge of the people involved in the process.

Current practice by the MoD shows that prioritization is done through TRL levels but the prioritization within thematic buckets, different departments, and focus areas is done by balancing without clear steering into these domains (R9, R12, R24). Respondent 14 involved in the evaluation process of S&T project proposals of the CZSK said the following:

> "We currently distribute our attention across everything and have to determine each time what we find interesting or important. Therefore, there is never one thing on which we can truly focus more on"

.

Tactical portfolio decision-making takes place at multiple levels within the organization, similar to literature studies such as Peerenboom et al (1989)[Peerenboom et al., 1989]. The results show how portfolio review decision-making relies heavily on strategic input provided in the strategy and strategic decision-making layers. Understanding where priorities lie and what strategies are dominant is something that all departments seem to struggle with, respondent 15 described that within the military there is an abundance of strategies making it difficult to understand which strategy is leading

> "The problem is that there are too many strategies, and it is not made easy to understand what we want"

The portfolio reviews are based around funding projects and do not reconsider previous projects as these are already funded and external parties have received the money to pursue the projects. For the MoD to still be able to control its innovation process its process is split not only in the three main categories of KD, TD, and KCI but in seven project types. For product development, the MoD can fund a project from one phase to the next becoming increasingly *smarter* in the project requests to partners. This process is indirectly the review process where with each new stage the MoD can choose to fund a project or not.

The "demand-driven" project proposals are often derived from the roadmaps and therefore have a strategic allocation-driven character. Departments without roadmaps are revealed to have less direction in their innovation endeavors and rely more on overall MoD-wide strategies. The MoD process shows that departments are responsible to evaluate and balance proposals before they are sent to either S&T or FRONT. The departments do not follow a uniform process when it comes to this evaluation whereas the centralized bodies of S&T and POIND have a more structured process in place.

The project proposals valuation for S&T projects is done on the parameters of *relevance* and *urgency* which is similar to *mission relevance* and *momentum* as described by Linquitti (2015) [Linquiti, 2015]. Balancing all proposals is eventually done centrally within S&T by balancing the dimensions of departments and thematic areas. The S&T members do this without specifics on how priority is given, and the process is trusted on the knowledge of the decision-makers. The recognized danger, acknowledged by respondent 25, lies in the fact that military personnel change function on average every

three years which can impact the consistency of the decision-making(R25). For the entire IPM decision-making process respondents mentioned the change of military personnel as an obstacle to clear prioritization and strategic alignment in the choice of project proposals. Within the departments for both S&T as well as KCI projects there is currently no uniformity by the departments in how proposals are evaluated. Within the centralized funding bodies S&T and POIND do show clear guidelines within its evaluation methodologies.

As two final remarks on the results, within this thesis, the main funding process for projects within the MoD has been researched. To receive funding for a project there are however different budgets available within the MoD as well as within the European Defense fund. These different budgets allow project owners to specifically target budgets based on the budgets available. Respondent 3 said the following on this topic:

> "as an innovation team we don't have a set amount of money or people. If the CLAS does not see the benefit of a project we could still go to FRONT and see if they see the benefit of the project from an interdepartmental view, and if that doesn't work we could still try and receive funds from the EU to develop the project"

.

This phenomenon in the MoD is called "shopping" (R24,R27).

The second remark is on the current transition the MoD is in. The public spending on the MoD and its R&D has significantly increased since the war in Ukraine which has created an unprecedented situation for the MoD to process the increased resources into effective public spending.

5

Discussion

In this study, a theoretical framework is applied which has been obtained from literature [Cooper, 2017b]. This theoretical framework, with its different facets, is a primary source for innovation portfolio management in the private sector and was used to analyze the IPM structure in place at the MoD. The previous chapter thereby gave insights into the sub-questions one two and three. To answer the main research question How does innovation portfolio management in the public sector, as exemplified by a case study within the Ministry of Defense, differ from private sector innovation portfolio management literature?, sub-questions four and five pertaining to the difference of the case study of the MoD compared to available private sector literature as well as SQ5 comparing the case study to the entire public sector, need to be answered. The discussion will first delve into SQ four and five after which the limitations and future research opportunities are discussed.

5.1. How does IPM in the MoD differ from IPM private sector literature?

First, the IPM at the MoD will be compared to IPM literature in the private sector. Figure 5.1 shows some of the key differences between IPM in the private sector vs IPM in the MoD.

Considering the difference in business and product innovation strategies in both sectors the insights are not particularly new however the impact on portfolio decision-making has not been discussed in great depth in previous literature [Cooper, 2017b, Linquiti, 2015, Baškarada and Hanlon, 2018, Roberts and Hamilton Edwards, 2023].

The differences in strategies in the private sector compared to the public sector rely on the inherent difference in the goals of the organizations. Private-sector organizations need to satisfy shareholder value and their main aim is often profit maximization. Prioritization for private companies resides in market share, financial advantage, return on investment, competition, and strategy [Moore, 2013, Cooper, 2017b].

Table 5.1: Private Sector IPM vs MoD IPM

	Private sector	**Public sector** (MoD)
Business strategy and product innovation strategy	Profit oriented, development can be focused on different markets	Public interest oriented, development of technology relies on national market development.
Strategic decision-making	Prioritization based on financial advantage, risk, return on investment, and market share, qualitative as well as quantitative.	Prioritization based on innovative character in the form of KD, TD, KCI (risk), and strategy in the form of balancing. Methods are underdeveloped compared to the private sector and are currently mainly qualitative. Parameters such as *urgency* and *relevance* differ from known private literature.
Tactical decision making	Reviews based on empirical data, projects often performed within the company.	Reviews based on normative data. Projects not developed by "own R\&D" department but outsourced. Milestones and gates are not included in projects but projects are split up in development stages.

Strategy for the MoD on the other hand focuses on national security and how to best defend public interest. The task who is responsible for strategic decision-making within the MoD seems to be more difficult than private sector businesses where the MoD has to deal with continually changing political guidance, changing threat levels, and the fast-changing roles of key decision-makers.

In the realm of private sector literature, there exists a prescription advocating the differentiation of specific strategies tailored to distinct departments [Viki et al., 2018, Cooper, 2017b]. A similar pattern emerges within the Ministry of Defense (MoD), where the executive staff is responsible for allocating funds among departments but lacks the necessary expertise for making technology-related decisions. Consequently, several departments within the MoD have taken the initiative to craft their own innovation and technology strategies. These departmental strategies are strategically aligned with the broader organizational strategy, emphasizing capability and risk sharing in line with international obligations.

With regards to the strategic decision-making realm the private sector literature prescribes that the best innovators steer and prioritize the technology endeavors and not merely use portfolios to look backward [Cooper et al., 2002a, Cooper and Edgett, 2015]. Within the MoD a formalized, written resource allocation strategy is absent however as mentioned the departments do create their strategies that guide project proposals.

Moreover, strategies such as those presented in table 5.1 provide an overview of the prioritization approach employed within the Ministry of Defense (MoD). One notable distinction to be made here is that in the private sector, a company's strategy is often contingent on the global landscape of R&D, whereas the MoD places greater emphasis on R&D developments within the national market. Moreover, private sector firms utilize familiarity matrices to gauge their familiarity with technology development, while the MoD assesses this by considering the familiarity of its innovation partners and the national product market.

The strategies used within the MoD, do not include resource allocation distribution but do give some direction for the departments, after which balancing is done at the executive level. The lack of prioritization within the MoD was attributed to the current lack of a central strategy, lack of specific knowledge for the needs within different departments as well as the inherent nature of the MoD to diversify its capabilities, and lastly the perception of an "abundance" of funding available for R&D endeavors within the MoD, which may reduce the urgency for strict prioritization. The lack of a central strategy and specific knowledge can both be found in private literature however the intrinsic obligation to diversify as well as the consistent security of funding seem specific for the MoD and public sector in general [Viki et al., 2018, Cooper, 2017b].

Thereby the MoD its risk profile differs from private sector organizations, as it can consistently secure funding year after year as long as politics adhere to the NATO agreements. The challenge for the MoD currently lies in allocating increased investments effectively, rather than mitigating financial risks. Unlike private entities that often specialize in enhancing profitability and reducing obsolescence risks, the MoD's focus centers on preserving public value [Meskendahl, 2010, Page, 1993, Linquiti, 2015]. Consequently, the MoD is bound by international commitments not to overly specialize, although it aims to enhance its strengths on the global stage [Nato innovation Fund, , NATO, 2021, Ministerie van Defensie, 2020a].

The private sector literature suggests a divide of 70/20/10 % of core, adjacent, and transformative innovation or 35/25/25/15 split from incremental to innovations new to market and business[Viki et al., 2018, Cooper, 2017b]. The current split within the MoD is not clear-cut but seems to lean more toward a higher investment in KD and TD projects which are often adjacent and transformative.

It is important to note that, as discussed in the previous chapter, prioritization is primarily applied by the distinction of KD, TD, and KCI projects, each of which has its allocated budget. A specific priority list in thematic areas within S&T and POIND is currently not used. The process of balancing and setting priority in strategic themes and between the various departments is carried out by the decision-makers within both S&T and POIND. This method differs from the practices observed among top innovators, as discussed earlier in this study, which often involve predetermined priorities.

The prioritization approach in the MoD significantly deviates from that in the private sector, primarily due to inherent differences in strategic goals. While the private sector can leverage well-established financial metrics and prioritization methods, the MoD relies on an MCA as the main prioritization method. The parameters within the MCA of POIND and S&T described in sections 4.2 and 4.2 differ from each other but both show some similarities to the evaluation of the six-predictors of success for portfolio management identified in the literature [Cooper, 2017a]. The six predictors of success are alignment with the organization's strategy, product advantage, leverage core competencies, Market attractiveness, Technical feasibility, risk, and return [Cooper, 2017a].

The alignment with strategic objectives and the potential for product advantage is consistently emphasized throughout the innovation process. This alignment is evident in the criteria used for evaluating projects, which is true for both Science and Technology (S&T) and POIND assessments. When the parameters employed by POIND, such as CML, implementation, and project horizons are examined parallels can be drawn to market attractiveness, technological feasibility, risk assessment, and potential return on investment. Notably, the concept of leveraging core competencies and assessing potential return may not be explicitly mentioned in the process, but they can be interpreted within the MoD context as evaluating the project's urgency and relevance. These considerations are often evaluated by the members involved in the assessment, who assess whether the project aligns with the MoD's strategic directives, including roadmaps and other guiding documents.

This starts the discussion on tactical decision-making since the evaluation methodologies used in the portfolio reviews in the public sector rely on more normative data than private sector organizations. The process of portfolio reviews however seems to be in line with the literature since every organization is different and organizes differently. About its reviews, not much can be said about the specific organization of the reviews compared to the private sector. The responsibilities however that lie within the reviews do seem to be slightly different.

Departmental reviews typically serve as advisory steps in the funding review process, which is not fundamentally distinct from private sector practices. However, the key differentiation lies in the public sector's role as a primary R&D funder rather than a product developer. Consequently, project evaluations predominantly occur prior to funding allocation, differing from private sector approaches that involve pausing or deprioritizing ongoing projects [Cooper et al., 2000].

This is overcome within the MoD by splitting its projects up into seven distinct phases. Each new project phase serves as an opportunity to evolve into a *smart buyer* and *smart specifier* for subsequent projects, aligning with the overarching goal of enhancing efficiency and effectiveness.

The integrated approach involving portfolio reviews, gates, and innovation product roadmaps appears to be less pronounced within the observed context. Notably, gates can be identified within the product development stages, subdivided into seven distinct processes. However, the extent to which the progress, continuation, or termination of projects is deliberated during reviews remains uncertain, raising questions about the depth of senior management's insight in these instances. On the other hand in the current system projects are mainly started by the knowledge centers and innovation units which are responsible for processing the gained knowledge of previous projects, thereby this should ensure previous studies give insight into new project development projects.

5.2. HOW DOES IPM AT THE MOD DIFFER FROM IPM IN THE PUBLIC SECTOR LITERATURE?

This section is twofold, as it will discuss the disparities of MoD practice with the literature found on public sector portfolio management and discuss the relevance of these findings for the entire public sector.

The outcomes of chapter 4 show some similarities with public sector literature. First, the organizational structure of the MoD where strategic prioritization is done on a central as well as decentralized level is similar to the research of Peerenboom et al (1989) [Peerenboom et al., 1989]. Another similarity is that the MoD primarily funds projects but does not steer after funding is allocated. The difference is however that the paper of Peerenboom et al (1989) discusses a one-time funding moment whereas the MoD is continuous. Moreover, Peerenboom et al (1989) suggest prioritization and the use of performance curves where proposal plans are weighed against the costs to distill the projects with the lowest benefit-to-cost ratio for the central strategy [Peerenboom et al., 1989]. Other differences include the prioritization method based on expected utility against the uncertainty of projects [Peerenboom et al., 1989]. Peerenboom et al (1989) provide an example to display the MoD and its process [Peerenboom et al., 1989]. Appendix D expands on how Peerenboom et al (1989) as well as other practices found in the literature can support the MoD and its IPM model.

The parameters *urgency* and *relevance* found in the evaluation of the method show great similarity to previous papers found on military evaluation of projects [Linquiti, 2015]. This thesis gives insights into how these parameters are used in the evaluation process and which other parameters such as departmental and thematic balance play a role in the decision-making process. Other papers such as Chow et al (2012) and Vonartas and Hertzfeld (1989) show the normality for public parties to continually split projects in

project types as previously discussed[Chow et al., 2012, Vonortas and Hertzfeld, 1998]. Both papers differ in the sense that they are mainly focused on large equipment S&T within the military and NASA with budgets in the billion [Chow et al., 2012, Vonortas and Hertzfeld, 1 The IPM valuation method proposed by Chow et al. (2012) introduces the categorization of projects into "must-haves" and "desirables" based on their costs. On the other hand, Vonortas and Hertzfeld (1998) employ Net Present Value (NPV) as a metric to assess risk within the market. Both the models developed by Chow et al. (2012) and Vonortas and Herzfeld (1998) demonstrate that cost considerations can play a pivotal role in the decision-making process, especially in the context of larger equipment projects [Chow et al., 2012, Vonortas and Hertzfeld, 1998]. This differs from the evaluation methods found in the MoD where costs did not seem to play a significant role.

The papers discuss similarly to the results in this paper the inherent difficulties in the valuation of the benefit of a project which is in both papers done by experts trained in the field to make the right estimation, similar to S&T its final decision-making process. The model proposed by Chow et al (2012) revealed that at least for large projects, implementation costs should always be included as costs can rise significantly if project proposals continue without clear indications on future implementation costs [Chow et al., 2012]. Within this research, it was found that implementation costs were included in the MCA of POIND but not actively steered or used for valuations at later stages. This is also because the MoD does not necessitate the use of stage gates in its innovation process.

What, then, are the broader implications of the findings presented in this paper for the wider public sector, and how can these insights be extrapolated to benefit other public organizations? To begin, it is essential to recognize the unique context of the Ministry of Defence (MoD). The MoD operates within a highly technical domain and commands a substantial budget allocated for research and development (R&D) endeavors, setting it apart from most other public sectors. Furthermore, the Dutch MoD is compelled to engage in innovation efforts due to international commitments that secure an annual budget for R&D activities within the organization. The symbiotic relationship between the security sector and the MoD necessitates investments in its capabilities to reduce reliance on security provisions from partner nations. These distinctive attributes render the MoD a markedly distinct public entity compared to other governmental organizations.

Nonetheless, this study has contributed to an enhanced understanding of how Innovation Portfolio Management (IPM) can be effectively implemented within the public sector. It has demonstrated that the IPM framework proposed by Cooper (2017) offers a suitable structure for delineating the various stages of the IPM process within a public sector context. Moreover, the inclusion of parameters such as *urgency* and *relevance* along with the multi-criteria analysis (MCA) method, provides valuable tools for assessing project proposals in the public sector. Urgency and relevance align with the notions of *value* and *legitimacy and support* as articulated by Moore in the context of project proposals within the MoD [Moore, 2013]. It is important to note that other public entities may require additional or different parameters, depending on their specific objectives.

For instance, parameters related to reducing travel time in public transport or assessing healthcare benefits might be relevant for other public sectors. Therefore, to comprehensively grasp the dynamics of IPM across the entire public sector, further investigations into various public entities are warranted.

5.3. CONTRIBUTION AND IMPLICATIONS OF THE RESEARCH

This research significantly contributes to the nuanced understanding of the applicability and relevance of innovation portfolio management (IPM) in diverse public organizations. It offers insights into the current IPM practices within the Dutch Ministry of Defence (MoD) while providing valuable lessons on structuring portfolio management in the face of strategic complexities. Additionally, the research illuminates the quantification of subjective parameters, such as relevance and urgency, within the public sector, through the effective utilization of Multi-Criteria Analysis (MCA).

Moreover, the research reveals the application of thematic "buckets" for knowledge sharing, the use of strategic roadmaps as guidance for R&D project proposals, and balancing done within the public sector. These findings offer valuable insights into tailoring and optimizing IPM for diverse public organizations with unique challenges and priorities. The added literature found both within the public, as well as private sector, add to this study for public sector development in innovation portfolio management.

Furthermore, the research highlights the intricate dynamics of technology push and capability pull within public organizations, exemplified by the MoD. The MoD's reliance on market expertise for product development, coupled with limited in-house technology development, necessitates alignment with the market's technology push. This dynamic becomes a defining characteristic of the MoD's innovation landscape.

The study underscores the substantial impact of political dynamics and evolving operational cultures on the investment culture of public organizations. Shifting from years of budget cuts to managing an abundance of budget relative to projects and personnel, the MoD's need for prioritization has got a new character.

Within the broader public sector context, the study addresses the growing trend of open innovation practices involving collaboration with private entities. It serves as a valuable resource for elucidating methodologies to navigate project and program organization and prioritization within this domain. Particularly noteworthy is the observed disparity in the MoD's involvement in projects with varying Technology Readiness Levels (TRLs), emphasizing an escalation in participation as TRLs increase.

Lastly, the study identifies the practical implementation of the IPM framework within the MoD, particularly emphasizing the role of portfolio reviews and strategic product roadmaps in shaping strategic prioritization strategies.

5.3.1. COMPARISON WITH OTHER STUDIES

Until now, there has been limited research on the utilization of innovation portfolio management (IPM) within the public sector, although some existing literature exhibits a strong connection to this study. In chapter three of Linquiti's book, several papers and research findings pertaining to portfolio management within the public sector are discussed. The book places particular emphasis on valuation methods that could be adapted for public sector applications. The paper discussed, for example, Vonortas and Herzfeld's paper (1998) which highlights the use of financial tools by NASA in collaboration with private entities. Additionally, other papers such as those by Chow et al (2012) and Peerenboom et al (1989) provide examples of valuation methods applied in the military and energy context, respectively, to assess projects within programs[**?**, Chow et al., 2012, Peerenboom et al., 1989]. However, none of the papers found delve into the strategic aspects of portfolio management, including the prioritization of programs, roadmaps, or strategic visions, as elaborated by Cooper [Cooper et al., 2000, Cooper, 2017b].

Furthermore, Linquiti's book offers valuable insights into the intricacies of risk management within the public sector, advocating for policymakers to address risk factors at macro, meso, and micro levels[Linquiti, 2015]. It predominantly focuses on large-scale projects and lacks coverage of recent developments in short-cycle innovations with close collaboration with the industry.

Peerenboom et al.'s work (1989) provides a more practical perspective on how IPM can be implemented in an energy program, offering tangible insights into the application of portfolio management within the public sector, although it remains centered on a single program[Peerenboom et al., 1989].

Lastly, numerous papers in the private sector underscore the significance of innovation portfolio management, while also emphasizing the need for practical examples of its application [Kester et al., 2014, Meifort, 2016]. This research endeavors to provide a comprehensive description of the Dutch MoD's IPM system, highlighting its relevance and distinctiveness compared to existing literature. Notably, this includes disparities in prioritization, the use of gates, roadmaps, portfolio reviews, and the formulation of product development strategies.

5.3.2. LIMITATION OF THE RESEARCH

In addressing the research's validity, several salient points warrant consideration. It is essential to acknowledge the inherent limitations within any study, as this elucidates the specific conditions under which the research findings should be interpreted.

The foremost limitation pertains to the research sample. The investigation illuminated disparities between public and private innovation portfolio management through a comprehensive case study conducted within the Ministry of Defense (MoD). However, it is pivotal to underscore the challenge of extrapolating the case study's conclusions to other public organizations. This challenge arises due to the MoD's distinctive strategic landscape, setting it apart from its counterparts in the public sector.

To attain a more robust understanding of IPM in the public sector, the inclusion of research encompassing diverse public organizations would have been instrumental yet time would not allow such a research.

Secondly, this research only helped to give an understanding of the use of an IPM framework within the public sector, it did not provide insights into the success of its innovation endeavors. It would be interesting to test the MoD its effectiveness in its innovation endeavours. In the private sector, this is often done by comparison of the profit that has been made with new products compared to the spending into it R&D. For the MoD success and successful projects have different definitions. Research into the definition of a successful project within the public sector could potentially help public sectors evaluate their own IPM process.

A final limitation pertains to the temporal dimension of this research endeavor. The MoD has been undergoing a transitional phase in its innovation initiatives, with its various departments navigating the establishment of their respective innovation networks, as evidenced in the case descriptions and results. Moreover, the recent surge in public interest and augmented public spending allocated to the MoD has introduced an additional layer of complexity. This surge may potentially skew the perception of the MoD's portfolio management, as it grapples with the challenge of spending the allocated money, reducing the urge for project prioritization strategies.

5.3.3. FUTURE RESEARCH OPPORTUNITIES

Exploring future research opportunities in the realm of innovation portfolio management reveals several promising avenues for investigation. Firstly, there is a need to delve into the adaptability of IPM across various public sectors, aiming to uncover key distinctions and potentially formulate a specialized framework tailored specifically for public domain utilization.

Furthermore, it is essential to address the issue of prioritization within innovation strategies, particularly within the intricate system dynamics of the MoD and its strategic partners. New research could help increase the understanding of effective strategies for strategic prioritization in complex public sector environments. Specifically, different valuation methods within the MoD could be considered for future research.

Another avenue of research could focus on evaluating the efficacy of an IPM structure within the context of public organizations, particularly drawing comparisons with the private sector's proven success in terms of product launches and profitability. This research may extend its focus to assess the achievements of public sector product launches in terms of social value, rather than purely financial gains. As the previous section described definitions of project success, portfolio sufficiency, and resource adequacy are now vague and could be made more explicit with new research. A first attempt to make project success more explicit is provided in appendix D.

Lastly, the research could investigate how public organizations navigate situations characterized by government spending surpluses. In such contexts, where resource scarcity is reduced, understanding optimal strategies for decision-making and prioritization becomes paramount.

These future research directions offer opportunities to further enhance our understanding of IPM's role and effectiveness in diverse public sector contexts, potentially leading to the development of tailored frameworks and strategies that can drive innovation and societal benefit.

5.3.4. RECOMMENDATIONS

This study has elucidated critical insights into IPM practices within the context of the Dutch Ministry of Defence (MoD) and offers several recommendations aimed at enhancing the effectiveness of IPM within the MoD. While these recommendations are intended to inform and guide, they are framed within the academic context rather than a consultancy perspective to maintain a rigorous research-oriented approach. The recommendations specific to the organization its structure and current practice are further elaborated on in appendix D.

STRATEGIC PRIORITIZATION WITHIN IPM

One of the fundamental recommendations for the MoD is to delve deeper into the key aspects of the IPM framework, specifically in terms of prioritization within innovation strategies. The MoD should consider creating a more structured approach to prioritizing strategies, ensuring clarity regarding which strategies should be adopted by departments and how these strategies should be implemented. This approach can foster a more systematic and coherent alignment of projects with overarching strategic goals, preventing the need for ad-hoc evaluations on a case-by-case basis.

STANDARDIZATION OF IPM PROCESS

The existing IPM process exhibits a pronounced dependency on individual departments, with each department adhering to its unique set of procedures and protocols. While departmental autonomy is essential for aligning with specific strategic priorities, the adoption of a standardized IPM framework, as articulated by Peerenboom et al. (1989) and Archer and Ghasemzadeh (1999), has the potential to enhance our comprehension of the overall IPM decision-making process[Peerenboom et al., 1989, Archer and Ghasemzadeh, 1999]. Such standardization holds the promise of augmenting IPM effectiveness by facilitating a more cohesive and integrated approach to portfolio management across the organization [Archer and Ghasemzadeh, 1999, Peerenboom et al., 1989]. More insights into how this could be done are described in Appendix D.

STANDARDIZATION OF NOMENCLATURE

Similar to the recommendation above, within the innovation domain of the MoD, there exists a proliferation of strategies and nomenclature. To enhance clarity and communication, the MoD should strive to establish a more common and standardized language for innovation-related terminology. This standardization can facilitate smoother collaboration and knowledge sharing among different departments and stakeholders.

INTEGRATION OF GATES

The MoD should explore the applicability of milestone or gate systems within project development. While projects are already divided into distinct phases, the incorporation of stage gates can further catalyze innovation by involving relevant stakeholders at critical milestones. For example, as projects near completion, the involvement of "assortment managers" can facilitate smoother transitions toward implementation [Cooper, 2008]. The strategic utilization of gate systems can help streamline project progress and decision-making.

EVALUATION OF BUDGET ALLOCATION METHODS

The MoD should conduct in-depth research to evaluate the effectiveness of different budget allocation methods. Particularly when project owners seek budget allocations, understanding the basis on which various budget holders evaluate projects is crucial. This research can help identify the most effective valuation methods that result in optimal project outcomes. Furthermore, the MoD should emphasize the exploration and implementation of financial metrics wherever feasible to assess project value. The works of Chow et al (2012) and Linquitti (2015) offer valuable insights into applicable valuation methods within both military and public sector contexts[Chow et al., 2012, Linquiti, 2015]. Additionally, the MoD should further develop the use of its MCA as a decision-making tool, where algorithmic calculations to provide the best set of projects to different prioritization strategies can increase deliberate decision-making. Again, appendix D provides more insight into the evaluation of the MoD its current methods and potential use for future methods.

TACTICAL PORTFOLIO MANAGEMENT METRICS

The innovation units or knowledge networks within the MoD, responsible for tactical portfolio management, should consider introducing metrics to measure *portfolio sufficiency* and *resource adequacy*. The lack of quantitative metrics for these aspects can hinder effective decision-making [Cooper, 2017b]. Additionally, the MoD should explore ways to shift from a primarily request-based approach to project submissions to a more proactive scouting strategy. This shift can enhance portfolio management by identifying promising projects and technologies in the market. Moreover, once prioritization within innovation strategies is made more explicit regarding resource and budget allocation the MoD is able to steer its human resources towards these priorities[Meskendahl, 2010, Cooper, 2017a].

To prioritize within the MoD is crucial to first understand the current division of its resources. Therefore it is recommended that the MoD does an in-depth analysis of its own KD, TD, and KCI projects as well as long-term acquisition projects such as the submarines to understand the current division of resources in new technologies, thematic buckets, and horizons. To understand where you want to steer to it is important to first understand the current division status [Cooper et al., 2000, Cooper, 2017b, Viki et al., 2018].

In conclusion, these recommendations provide a research-oriented roadmap for the MoD to further enhance its IPM practices. By addressing these areas, the MoD can refine its approach to innovation portfolio management, align projects with strategic objectives, and ensure efficient resource allocation, ultimately fostering a culture of innovation and strategic decision-making. These recommendations aim to contribute to ongoing efforts to optimize IPM within public organizations like the MoD while maintaining a rigorous academic perspective.

6

CONCLUSION

The study its title "Security with New Products" is a reference to one of the most cited books in this research by Robert G. Cooper called "Winning at New Products"[Cooper, 2017b]. Winning in the public context is something different than within private businesses. The study revealed how current innovation portfolio management is performed within the Dutch Ministry of Defense and makes comparisons to literature found in the private as well as in the public sector.

The main research question *How does innovation portfolio management in the public sector, as exemplified by a case study within the Ministry of Defense, differ from private sector innovation portfolio management literature?* was discussed through the use of the IPM framework provided by Cooper (2017)[Cooper, 2017b]. Sub-questions one, two, and three discuss how IPM is performed at the MoD by specifically discussing the MoD its strategy, strategic decision-making, and tactical decision-making. The study showed how the IPM framework by Cooper (2017) is present within the MoD albeit with serious differences in how it is performed compared to private sector literature standards. The MoD its IPM framework showed that the MoD's innovation strategy is split up within its departments and that the departments as well as the centralized body of the MoD rely on continually changing political guidance, changing threat levels, and the fast-changing roles of key decision-makers.

In the realm of strategic decision-making, the MoD has demonstrated several distinctive characteristics. Firstly, the allocation of its resources does not adhere to specific thematic buckets; instead, it places substantial reliance on strategic product roadmaps to guide its innovation endeavors. Secondly, the inherent nature of the MoD necessitates a diversified approach to innovation, reflecting its multifaceted mission. Lastly, the MoD's risk profile is intricately linked to the funding it receives from the central government, a factor that diverges significantly from the dynamics found in private sector literature.

Furthermore, prioritization performed within the MoD relies on subjective metrics and projects, and the portfolio is ranked and balanced based on senior management their assessment of metrics such as *relevance* and *urgency*, as well as the *right* division between departments. These metrics are rooted in the assessments conducted by decision-makers within the MoD. These assessments draw upon the insights presented in strategic documents generated within the organization. Furthermore, projects undergo a scaling process through a multi-criteria Analysis (MCA) that considers these metrics, along with minimal project requirements. Notably, the MCA framework is adapted to accommodate projects at varying stages, distinguishing between lower Technology Readiness Level (TRL) and higher TRL projects.

In the context of tactical decision-making explored in this thesis, it becomes evident that public sector organizations often do not serve as the primary developers of their technologies. Consequently, they are compelled to procure these technologies before engaging in experimentation. The approach employed by the MoD, which is also common in the broader public sector, involves segmenting project development into discrete stages for each new procurement cycle. An interesting observation is that public organizations tend to place their trust in the market for technology development. Their innovation strategy is formulated with a strong reliance on the innovative capacities of the market, underscoring the significance of technology push driven by market-based R&D development. Furthermore, the MoD does not utilize stage gates in its present project proposals but segments projects as described above.

These practices described give insights into sq four and five on the differences between public and private sector literature. As a general note the literature on (innovation) portfolio management within the public sector was found to be much less developed therefore this research adds to a potentially valuable and growing literature for enhancing the public sector its innovation efforts. Compared to the public sector the MoD showed a few significant differences to available literature among which the biggest might be the sheer size of its innovation budget as well as its difference in products it is required to innovate in. The study revealed what was already signified in literature for the private sector that IPM cannot be studied by only looking at single criteria of success within a project or program but should be studied from the entire organization its perspective.

7

REFLECTION

7.1. METHODOLOGY AND RESULTS:

As described in the methods section the study was split into two sections. The reason for this was that the first research-study set-up was focused on finding the six success factors for portfolio management and which criteria within the literature were found back in project and program management decision-making. During these interviews, it was found that conversation steered towards project management criteria within decision-making and did not match some of the literature found on portfolio management.

As mentioned in chapter 3 the research methodology chosen gave a poor understanding of the research question. Although it would be interesting to see what parameters play a key role in successful portfolio management it is necessary to first understand how *effective* or *successful* can be defined with regards to portfolio management in the public sector. Additionally, the first set-up did not work from a specific framework which is essential in case-study research as described by [Yin, 2015]. Even though the first research lacked specificity it provided useful insights into how project evaluation and portfolio reviews were performed within the MoD. Further reading and a deeper understanding of the topic of IPM found that to really understand portfolio management practices one should not merely focus on project and program management but look at all facets of IPM including executive level and strategic decision-making, since portfolio management is in its nature a strategic decision-making process by senior management.

The second part of the research helped to create a much deeper understanding of decision-making from a portfolio management perspective. For future studies into the IPM process, one should always consider portfolio management from a strategic perspective and not aim to merely find criteria to rate. Since this study was only done for the MoD, the applicability to the rest of the public sector can be debatable. The reason however was also explained in the research setup and results since the MoD was seen as one of the larger innovators in the public sector. During primary interviews and talks

within the team of FRONT where I did my study, I got a first understanding of the magnitude of the innovation network of the MoD which made the decision to only take the MoD as a case for this study to ensure rigidity of the results. Understanding the decision-making process within the MoD was one of the hardest things to get an understanding of and crucial for the holistic case study description on innovation portfolio management.

For future studies, I hope this study helps to give direction to ensure that other departments can be studied in a quicker fashion. New studies can then improve the overall understanding of innovation portfolio management in the entire public sector. Furthermore, it should be noted that this study exclusively employed the Dutch Ministry of Defence as a case example. Literature exploration revealed that portfolio management thinking has been in existence in the United States for an extended period [Axelos, 2011, Project Management Institute, , Chow et al., 2012, Linquiti, 2015]. Thus, an intriguing avenue for future research lies in investigating how ministries in various countries execute their innovation portfolio management. This could offer invaluable insights into IPM within the broader public sector.

Considering the ongoing dynamic transformation within the MoD and its unwavering commitment to enhancing portfolio management practices, it would be intriguing to revisit a similar study in the span of three to five years. Such an undertaking could serve as a valuable means to assess the evolution of the MoD's practices, shedding light on whether specific strategic focal points have garnered heightened attention or if the strategic landscape continues to exhibit its characteristic breadth and complexity. Notably, the current study has already provided valuable insights into the MoD's IPM process and its distinctive features, thus making the prospect of a future study considerably more streamlined. Furthermore, the MoD's recent embrace of portfolio management as a standard practice, commencing in 2023, suggests that the structural aspects of how the MoD conducts portfolio management may become even more refined in the wake of this research.

Conversations with key stakeholders within the MoD instill confidence that they will continually seek opportunities for improvement, making it all the more compelling to observe what conclusions and findings persist, and how the MoD's capacity to prioritize strategic areas may evolve over time.

7.2. PERSONAL:

During my previous engagement with the Ministry of Defense, particularly within one of their army innovation teams, I observed a disconnect between some of the innovation and decision-making theories I had been taught during my Master's program in Management of Technology at TU Delft. Of particular concern was the allocation of time, effort, and resources to projects and programs, which at times appeared inconsistent or inadequately deliberated.

This observation prompted an inquiry into the existing decision-making tools and the potential avenues for establishing and enhancing consistent decision-making practices. Literature addressing innovation portfolio management (IPM) as a means to optimize decision-making on an entire portfolio of projects was identified, although its application in the public sector, was scarcely explored.

This research has taught me a lot about research, portfolio management, and personal time management. This thesis will be finished in a period of eight months, where my thesis was not continuously the main focus for a 40-hour work week. The study of portfolio management also gave insight into my own priorities. I could have the right criteria to perform a thesis study, with the right guidance, and theory in place but if I did not put in the required time I found that progress on my thesis stagnated and I was continuously doing a bit of everything without excelling in any one of the things I was doing.

Another analogy for me is on balance we all know from our lives considering for example social lives, sports, and diets, you need to balance: time, money, and attention; technique, fitness, and tactics; fruits, vegetables, carbs, protein, and other nutrients; Depending on your social live, sport or diet goals your balance will be different and your balance in one can influence the others. Those who deliberately plan to achieve a goal and seek a balance in their lives will most likely be more successful in their endeavors. Without taking this analogy any further organizations have similar opportunities to plan for success. Maybe not the best analogy for my thesis but it is a valuable insight into life.

Regarding my research, I found that reading up on the theory of a bit of everything did not give you a valuable source. It is not that I did not learn this during my previous studies but during thesis writing one can truly find out how you can lost in theory. Moreover, it became apparent how books by the most cited and sourced people in the field can improve an understanding of a topic significantly. For my research, the process of writing my thesis was one of continuously learning and improving an understanding of a topic, and interviews with experts in the field can be of extremely valuable source for understanding the entire topic. One of the portfolio experts interviewed for this thesis described portfolio thinking not as a method but as a way of thinking that should be engraved in every process.

In the acknowledgments, I will go into more depth on this but I would like to thank everyone who helped me during my thesis, the people I interviewed the people who helped me think about a good research setup, and the people that supported me at home. During the past three years of my study, I was ill and injured for quite a long period. Friends, family, and colleagues have helped me finish my thesis and I'm grateful for it. Lastly, in the last few months, I attempted to do all the things I wanted to do during the entire three years, which I couldn't do in those years due to the previously mentioned reasons. This challenge for me was a beautiful experience on how to manage or (not) manage your life.

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ACRONYMS

CD and E Concept Development and Experimentation. 35, 37, 39

FRONT Future Relevant Operations with Next generation Technology and thinking. 37

KCI Kort-cyclische innovatie. 24, 35

KD Knowledge Development. 35, 39

S and T Science and Technology. 24, 37

TD Technology Development. 35, 39

GLOSSARY

Research and Technology in the Defense context Research and Technology is defined as 'Basic research, applied research and technology demonstration for Defense purposes. It is a subset of R&D expenditure' and R&D is subsequently defined as 'Any R&D programs up to the point where expenditure for equipment production starts to be incurred.[European Defense Agency, 2023]'. 34

Technology readiness level Technology readiness level refers to the maturity of a technology. There are 9 TRL levels where TRL 1-3 refers to discovery phase of a technology, TRL 4 to 6 refers to development phase, TRL 7 and 8 to the demonstration phase and trl 9 the deployment phase of a technology.[Rijksoverheid, 2023]'. 17

A

APPENDIX A

Delft University of Technology

HUMAN RESEARCH ETHICS

INFORMED CONSENT

By

Samuel Mouton

U wordt uitgenodigd om deel te nemen aan een onderzoek genaamd Innovatie portfolio management at the MoD. Dit onderzoek wordt uitgevoerd door Samuel Mouton van de TU Delft in samenwerking met FRONT van het Ministerie van Defensie. Het doel van dit onderzoek is om een beeld te krijgen hoe portfolio management is ingericht in een publieke organisatie. Daarbij is er een focus op clustering van projecten en wordt er onderzocht wat de redenen zijn om een project te starten, door te gaan en te stoppen en hoe projecten worden gelinkt in een groter balans van projecten. Het interview zal ongeveer 90 minuten in beslag nemen. De data zal gebruikt worden voor wetenschappelijk onderzoek voor het afstudeerproject van Samuel Mouton en zal verder gebruikt worden door FRONT om de organisatie een beter beeld te geven hoe momenteel projecten worden beoordeeld binnen een groep van projecten. Deze kennis kan wetenschappelijk bijdrage aan een betere kennis hoe overheidsinstanties innoveren en hoe het MvD beter inzicht kan krijgen in haar innovatietrajecten en projecten kan bevorderen en

A

sneller richting implementatie kan gaan. U wordt gevraagd om waar mogelijk zo open en eerlijk mogelijk antwoord te geven op de vragen en bent vrij om binnen de vragen af te wijken naar voorbeelden en belangrijke anekdotes met betrekking tot het project dat besproken wordt. Zoals bij elke online activiteit is het risico van een databreuk aanwezig. Wij doen ons best om uw antwoorden vertrouwelijk te houden. We minimaliseren de risico's door geen namen online te verwerken, persoonlijke gegevens te anonimiseren en ook zorgvuldig om te gaan met mogelijke impliciete verwijzingen. Mocht er aanleiding zijn om directe quotes te gebruiken dan zal hier contact over opgenomen worden. Alle verzamelde data m.b.t. audio opnames wordt enkel tijdens het onderzoek opgeslagen en zal direct na het afronden van het onderzoek verwijderd worden. Verder zal de data enkel gebruikt worden voor wetenschappelijke doeleinden en enkel gebruikt worden door de onderzoeker. Uw deelname aan dit onderzoek is volledig vrijwillig, en u kunt zich elk moment terugtrekken zonder reden op te geven. U bent vrij om vragen niet te beantwoorden.

Samuel Mouton Master student - Management of Technology Technische universiteit Delft

PLEASE TICK THE APPROPRIATE BOXES	Yes
A: GENERAL AGREEMENT – RESEARCH GOALS, PARTICPANT TASKS AND VOLUNTARY PARTICIPATION	
1. Ik heb de informatie over het onderzoek gedateerd [*DD/MM/YYYY*] gelezen en begrepen, of deze is aan mij voorgelezen. Ik heb de mogelijkheid gehad om vragen te stellen over het onderzoek en mijn vragen zijn naar tevredenheid beantwoord.	☐
2. Ik doe vrijwillig mee aan dit onderzoek, en ik begrijp dat ik kan weigeren vragen te beantwoorden en mij op elk moment kan terugtrekken uit de studie, zonder een reden op te hoeven geven.	☐
3. Ik begrijp dat mijn deelname aan het onderzoek de volgende punten betekent [zie punten hieronder]	☐
- *Informatie gedeeld word geanonimiseerd* - *De informatie wordt gebruikt voor een wetenschappelijk onderzoek aan de tu delft* - *Alle informatie wordt dubbel gecheckt op mogelijke gevoelige informatie, dit zal verwijderd worden indien nodig.* - *Mocht er onduidelijkheden zijn zal de onderzoeker contact met u opnemen en andersom is er altijd mogelijkheid met de onderzoeker contact op te nemen.*	
4. Ik begrijp dat de studie maximaal tot December doorloopt.	
B: POTENTIAL RISKS OF PARTICIPATING (INCLUDING DATA PROTECTION)	
5. Ik begrijp dat de volgende stappen worden ondernomen om het risico van een databreuk te minimaliseren, en dat mijn identiteit op de volgende manieren wordt beschermd in het geval van een databreuk	☐
- *Er worden geen namen gebanden aan het onderzoek.* - *Er wordt ten alle tijden rekening gehouden met persoonlijke gegevens en privacy en geen gevoelige informatie zal gedeeld worden binnen dan wel buiten dit onderzoek.* - *Het onderzoek is wetenschappelijk en daarmee onafhankelijk en informatie dat gedeeld wordt met de data verzamelaar zal te allen tijde met respect en integer omgaan met de gedeelde informatie*	
6. Ik begrijp dat de persoonlijke data die over mij verzameld wordt, vernietigd wordt op December 2023. Persoonlijke data wordt via een data management plan veilig onderhouden, u kunt te allen tijde aanspraak maken op uw eigen data uit het data management plan.	☐
C: RESEARCH PUBLICATION, DISSEMINATION AND APPLICATION	
7. Ik begrijp dat na het onderzoek de geanonimiseerde informatie gebruikt zal worden voor het scriptie onderzoek met betrekking tot Innovatie portfolio management bij het ministerie van Defensie. Deze zullen verwerkt worden in een scriptie publicatie van Sam Mouton.	☐

A

Signatures

Naam deelnemer	Handtekening	Datum

Ik, **de wettelijke vertegenwoordiger**, verklaar dat de informatie en het instemmingsformulier aan de potentiële deelnemer correct zijn voorgelezen, en dat hij/zij de kans heeft gekregen om vragen te stellen. Ik verklaar dat de potentiële deelnemer zijn/haar instemming vrijwillig heeft gegeven.

Naam wettelijke vertegenwoordiger	Handtekening	Datum

Ik, **de onderzoeker**, verklaar dat ik de informatie en het instemmingsformulier correct aan de potentiële deelnemer heb voorgelezen en, naar het beste van mijn vermogen, heb verzekerd dat de deelnemer begrijpt waar hij/zij vrijwillig mee instemt.

Sam Mouton 

Naam onderzoeker	Handtekening	Datum

Contactgegevens van de onderzoeker voor verdere informatie: [Naam, telefoonnummer, emailadres]

B

APPENDIX B

Research 1, which was set-up to find out how portfolio making was included in the decision-making within projects and programs.

SCRIPTIE INTERVIEW VRAGENLIJST

Eerst volgt een korte uitleg over de scriptie, gevolgd door een vragenlijst. De vragenlijst wordt zo veel mogelijk aangehouden, maar kan worden aangepast op basis van de antwoorden van de respondenten.

ROL EN VERANTWOORDELIJKHEDEN

- Wat is uw rol binnen XXXX (afdeling) en wat was uw rol binnen project X?
- Welke andere projecten was u verantwoordelijk voor tijdens dit project?
- Was u vanaf het begin betrokken bij het project?

KENMERKEN VAN HET PROJECT

- Wanneer is het project gestart?
- Wie was bij het project betrokken?
- Hoelang duurde het project?
- Kunt u het proces van de projectontwikkeling omschrijven?
- Maakte het project deel uit van een cluster projecten?
- Wat waren de kenmerken van dit cluster?

B

PROJECT TRACING

- Wanneer werden er beslissingen genomen over de voortzetting van het project? Werden er regelmatig bijeenkomsten gehouden om de voortgang van het project te bespreken?

- Welke specifieke onderwerpen of aspecten werden doorgaans besproken tijdens deze projectbijeenkomsten?

- Wie waren de belangrijkste personen die betrokken waren bij de besluitvormingsmomenten gedurende het project? Wie namen deel aan deze bijeenkomsten?

- Wat waren de rollen en verantwoordelijkheden van elke persoon die betrokken was bij de besluitvormingsmomenten?

- Met welke factoren of overwegingen werd rekening gehouden tijdens deze besluitvormingsmomenten gedurende het project?

- Kunt u mij een tijdlijn geven waarop de betrokken personen op verschillende momenten staan vermeld? Kunt u daarnaast hun betrokkenheid tijdens specifieke besluitvormingsmomenten specificeren?

- Zijn er aanvullende besluitvormingsmomenten of belangrijke mijlpalen in het project die moeten worden opgenomen in de tijdlijn?

- Zijn er uitdagingen of obstakels tijdens het besluitvormingsproces?

- Hoe werd er omgegaan met conflicterende standpunten of meningsverschillen tijdens de besluitvormingsmomenten?

- Waren er externe factoren of invloeden die het besluitvormingsproces hebben beïnvloed?

- Hoe werden projectrisico's en onzekerheden overwogen en gemanaged tijdens de besluitvormingsmomenten?

- Zijn er wijzigingen of aanpassingen aangebracht in het projectplan of de strategie op basis van de uitkomsten van de besluitvormingsmomenten?

- Hoe werd het besluit gecommuniceerd naar het projectteam en andere relevante belanghebbenden?

- Wat waren de uitkomsten of resultaten van de beslismomenten en hoe hebben deze het verloop van het project beïnvloed?

- Zijn er, achteraf gezien, beslissingen of acties tijdens het project die je anders zou hebben gedaan?

- Hoe heeft het besluitvormingsproces bijgedragen aan het algehele succes of de uitdagingen waar het project voor stond?

Beslissingskenmerken met betrekking tot Clusters

- Speelden andere projecten (binnen het cluster) een rol in de beslissing om een project wel of niet te starten?
- Met welke factoren wordt rekening gehouden bij het plaatsen van een project binnen een cluster?
- Zijn er specifieke criteria of richtlijnen die bepalen welke projecten in een bepaald cluster worden opgenomen?
- Hoe beïnvloedt de strategische afstemming van een project zijn plaatsing binnen een bepaald cluster?
- Zijn er specifieke doelen of doelstellingen die het cluster nastreeft en hoe draagt een project bij aan deze doelen?
- Welke rol speelt de innovatieve impact van een project (optimalisatie, innovatie, transformatie) bij de plaatsing binnen een cluster?
- Wordt de haalbaarheid of waarschijnlijkheid van succes van een project overwogen voordat het in een cluster wordt opgenomen?
- Hoe wordt rekening gehouden met de potentiële impact van een project op verschillende componenten of aspecten bij het bepalen van de plaatsing ervan binnen een cluster? (bijv. multi-inzetbaarheid, modulariteit)

Kenmerken van de Besluitvorming

- Speelde andere projecten (binnen het cluster) een rol bij het besluit om een project wel of niet te starten?
- Welke redenen worden er gebruikt om een project te starten en in een bepaald cluster te zetten?
- Wie zijn er betrokken bij het besluit om een project te starten en in een cluster te zetten?
- Is er tijdens het project nog een evaluatiemoment om door te gaan met het project, welke dingen worden hier dan in overweging genomen?
- Wie is er bij een dergelijke evaluatie betrokken en wat zijn de overwegingen die hierin worden meegenomen? (bijv. of het in het cluster past, of de doelen van het cluster behaald, zijn er nog andere overwegingen?)

Project/Cluster Specifieke Kenmerken

- Het cluster gaat steeds over X (kennisdeling), zijn er ook andere dingen die in overweging worden genomen wanneer een project in een cluster wordt opgenomen?
- Worden karakteristieken van een project zoals de innovatieve impact (optimalisatie, vernieuwing, transformatie) meegenomen wanneer een project in een cluster wordt gestopt?

- Wordt de kans van slagen van een project overwogen voordat het in een cluster wordt gestopt?
- Wordt de impact van een project op verschillende onderdelen meegenomen wanneer een project wordt gestart? (de multi-inzetbaarheid/modulariteit)
- Wordt de impact op andere technologieën en producten meegenomen wanneer een project wordt gestart?
- Op welke manier wordt gekeken naar de strategie voordat een project wordt gestart? Strategie/doel van een cluster maar ook hoe een project impact kan hebben op de gehele strategie van departement XXX. Wat zijn de meest belangrijke strategische factoren voor een project/cluster?
- Als een van deze factoren terugkomt wanneer komt dat dan terug, hoe komt het terug in de besluitvorming van een project en door wie worden die factoren aangedragen om mee te nemen?
- Hoe wordt geprobeerd balans te creëren in de projectclusters?
- Wordt er bij het plaatsen van een project in een cluster rekening gehouden met de mogelijke gevolgen voor andere technologieën en producten?
- Hoe beïnvloedt de algemene strategie van de afdeling of organisatie de beslissing om een project in een specifiek cluster op te nemen?
- Welke belangrijke strategische factoren worden overwogen bij het plaatsen van een project binnen een cluster?
- Hoe worden deze strategische factoren geïntegreerd in het besluitvormingsproces en wie levert input voor de integratie ervan?
- Zijn er specifieke uitdagingen of overwegingen met betrekking tot het plaatsen van projecten binnen een cluster waarmee rekening moet worden gehouden tijdens het besluitvormingsproces?
- Hoe worden de beslissingen over het plaatsen van projecten binnen een cluster gecommuniceerd met relevante belanghebbenden?
- Wie is betrokken bij de beslissing om een project in een bepaald cluster te plaatsen?
- Zijn er evaluaties om te heroverwegen of een project nog steeds past bij de strategische doelen van het cluster? Wie is betrokken bij een dergelijke evaluatie?
- Zijn er achteraf lessen geleerd of inzichten opgedaan uit het besluitvormingsproces voor het plaatsen van projecten binnen een cluster?
- Hoe draagt het clusteringproces bij aan het algehele succes of de uitdagingen waarmee de projecten binnen het cluster worden geconfronteerd?

Cluster Specifiek

- Hoe wordt balans gecreëerd tussen projecten in een cluster? Worden hier specifieke factoren in meegenomen?

- Is er een strategie voor een bepaalde balans tussen projecten?

Laatste Opmerking

- Mag ik nog een keer contact met u opnemen als er dingen opkomen die toch niet volledig zijn behandeld in dit gesprek?

C

APPENDIX C

Interview guide for research 2.

SCRIPTIE INTERVIEW VRAGENLIJST

Vooraf wordt het IPM framework uitgelegd en is er ruimte voor vragen m.b.t. termen als roadmaps, portfolio reviews, buckets en gates.

ROL EN VERANTWOORDELIJKHEDEN

- Wat is uw rol binnen XXXX (afdeling) en wat is uw rol m.b.t. portfolio management?
- In hoeverre bent u betrokken bij het maken van strategie voor portfolio management?
- Hoelang bent u hier al bij betrokken?

SPECIFIEK VOOR IPM

- Kunt u mij wat meer vertellen over uw afdeling?
- Wat kunt u mij vertellen over portfolio management binnen het MvD?
- Welke strategie of welke beleidsstukken worden er binnen uw departement gebruikt om van strategie naar uitvoering van projecten te gaan?
- Wordt er gebruik gemaakt van roadmaps of iets soortgelijks?
- Waar in het proces van kennisontwikkeling, technologieontwikkeling en Kortcyclische innovatie vinden besluiten plaats waar de strategie en portfoliodenken in wordt meegenomen?
- Wie zijn er bij deze besluiten betrokken?

- Hoe wordt er geprioriteerd tussen verschillende projecten, roadmaps, programma's en portfolios?
- Op welke manieren verdeelt uw departement haar mensen, middelen en geld op projecten? Op welke manieren verdeelt het MvD haar middelen via buckets?
- Zijn er nog andere vormen van buckets die u herkent na het zien van het IPM framework?

LAATSTE OPMERKING

- Heeft u nog aanbevelingen voor mijn studie?
- Mag ik nog een keer contact met u opnemen als er dingen opkomen die toch niet volledig zijn behandeld in dit gesprek?

D

APPENDIX D

Figures D.1 and D.2 give an indication how the MoD could organize for its IPM. Within figure D.1 the bleu signs show where the MoD currently differs from private sector literature or where currently an obstacle is identified for the MoD its IPM process.

Figure D.2 is inspired by the paper by Peerenboom et al (1989) which gives a good insight into how portfolio management can be put in place. The paper discussed the intrinsic difficulty for a private sector to invest in the variety of objectives in different technical areas, the uncertainties on research requirements, data, and costs, the organization its divided decision and knowledge levels as well as the vast amount of funding strategies depending on a great group of studies all impacting the portfolio decision-making process.

The paper suggests that a decision-analysis procedure provides clear insights into research trade-offs, and creates recommendations based on well-documented and traceable decision processes. Trade-offs within the projects were necessary due to the imbalance of proposed research projects with the funding available for the project. The decision analysis process involved several deliberate steps. It started by defining the goals and attributes of the portfolio. Then, the studies within the portfolio were ranked and performance curves were created based on potential benefit vs costs per project. Next, the preferences for the portfolio objectives were measured[Peerenboom et al., 1989].

Finally, different funding strategies were evaluated and compared. This method helped to optimize the portfolio and decide how resources should be allocated. This paper follows a four-step approach. The first step is about setting the overall strategy, as explained in Cooper's framework. Steps 2 and 3 involve defining and measuring objectives related to strategy and managing the strategic portfolio. Step 4 deals with choosing the right projects to go through portfolio reviews [Peerenboom et al., 1989].

The paper is a practical example of how these three layers described by Cooper (2017)

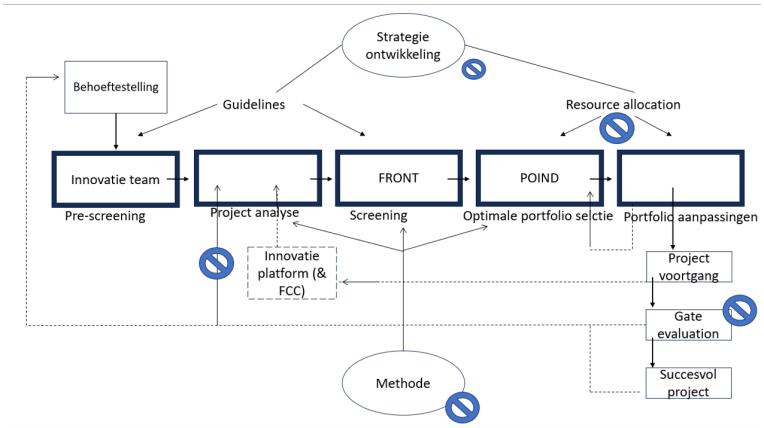

Figure D.1: Inspired by Archer et al

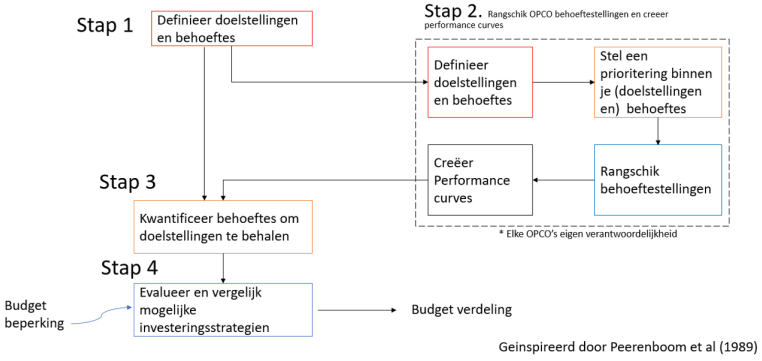

Figure D.2: Inspired by Peerenboom et al

continually interact. It shows that creating a funding strategy isn't a one-time event but an ongoing process.

Within these steps various parameters of balance are considered, strategy alignment is the first to be defined and projects to be ranked on, probability of technical success is then considered in the study ranking as well as the importance to the strategy. Performance curves were used to quantify the research plan's impact on the portfolio strategy.

Furthermore, utility to the portfolio which can be translated into the parameter of importance to the strategy was used to rank projects from highest to lowest where the lowest utility projects were the first to be eliminated. The different subprograms with the listed study projects were then ranked on their utility to the overall portfolio. Finally, funding strategies were evaluated based on an optimization model[Peerenboom et al., 1989]. These rankings were all done via Likert scale subjective measures.

Schilling (Chapter 7, 2020) proposes an approach that overcomes the challenge of subjectivity and the exclusive reliance on the qualitative analysis found in Peerenboom's method. Schilling recommends utilizing a Data Envelopment analysis (DEA) method, which integrates both qualitative and quantitative data, for comparing projects [Schilling, 2016, Linton et al., 2002].

The process described by Peerenboom is very similar to the current process within the MoD. The difference lies in the deliberate steps that are undertaken and the understanding within the MoD of the process that is in place. Figure D.2 can offer insights to visualize the MoD its process.

As mentioned in the recommendations standardization within the IPM process is recommended. These figures can offer a first insight into these standardizations. Additional resources, such as the PDMA handbook, can provide valuable insights into standardization practices that may benefit the MoD. For instance, the PDMA handbook includes maturity level evaluation methods tailored to portfolio managers, including O'Connor's PPM spiral-up maturity level model (2004). These resources offer complementary knowledge that can enhance standardization efforts within the MoD.

With regards to the advice for future research to make project success more explicit first insights can be drawn from the SKIA and the aim of projects to make the MoD a *smart developer*, *smart buyer* or *smart specifier*. If projects were evaluated at the end of the project on exactly these terms, it could offer the MoD insight into how well its projects help it become smart buyers and specifiers. It could also do this on a Likert scale basis where project results would need to be rated on these aspects.

E

APPENDIXE

In the 2018 "Innovatiestrategie" Defense paper [Ministerie van Defensie, 2018] there were several things that stood out. First of all a fundamental aspect of comprehending innovation portfolio management involves gaining clarity regarding the definition and process of innovation within an organization [Cooper, 2017b]. The absence of well-defined boundaries surrounding innovation can introduce ambiguity into the portfolio [Cooper, 2017b, Cooper and Edgett, 2015]. The two most recently published innovation strategies by the MoD namely the "SKIA" and "innovatie strategie Defensie", innovation strategy MoD, are discussed to understand how innovation is defined within the MoD. These papers best help to gain an insight into the MoD its innovation definition and understand some of the MoD its innovation process [Ministerie van Defensie, 2020b, Ministerie van Defensie, 2018].

In the 2018 innovation strategy, the definition of innovation was adopted from the Advisory Council for Science, Technology, and Innovation (AWTI), which defines innovation as "The implementation of a new or significantly updated product or service, process, new marketing method, or a new organizational model"[AWTI,]. It is worth noting that they do not categorize minor, ongoing changes as innovation but reserve the term for initiatives that are novel to the organization, substantial in nature, and enduring enough to alter the organization's mode of operation or character significantly [Ministerie van Defensie, 2018, AWTI,].

The definition of the Oslo manual on innovation discussed in theory 2 is in line with the AWTI definition emphasizing the importance of achieving significant changes rather than mere incremental improvements [AWTI,]. For the MoD its product would be "safety" and it continuously aims to improve its business processes to guard that safety as well as produce new products to maintain safety in changing environments[Ministerie van Defensie, 202

The innovation strategy 2018 emphasizes why to innovate, and what broadly defined innovation capabilities as an organization to invest in[Ministerie van Defensie, 2018]. The Strategic Knowledge and Innovation Agenda (SKIA) 2021-2025 provides direction to

knowledge building, technology development, and innovation [Ministerie van Defensie, 2020b]. The SKIA is not focused on the decision-making process within the MoD but more broadly defines how the MoD aims to develop itself and what factors and strategies play a role in the knowledge-building, technology development, and innovation domain within the MoD. It is imperative to emphasize that these three facets, namely knowledge development, technology development, and innovation, serve as instrumental tools in aiding the MoD's overarching mission of "securing safety" for the Kingdom. The definition for innovation here seems to therefore only be applied to technologies that are implemented but the SKIA also describes the innovating capacity of the MoD on the one hand as the development and applicability of technologies through R&T, and on the other hand, on the successful implementation of these technologies. Describing R&T which refers to knowledge - and technology development as innovation capacity but excluding it from innovation creates ambiguity in how Innovation is actually defined and used by the MoD. This is something that should be avoided according to Cooper (2017) [**?**].

The disparity between academic definitions and the practical delineation of how innovation is structured within the Ministry of Defense underscores the ambiguity surrounding the concept of "innovation." The definition proposed by the Advisory Council for Science, Technology and Innovation (AWTI) primarily encompasses Concept Development and Experimentation (CD&E) and, to a larger extent, project implementation as constituents of innovation. In contrast, the actual organizational framework for innovation within the Ministry of Defense places significant emphasis on Research and Technology (R&T) development. Consequently, in the context of this study, R&T has been incorporated into the innovation framework within the purview of "innovation portfolio management." This inclusion acknowledges the multifaceted nature of innovation as practiced within the Ministry of Defense, thereby aligning with the practical nuances of its operational landscape.

Moreover, the SKIA describes the use of the terminology Technology Push as an analysis of technologies that can become relevant for the MoD however when discussing the term with interviewees multiple interviewees describe technology push as "the technologies the MoD aims to be actively involved in developing" and technology pull as"technologies the MoD aims to let the market develop". It fact that these two definitions are not clearly understood is something the MoD should be aware of.

Image E.1 shows an image shared in the MoD strategy [Ministerie van Defensie, 2018]. Comments on nomenclature used within the funnel are already broadly debated within the MoD so I will not discuss that any further. An interesting note on the funnel pertaining to my research is the idea to use a funnel to represent the innovation process. How would and should this funnel be interpreted does not become clear but when looking at the funnel it seems like the dots are meant to be ideas or projects that the organization has to deal with. When this is merely a funnel representing ideas particular to a problem and the eventual selection of projects for that problem the funnel might be somewhat correct but still vague. When however the funnel should represent the projects the MoD undertakes in different TRL/R&D stages then the funnel is very wrong in its representations. My research has not delved deeper into what parameters should be included

[htp]

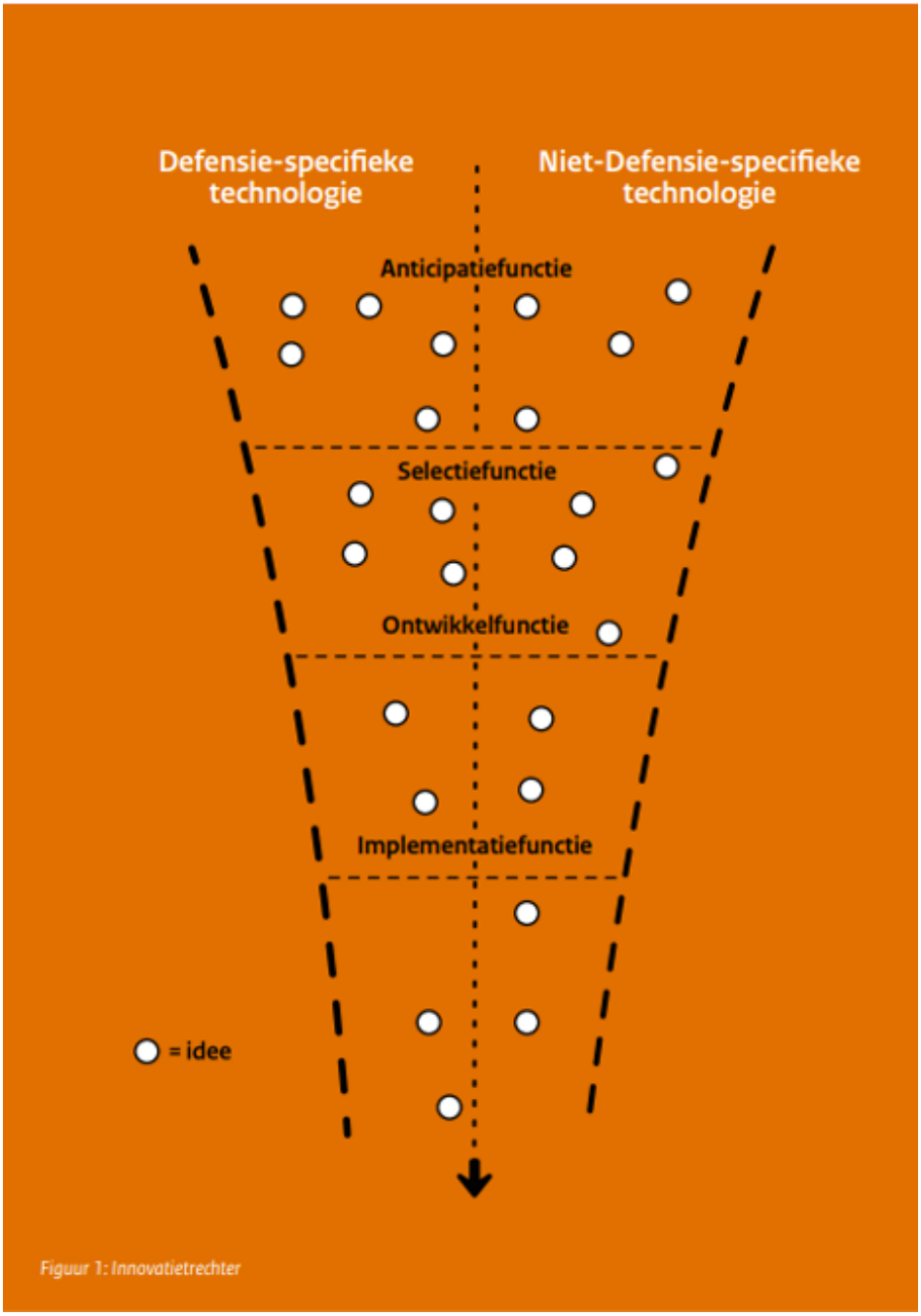

Figure E.1: Funnel

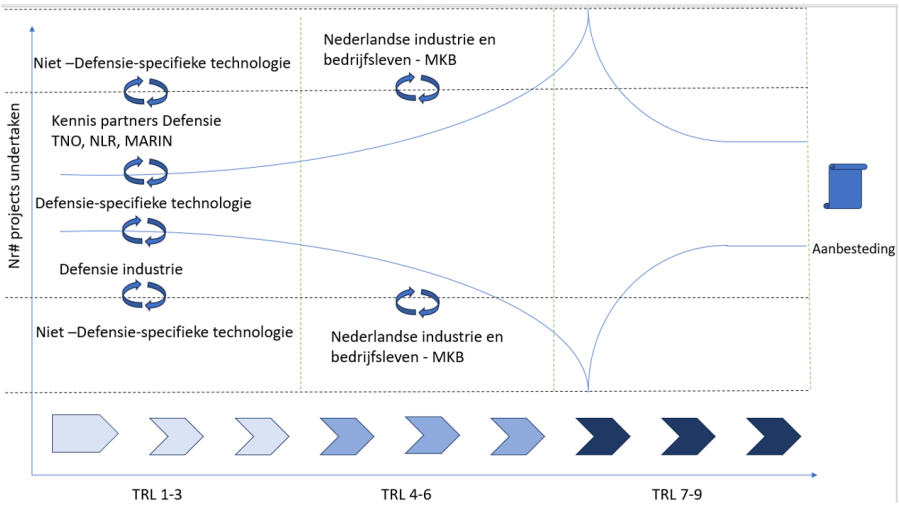

Figure E.2: Funnel - Nr of projects x TRL

within a funnel but in my understanding funnel can be used as long as the parameters are clearly defined. Image E.2 shows how the MoD its "funnel" which looks more like a misformed cone or bowling pint would look like when we solely consider the Nr of projects undertaken within the MoD, compared to the development stage. Another figure that could be interesting to look at is the amount of money compared to the development stage or the amount of people involved compared to the development stage. This images might look more like a funnel but again this research did not delve into resource distribution and therefor this could investigated to get a better understanding of the resource distribution within the innovation network. It is however imminent that the representation given in the [Ministerie van Defensie, 2018] is not only vague but could be misleading if interpreted in the wrong way.