Project portfolio management (PPM) in highly uncertain environments

Master of Science Thesis
Delft University of Technology
S. Lagerwey

TU Delft AT OSBORNE Schiphol Group

Delft University of Technology

Master Thesis

Project portfolio management (PPM) in highly uncertain environments

Case study at Schiphol Airport

Stijn Lagerwey (4554132)

Supervisors TU Delft:
Chairman: Dr. D.F.J. Schraven
Main supervisor: Dr. Ir. M.G.C. Bosch-Rekveldt
Second examiner: Shubham Sharma

External Supervisors:
Schiphol: Bas Blokland
AT Osborne: Kimon Panagiotopoulos

January 11, 2025

Preface

This master's thesis represents the conclusion of my academic journey at Delft University of Technology, where I have had the privilege to develop both professionally and personally. Throughout my studies in Construction Management Engineering, I've gained valuable insights into the complexities of managing construction projects and the challenges of implementing strategies in the face of uncertainty.

During my time at TU Delft, AT Osborne, and Schiphol Airport, I was fortunate to observe firsthand the impact of dynamic disruptions on project portfolios. My research focuses on how dynamic capabilities and ad-hoc problem-solving approaches can be employed to address these disruptions in real-time, providing a practical framework for managing uncertainty within the construction sector. This study is not only an academic exercise but also a collaboration between the theoretical knowledge from TU Delft, the consultancy expertise of AT Osborne, and the practical insights from Schiphol Airport.

I would like to extend my deepest gratitude to my supervisors at TU Delft, chairman Daan Schraven, main supervisor Marian Bosch-Rekveldt, and second supervisor Shubham Sharma, for their valuable feedback and guidance throughout the research process. Special thanks also go to Bas Blokland from Schiphol and Kimon Panagiotopoulos from AT Osborne, whose real-world insights were instrumental in shaping the direction of this research.

I also owe much of the success of this thesis to the various professionals who generously shared their experiences with me during interviews. Their candid reflections provided essential context and depth to the research findings.

Lastly, I would like to thank my family and friends for their constant support and encouragement. Their understanding and patience during this demanding time were crucial in helping me complete this thesis.

I hope that this research will contribute to the field of construction management by providing a more nuanced understanding of how disruptions can be managed in project portfolios. I also hope it serves as a valuable resource for industry practitioners looking to navigate the uncertainties of today's fast-paced construction environment.

Stijn Lagerwey

Executive Summary

Schiphol Airport, a critical hub for international travel, operates in a highly unpredictable environment, influenced by economic instability, changing regulations, resource shortages, and geopolitical tensions. Despite these challenges, Schiphol remains one of the world's leading airports, with plans for continued growth, including a six-billion-euro investment in future maintenance and projects. Managing this dynamic landscape requires a resilient approach to project portfolio management (PPM), which has traditionally focused on aligning projects with broader organizational goals. However, increasing uncertainty poses significant challenges.

Traditional PPM can be extended through the application of two types of capabilities: Dynamic and Ad-hoc. Dynamic capabilities are structured, formalized capabilities enabling organizations to sense uncertainties, seize opportunities, and reconfigure portfolios to adapt to disruptions. In contrast, ad-hoc capabilities provide flexible, improvised responses grounded in situational judgment to address unforeseen challenges. By integrating these capabilities, a hybrid approach could balance different responses, enhancing resilience in dynamic environments. Therefore, this research explores the hybrid application of dynamic capabilities (DCs) and ad-hoc capabilities (AHCs) to manage disruptions within Schiphol's project portfolio.

Using Schiphol Airport as a case study, the research investigates when and how dynamic capabilities are complemented by ad-hoc capabilities to manage disruptions. The study aims to answer the **main research question:** *In what context can ad-hoc and dynamic capabilities complement each other to manage disruptions in project portfolios?*

This question is answered through a comprehensive literature review, document analysis, interviews with 11 decision-makers, and an expert judgment session with seven professionals. The research explores how these capabilities are applied in practice and offers recommendations for managing uncertainty in complex environments.

The case study of Schiphol Airport identified 13 disruptions, stemming from different sources of uncertainty, namely single-project (e.g., unexpected weather), organizational complexity (e.g., resource shortages), and environmental (e.g., COVID-19 impacts) disruptions. The analysis revealed 24 capabilities employed to manage these disruptions. Dynamic capabilities included sensing capabilities (e.g., resource monitoring), seizing capabilities (e.g., prioritization, escalation), and reconfiguration capabilities (e.g., workforce adjustments, project postponements). Ad-hoc capabilities comprised situational data gathering and improvised problem-solving, which addressed immediate challenges when structured approaches were insufficient.

The findings illustrate how a hybrid approach integrates ad-hoc and dynamic capabilities to manage both foreseen and unforeseen disruptions through two types of hybrid approaches. Type 1 involves ad-hoc data gathering complementing dynamic sensing and seizing by providing situational insights during critical decision-making. Type 2 involves ad-hoc problem-solving offering immediate responses to challenges such as resource shortages and severe weather impacts, filling gaps when dynamic capabilities alone are inadequate.

Schiphol Airport's hybrid approach to managing disruptions also demonstrates the complementary roles of dynamic capabilities (DCs) and ad-hoc capabilities (AHCs) under different conditions:

- **Impact and Capabilities:** AHCs are used for localized disruptions, like security lane shortages or weather-related issues, where quick adjustments are needed without portfolio-wide coordination. In contrast, when disruptions affect broader operations, DCs are essential for coordinated, strategic responses, as seen with the pandemic or security personnel shortages.
- **Response Time and Capabilities:** Delayed responses limit the applicability of DCs, leading to an increased reliance on AHCs. For example, delays in addressing security personnel shortages or weather conditions required Schiphol to use reactive, ad-hoc measures. Timely identification of disruptions is crucial to fully leverage DCs, while delays necessitate improvised solutions.
- **The expert judgment session** reinforced these findings, suggesting the need to integrate lessons from AHCs into structured decision-making at the portfolio level. This integration could strengthen the hybrid approach, offering a more cohesive strategy for managing disruptions across both project and portfolio levels.

Contents

Nomenclature

Abbreviation	Definition
AHCs	Ad-hoc Capabilities
DCs	Dynamic Capabilities
PPM	Project Portfolio Management
ADT	Airport Development Team
CLP	Capital Life Cycle Process
PPMIS	Project Portfolio Management Information System
IPW	Integrated Planning Work
PMI	Project Management Institute

Table 1: Abbreviations Table

1 Introduction

1.1 Context

1.1.1 Uncertainty in Schiphol's Environment

Influenced by economic instability, changing regulations, and fluctuations in resource demand and supply, the aviation sector was forced to operate in an uncertain landscape the past years (Pasquini & De Smedt, 2023). The Dutch government plans (2022) to enforce a cap on flights, geopolitical uncertainty as a result of the war in Ukraine, the ongoing conflict in the Middle East, and the aftereffects of the COVID-19 pandemic, caused the operating landscape of Schiphol Airport to be unstable. With 305 direct destinations, transporting a total of 61.9 million people in 2023, Schiphol is still recovering from this turbulent time (SchipholGroup, 2023b). This signifies the highly volatile and uncertain environment of Schiphol's operations.
Nonetheless, Schiphol Airport is proclaimed to be, based on direct flights, the world's second-best airport in 2023 and, based on connection flights, the world's 4th best hub airport (SchipholGroup, 2023a). In order to keep this status, Schiphol announced investing six billion euros in maintenance and innovation projects during the coming three years (2024-2027) (SchipholGroup, n.d.). This encompasses investments in hundreds of projects, each requiring careful planning, execution, and monitoring. Hence, an effective approach to manage the collection of Schiphol's projects in highly uncertain environments is required.

1.1.2 Project Portfolio Management

Project Portfolio Management (PPM) is a strategic approach that organizations use to align projects with their overall strategic goals and objectives. It involves the centralized management of multiple projects, programs, and sub-portfolios to ensure they contribute to the organization's strategy (Martinsuo, 2013). The main goal of PPM is to optimize resource allocation, ensure alignment with organizational strategy, and maximize the overall value of the portfolio. Managing the entire portfolio involves selecting, bundling, and prioritizing the projects that maximize the generated value (Teller et al., 2012). Values, which are the main focus of portfolio management, can provide useful benefits for an organization, including tangible elements like monetary assets and intangible elements like reputation (Bible & Bivins, 2011). The process from selecting the projects to gaining the generated values, is often described through iterative sequential process with cycles.

1.1.3 Project Portfolio Management at Schiphol

Schiphol currently employs a PPM approach to manage this collection of projects. PPM at Schiphol Airport plays a vital role in aligning projects with the organization's strategic vision and mission to: "connect your world". Schiphol's PPM is structured into two key phases: strategic and tactical. In the strategic phase, the airport defines its overarching direction through a vision and a set of strategic pillars, such as sustainability, service quality, and operational robustness. The tactical phase focuses on translating these strategic pillars into actionable projects through structured selection, planning, and execution. This approach enables Schiphol to maintain a clear alignment between its long-term ambitions, such as becoming the world's most sustainable airport, and the efficient execution of projects and resource allocation.

However, Schiphol's ability to manage its project portfolios has been increasingly strained by disruptions in a highly uncertain operational environment. Geopolitical instability, such as COVID-19, for instance, disrupts passenger volumes, requiring re-evaluation of projects to align with decreased revenue. Similarly, growing environmental and sustainability priorities force Schiphol to adapt its strategy to meet stricter standards, reshaping project selection. The most demanding challenge, however, stems from resource constraints. Economic uncertainty, tight labor markets, or geopolitical tensions often lead to shortages in financial, human, or material resources, impacting project execution. As projects at Schiphol are highly interdependent, this impact can affect multiple projects, creating portfolio-wide issues. This illustrates how Schiphol's project portfolio management is increasingly challenged by disruptions stemming from an increasingly uncertain environment, ultimately creating cascading effects across its portfolio.

1.1.4 Dynamic and Ad-hoc Capabilities

Since 2010, PPM research has increasingly focused on finding ways to manage project portfolios in uncertain environments (Hanssen & Svejvig, 2022). Two trends have emerged in this context, which are ad-hoc capabilities (AHCs) and dynamic capabilities (DCs). AHCs involve problem-solving and decision-making in response to unexpected disruptions or crises. They allow managers to make quick, unplanned decisions in response to immediate disruptions without relying on predefined processes or structured frameworks (Winter, 2003). In the context of PPM, research highlights that AHCs can be useful in some scenarios without affecting the overall portfolio objectives, such as when unexpected disruptions cause the response time to be limited (Hepworth et al., 2017; Winter, 2003). In contrast, DCs represent a more structured and proactive approach to managing disrupted project portfolios. DCs refer to an organization's ability to adapt, integrate, and reconfigure internal and external resources to address rapidly changing environments (Barbosa & Carvalho, 2023a; Gemünden et al., 2023; Killen & Hunt, 2009; Kock & Killen, 2023; Teece et al., 1997). DCs allow organizations to continuously align the project portfolio with evolving strategic goals or allocate resources across projects to respond to unforeseen changes (Barbosa & Carvalho, 2023a).

Some researchers have suggested that the use of dynamic and AHCs could complement each other, potentially offering better responses to disruptions, particularly in complex environments where different types of disruptions occur (Ritala et al., 2016; Wang & Wang, 2017). Researchers suggest that DCs provide a structured and proactive framework for predictable disruptions, while AHCs can complement this by offering the flexibility needed to deal with unexpected, immediate disruptions. In combination, these approaches could potentially provide a balanced response to both diverse challenges, allowing organizations to remain both adaptive and flexible when faced with disruptions (Jerbrant & Gustavsson, 2013).

1.2 Knowledge gap

Despite the potential of this hybrid approach, how and when DCs and AHCs can complement each other remains insufficiently explored. Existing studies have primarily focused on theoretical discussions without sufficient empirical examples. Furthermore, most of this research has been conducted in the general organizational context rather than being tailored to the specific challenges of PPM (Ritala et al., 2016). As a result, there is a significant knowledge gap in under-

standing when and how these two approaches can be used in a complementary way to manage disrupted project portfolios.

1.3 Research Objectives

This research aims to explore how a hybrid approach combining DCs and AHCs is applied in PPM to address disruptions in uncertain environments. Specifically, it seeks to investigate when and how DCs are complemented by AHCs. By focusing on Schiphol Airport, the research examines how these capabilities can work together to manage disruption. Ultimately, the study aims to fill the knowledge gap regarding the practical application of this hybrid approach in managing disrupted project portfolios.

1.4 Research Questions

To address the research objective, the main research question is formulated as follows:

Main Research Question:
In what contexts can ad-hoc and dynamic capabilities complement each other in managing disruptions within project portfolios?

The following sub-research questions (SRQs) will help answer the main question:

- **SRQ1:** How do dynamic and ad-hoc capabilities support project portfolio management (PPM) in managing disruptions under varying uncertainty, and what role does a hybrid approach play?
- **SRQ2:** What disruptions has Schiphol encountered, and how have they impacted the project portfolio?
- **SRQ3:** What dynamic and ad-hoc capabilities does Schiphol employ to address disruptions?
- **SRQ4:** How were dynamic and ad-hoc capabilities used in a hybrid approach to manage disruptions at Schiphol?

1.5 Research Design

This research is structured into three phases: Theoretical Foundation, Empirical Exploration, and Synthesis, each aimed at systematically addressing the research questions.

Theoretical Foundation
The study begins by developing a theoretical framework through a comprehensive literature review. This phase explores the PPM context, goals, processes, and elements while classifying uncertainty and characterizing AHCs and DCs. The outcome addresses SRQ 1, laying the groundwork for understanding both types of capabilities and the conditions under which disruptions occur. This is used in further analysis to explore the application of approaches under different conditions.

Empirical Exploration
The second phase employs case studies to collect and analyze empirical data. Documentation and interviews are used to investigate disruptions that occurred at Schiphol and to identify what types of AHCs and DCs are used. This answers SRQ 2 (disruptions) and SRQ 3 (application of capabilities). Due to limited time, a selection from the identified disruptions will be made for further analysis. Follow-up interviews delve deeper into the selected disruptions to explore the application of a hybrid approach (both AHCs and DCs) in practice. This will answer SRQ 4 (hybrid approach in practice). The results aim to provide a nuanced understanding of how these capabilities complement each other while addressing disruptions.

Synthesis
Finally, findings from the theoretical and empirical phases are integrated to answer the main research question (MRQ). This phase synthesizes insights into the hybrid approach's applicability in managing disruptions under different conditions, offering practical recommendations and highlighting limitations. The expert judgment session, held with professionals from different fields, corroborated the research findings and provided further insights into how AHCs and DCs complement each other. The Theoretical Foundation identifies core concepts, Empirical Exploration validates them through real-world cases, and Synthesis consolidates the findings into a coherent conclusion. Figure 1 provides an overview of the thesis research design.

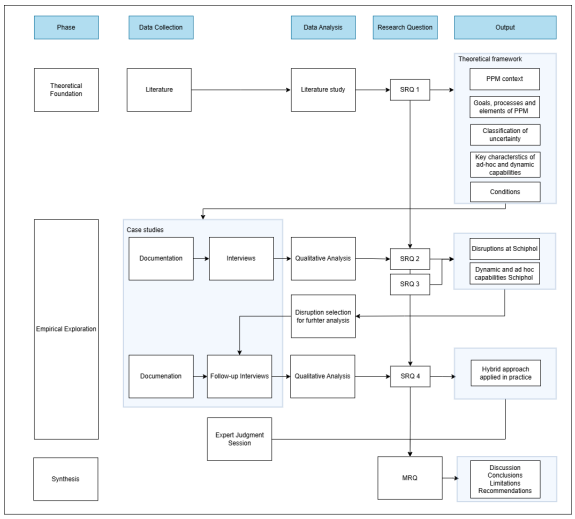


Figure 1: Research Design

1.6 Thesis Outline

After introducing the research problem, objectives, and main research question in **Section 1: Introduction**, this research continues with **Section 2: Methodology**, which outlines the methodology used to approach the study. Following the introduction, **Section 3: Literature Review** provides a comprehensive theoretical foundation, focusing on portfolio management, uncertainty, and dynamic and AHCs. Next, **Section 4: Background and Context Schiphol** offers operational context, setting the stage for a deeper analysis. **Section 5: Disruptions and Capabilities applied at Schiphol Airport** examines these disruptions and how dynamic and ad-hoc strategies have been applied in response. The research then examines **Section 6: Hybrid Approach applied at Schiphol Airport**, detailing how DCs and AHCs were applied in a hybrid approach. Insights from expert evaluations are presented in **Section D: Expert Judgment**, analyzing the sector-wide application of this hybrid approach. The findings are critically examined in **Section 8: Discussion**, where they are linked to the theoretical framework and research questions. The thesis concludes with **Section 9: Conclusions, Limitations, and Recommendations**, which provides a summary of key findings, practical recommendations, and identifies areas for future research. Figure 2 provides an overview of the thesis outline.

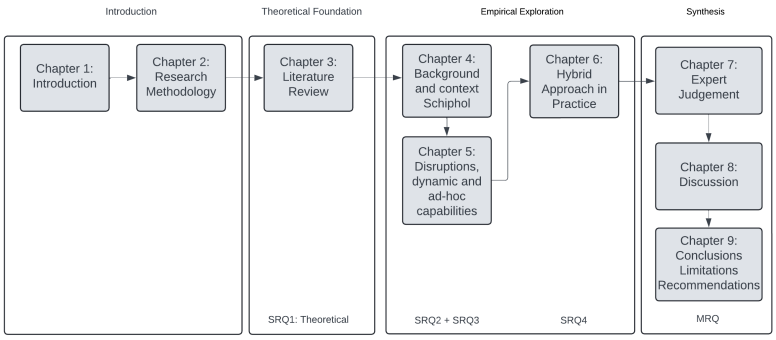


Figure 2: Thesis Outline. Source: author

2 Methodology

2.1 Data Collection

2.1.1 Literature Review

The literature review provides a theoretical foundation for the study's empirical phases. It begins with the historical development of Project Portfolio Management (PPM), followed by an exploration of core principles through key texts detailing PPM frameworks, elements, and processes. The review then focuses on PPM in dynamic environments, examining uncertainties and their impacts on project portfolios, and continues with literature on dynamic and AHCs. These findings provide background knowledge and inform subsequent research steps. Relevant literature was catalogued in Google Docs, sourced primarily through Google Scholar using targeted keywords. For disruptions, terms like "PPM processes" AND "dynamic environments" identified relevant papers, while "dynamic capabilities" AND "ad hoc problem solving" explored frameworks for managing disruptions. This structured approach ensures a focused basis for addressing Sub Research Question 1. This strategy ensured a comprehensive, layered approach to understanding PPM evolution, disruptions, DCs, and hybrid approaches, relevant to managing portfolios in uncertain environments.

2.1.2 Document Review

Internal documentation from Schiphol was analyzed, providing rich contextual data, including process overviews, decision-making documentation, disruption records, and memos. The documentation serves to gather empirical data on historical disruptions and formal processes and systems in place at Schiphol for disruption management. This can complement interview data by validating examples of disruptions and the organizational responses. In addition, these document reviews were used to select the appropriate sample for semi-structured interviews.

2.1.3 Semi-Structured Interviews

The semi-structured format allowed participants to provide detailed insights while ensuring consistency across interviews. The open-ended question format allowed for flexibility, encouraging participants to share detailed experiences while ensuring coverage of critical topics. The semi-structured interviews were conducted in two distinct rounds:

Round 1 involved 11 decision-makers from various levels within Schiphol, including project, program, and portfolio managers, as well as external contractors. These interviews aimed to identify the types of disruptions encountered, their impact on the portfolio, and the time to response. Additionally, this round aimed to identify the AHCs and DCs used at Schiphol Airport to manage the disruptions.

Round 2 focused on four decision-makers who were directly involved in specific cases identified in the first round. These follow-up interviews provided an in-depth exploration of specific disruptions, enabling the research to delve into how dynamic and AHCs were used in a complementary manner to manage disruptions.

2.2 Qualitative Data Analysis

2.2.1 Round 1: Initial Interviews

The first round of interviews involved 11 participants and was conducted via Microsoft Teams. The analysis process unfolded in a series of steps aimed at ensuring the accuracy and depth of the data. Initially, interviews were recorded with participant consent, and these recordings were transcribed. The transcripts were reviewed several times to ensure the accuracy and comprehensibility of the data. Afterward, the transcribed interviews were uploaded to Atlas.ti, a qualitative data analysis software.

- The first round of interviews involved 11 participants and was conducted via Microsoft Teams. The analysis process followed a structured approach to ensure a thorough examination of the data.
- Initially, interviews were recorded with participants' consent and transcribed. The transcripts were then reviewed multiple times to ensure accuracy and clarity. These transcriptions were uploaded to Atlas.ti, a qualitative data analysis software, for further analysis.
- In the initial coding phase, phrases were categorized into components of the theoretical framework by identifying patterns and meaningful information units. These units were grouped into categories such as "PPM elements, processes, and goals," "Uncertainty," "Management approaches," and "Conditions."
- A second round of labeling was undertaken to refine the initial categories based on theoretical insights. Words such as "improvised" or "unstructured" were categorized under AHCs, while terms like "formalized" or "structured" were classified as DCs. This process helped link the theoretical concepts to the empirical data.
- The initial coding and second round of labeling were merged to identify key themes. For instance, linking the category "management approach" with the term "improvised" led to the theme of "ad-hoc capability." This process also revealed patterns in DCs, types of uncertainty, disruption conditions, and PPM goals and processes.
- To ensure the disruptions selected for further analysis are representative and relevant to the research objectives, a set of criteria based on impact, response time, and uncertainty source will guide the selection process. Disruptions will be chosen from each of the three uncertainty sources—organizational complexity, single-project disruptions, and environmental disruptions—to provide a comprehensive view of different challenges faced by the organization. A second round of interviews was conducted to further explore these selected disruptions.

2.2.2 Round 2: Follow-up Interviews

The process for the second round of interviews closely followed the structure of the first round. After transcribing and reviewing the interviews, the focus shifted to analyzing the themes, disruptions, and their management by applying them to the conditions and uncertainty classifications established in the first round.

- In this round, the identified themes were linked to the specific conditions of the disruptions and their uncertainty classifications. This facilitated the categorization of disruptions

based on their type, response time, and patterns, providing a deeper understanding of how disruptions were managed across varying conditions.

- Next, the application of identified capabilities was explored to assess how they addressed similar disruptions in different scenarios. This analysis helped identify how both dynamic and AHCs were used in practice to respond to disruptions.
- An additional overview was created, focusing on the conditions of each disruption event, specifically considering impact, response time, and uncertainty classifications. This provided further context by organizing the patterns of disruptions under these classifications.
- Finally, overarching themes were identified to illustrate the use of a hybrid approach—integrating DCs and AHCs—across different conditions and uncertainty classifications. These findings underscored the practical application of this hybrid approach in managing disruptions in diverse scenarios.

2.2.3 Expert Judgment Session

The expert judgment session aimed to evaluate how DCs and AHCs are applied in managing disruptions within project portfolios across different industries. The session was conducted with seven participants from various roles within the infrastructure sector, including project management, project control, and contract advising. Initially, participants were introduced to the approaches under investigation. They were then presented with five predefined statements, for which they indicated their level of agreement on a 5-point Likert scale (ranging from Strongly Disagree to Strongly Agree). After each statement, a group discussion was facilitated to gather insights, along with real-world examples. Participants were asked to record their input and examples on provided forms, ensuring a collection of diverse perspectives and practical applications related to the hybrid approach in managing disruptions.

3 Literature Review

This literature study begins by exploring the origins and historical development of Project Portfolio Management (PPM), establishing a baseline for analyzing how dynamic and ad-hoc capabilities have emerged from traditional PPM approaches. It then examines the key elements and processes of PPM, with a focus on their interaction with management approaches. As noted in Section 1, increasing uncertainty disrupts PPM, which necessitates an analysis of disruption types and their impact on management strategies. The study further investigates sources of uncertainty and disruption characteristics to understand the conditions under which dynamic capabilities (DCs) and ad-hoc capabilities (AHCs) are adopted. Finally, the literature review explores the potential of combining these capabilities and summarizes key findings for further analysis.

3.1 Project Portfolio Management

The goal of this section is to provide a foundational understanding of PPM. It begins by tracing the origins and development of PPM, with a particular focus on its evolution in managing uncertainties. Following this, key processes, elements, and goals of PPM are discussed to establish a comprehensive context for the study.

3.1.1 Roots of PPM

Over the past seven decades, Project Portfolio Management (PPM) has evolved significantly, becoming the crucial link between an organization's strategy and its projects (Clegg et al., 2018). The foundation of PPM can be traced back to Harry Markowitz's financial portfolio theory introduced in 1952, which emphasized optimizing investments and managing risks through diversification (Markowitz, 1952). This theory laid the groundwork for PPM by applying similar principles to project management, focusing on balancing risks, returns, and strategic alignment. During the 1960s and 1970s, the need to manage multiple simultaneous projects efficiently gave rise to early PPM practices. Techniques like Hardingham's simplified model integrated financial practices to evaluate project proposals while ensuring alignment with business objectives and resource constraints (Hardingham, 1970). Due to shrinking market demands, the 1980s saw a growing interest in improving project selection and monitoring. This period marked the recognition of PPM not just as a set of tools but as a set of ongoing sequential processes aimed at enhancing resource efficiency (Cooper, 1981). In the 1990s, PPM evolved into a more comprehensive decision-making system. Work by Robert Cooper, Elko Kleinschmidt, and Scott Edgett played a crucial role in integrating PPM techniques into new product development (NPD)[1], thereby improving strategic alignment, project selection, and performance (Cooper et al., 1997). Among the most influential developments was Cooper's stage-gate model, which structured project processes into defined stages, followed by decision gates (go/kill) to evaluate project continuation (Cooper, 1990, 1981). This approach became widely adopted across industries for project selection and monitoring. From the 2010s onward, research has increasingly focused on managing the rising uncertainty and complexity within dynamic organizational environments, further advancing the field of PPM (Hanssen & Svejvig, 2022).

[1] NPD refers to the strategic, organizational process through which a new product is developed and brought to the market (Messina, 2023)

3.1.2 PPM elements

The Project Management Institute (PMI) defines a project portfolio as "a collection of elements, such as projects, programs, sub-portfolios, and operations that are grouped to meet strategic business objectives" (PMI, 2017, p.3). These elements—projects, programs, and portfolios—form the building blocks of PPM, each serving a specific purpose within the broader organizational strategy:

A project is "a temporary endeavor designed to deliver a specific service, product, or result." (PMI, 2017, p.3)

A program consists of "multiple related projects managed in a coordinated way to achieve benefits unattainable by managing them individually." (PMI, 2017, p.3)

A portfolio "encompasses a collection of projects, programs, sub-portfolios, and operations managed collectively to align with and achieve strategic objectives." (PMI, 2017, p.3)

These elements can be interdependent and often compete for limited resources, requiring a structured approach to evaluation, prioritization, and alignment with organizational goals (Bible & Bivins, 2011). Unlike individual projects or programs, portfolios have a longer life cycle, allowing for continual adaptation through the addition, termination, or reorganization of elements as strategic priorities evolve. Organizations may establish multiple sub-portfolios to address distinct business units, geographic regions, or functional areas, ensuring flexibility and focus across various domains (PMI, 2017). A core function of PPM is to maintain alignment between the portfolio and the organization's strategic objectives (Hanssen & Svejvig, 2023). When misalignment occurs, corrective actions such as adjusting, realigning, or removing projects and programs are required. PPM serves as a dynamic approach for an organization, ensuring that resources and efforts are consistently redirected toward alignment with strategic priorities. Figure 3 illustrates how these components interrelate.

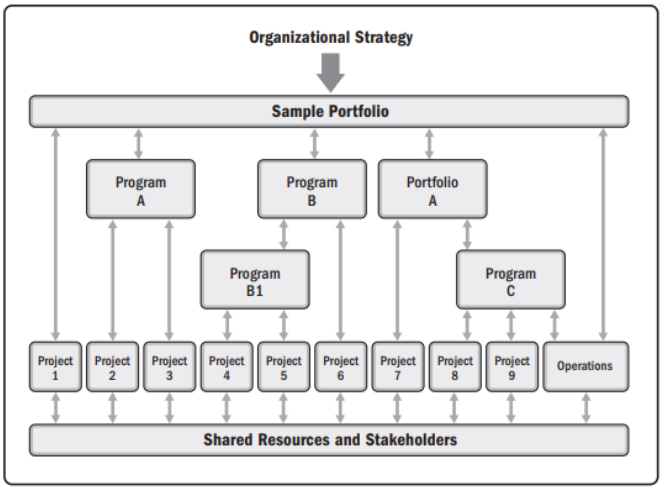


Figure 3: Portfolios, Programs, and Projects, source (PMI, 2017, figure.1.1)

3.1.3 PPM processes

Managing a project portfolio involves the strategic selection, bundling, and prioritization of projects to maximize the value generated for the organization (Teller et al., 2012). This process is often described as an iterative and sequential cycle, ensuring adaptability to dynamic organizational needs Bible and Bivins (2011). Bible's PPM framework outlines five key phases, each encompassing critical activities to achieve desired outcomes. The first phase, **Strategic**, establishes the organization's overarching mission, vision, goals, and objectives. This strategy serves as the foundation for the second phase, **Project Screening**, where proposed projects are evaluated and added to a potential project list. The third phase, **Portfolio Selection**, focuses on balancing factors such as strategic alignment, risks, and resource availability to determine the optimal set of projects. Here, "optimal" refers to achieving maximum value while adhering to strategic priorities. Once the portfolio is selected, the fourth phase, **Implementation**, begins. This involves setting up governance structures, appointing project and program managers, acquiring resources, and defining methodologies, policies, and regulation standards. This phase also includes continuous monitoring, controlling, and evaluating project and portfolio performance to ensure alignment with strategic goals. Finally, in the fifth phase, **Evaluation and Adjustment**, ongoing assessment ensures that the portfolio remains aligned with organizational strategy. Misalignment, such as resource shortages, triggers necessary adjustments within any phase of the process to realign activities with strategic goals. This framework emphasizes that monitoring and iterative reconsideration are not only required in the final phase but are integral throughout the entire PPM process. Figure 4 illustrates these phases and their respective activities, highlighting the dynamic and interconnected nature of portfolio management.

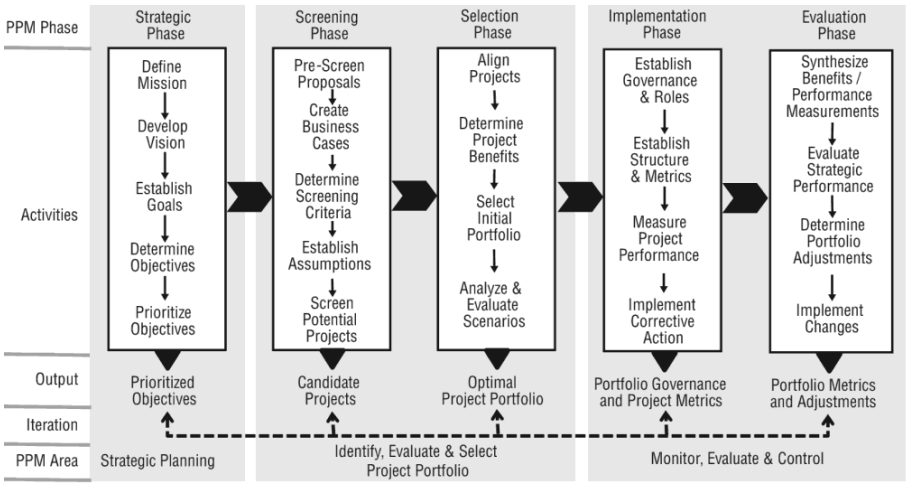


Figure 4: PPM Phases, source (Bible & Bivins, 2011, figure.1.1)

Findings on PPM Literature

- PPM integrates the strategic alignment of projects, programs, and portfolios to achieve organizational objectives.
- It combines elements (projects as temporary efforts, programs as interrelated groups of projects, and portfolios as collections aligned with strategic goals), processes (strategic planning, project screening, portfolio selection, implementation, and evaluation/adjustment), and goals (resource optimization, strategic adaptability, and organizational performance improvement).
- The iterative PPM process continuously monitors performance, adjusts priorities, and aligns with shifting strategic objectives.

3.2 Dynamic Environments

The previous sections provided a foundation by exploring the core elements and processes of PPM. However, these elements and processes are frequently disrupted by uncertainties, necessitating adaptive management approaches to maintain portfolio objectives Martinsuo and Geraldi (2020). This section focuses on investigating disruptions in detail, examining the conditions under which they arise and the sources from which they originate. Understanding these factors is crucial for identifying effective strategies to manage their impact on PPM.

3.2.1 Context

As mentioned in Section 1, portfolios operate in an environment characterized by continuous change and complexity. This dynamic is driven by the interplay between internal organizational dynamics and external forces (Martinsuo, 2013). Internally, strategic alignment within portfolios, programs, and projects ensures coherence with organizational goals. However, this alignment is often challenged by evolving priorities and operational interdependencies. Externally, organizations interact with factors such as fluctuating market conditions, shifting stakeholder demands, and regulatory pressures, all of which require management to maintain strategic alignment. For example, pressure from local governments and advocacy groups opposing the expansion forced Schiphol to revise its strategy, illustrating how external forces shape project portfolios and vice versa (van Infrastructuur en Waterstaat, 2024). Conversely, the expansion of Schiphol Airport significantly affected its surrounding context, including impacts on local livability and heightened environmental concerns (Oosterlee et al., 2018). These examples underscore the bilateral influence between organizations and their environments, where internal and external factors can lead to disruptions.

3.2.2 Disruptions

In PPM literature, disruptions are commonly defined as unexpected events that interfere with normal operations (Sawik, 2017; Zarghami & Zwikael, 2022). The occurrence of such disruptions often leads to project delays, cost overruns, and the need for re-planning, adding complexity to the PPM process (Haghighi & Ghasemi, 2018; Shenoy & Mahanty, 2024). For example, infrastructure projects can be significantly delayed when key team members leave, especially if the projects rely heavily on their expertise (Mahmoudi & Alidoosti, 2022; Zarghami & Zwikael, 2022).

Disruptions and delays frequently lead to "knock-on" effects, where one event triggers subsequent issues, further complicating project outcomes (Eden et al., 2000). Organizations may face both "sudden disruptions," such as natural disasters or economic shocks, and "creeping disruptions" that develop gradually over time (Usher, 2024). Mahmoudi and Alidoosti (2022, p. 2) emphasize the need for resilience in PPM, defining it as "an organization's ability to predict and respond to sudden disruptions in order to meet its objectives." To achieve this resilience, organizations require not only the capacity to manage known risks but also the ability to respond effectively to unforeseen disruptions that may impact the project portfolio. Martinsuo (2013) highlight the importance of understanding contextual conditions that influence an organization's ability to maintain resilience and adapt effectively to unforeseen events. As disruptions emerge or evolve, organizations must implement strategies to predict and respond effectively, thereby maintaining operational continuity (Mahmoudi & Alidoosti, 2022). The ability to anticipate and mitigate the risks associated with disruptions, whether sudden or creeping, is key to ensuring the successful delivery of project portfolios in complex and uncertain environments (Te Wu & Ren, 2024).

3.2.3 Conditions

Early detection of disruptions is critical for minimizing their effects and enhancing organizational resilience (Sheffi, 2015). Disruptions that occur early in a project life cycle allow for greater flexibility in implementing corrective actions, while disruptions that happen later may leave little room for adjustments and often necessitate quick, decisive actions to avoid further impact. Proactive management approaches, such as building organizational flexibility and maintaining human-resource spare capacity, are often effective in preparing for known or creeping disruptions (Te Wu & Ren, 2024). In contrast, sudden disruptions, such as unexpected supplier failures or extreme weather events, require more reactive strategies. These examples highlight that the application of different management approaches is influenced by the time available to respond to disruptions.

While timing is a vital factor, the impact of a disruption also influences the management approach. High-impact disruptions, such as major natural disasters or market disruptions, often require significant interventions, such as resource reallocation, project reprioritization, or emergency measures like extended work hours or additional personnel (Haghighi & Ghasemi, 2018). In contrast, lower-impact disruptions, though still requiring attention, may be managed with less drastic measures, such as minor rescheduling or optimizing existing resources (Biedenbach & Müller, 2012). The ability to determine the severity of the disruption helps organizations decide on the appropriate response. Howick and Eden (2008) highlight the relationship between impact and management, noting that if a disruption is not addressed promptly, it can lead to "knock-on" effects, where one event triggers subsequent issues, further complicating and delaying project outcomes (Eden et al., 2000). Wang et al. (2019) suggest that portfolio managers must adopt a strategic perspective, taking into account the broader impact of disruptions on multiple projects within the portfolio. This holistic view allows managers to coordinate their response in a way that mitigates the broader consequences of the disruption, ensuring that immediate project needs are balanced with long-term organizational objectives.

Ultimately, the appropriate approach to manage disruptions in PPM depends on the disruption's nature, including impact and timing. By understanding these key factors, organizations can better tailor their responses to disruptions, improving resilience to uncertainty.

3.2.4 Sources of uncertainties

These disruptions may emerge from diverse uncertainty sources, each posing unique challenges to operations and decision-making. External factors, such as weather-related events, or internal issues, like technical failures or the unexpected departure of a key team member, contribute to these disruptions (Eden et al., 2000; Zarghami & Zwikael, 2022). Understanding the origins of these uncertainties is crucial for tailoring strategies to mitigate their impact and maintain portfolio stability. The following section delves into these sources of uncertainty, classifying them and examining their implications for PPM. The uncertainties are mainly categorized into three sources: environmental, organizational complexity, and single projects.

Environmental
Various factors such as shifting customer preferences, rapid technological advancements and changing norms and regulations were highlighted as a significant source of environmental uncertainty (Korhonen et al., 2014; Petit, 2012; Petit & Hobbs, 2010; Voss & Kock, 2013). The authors indicate that this required frequent scope adjustments caused by the shifting priorities. In addition, these studies distinguished another environmental uncertainty source driven by external factors such as market and technological turbulence. Rapid technological advancements and changing market conditions formed a significant source of uncertainty for the companies that were analyzed. These factors caused problems for predicting the future environment in which the project portfolio operate, thereby challenging its management.

Organizational complexity
Various factors, such as shifting customer preferences, rapid technological advancements, and changing norms and regulations, were highlighted as significant sources of environmental uncertainty (Korhonen et al., 2014; Petit, 2012; Petit & Hobbs, 2010; Voss & Kock, 2013). The authors indicate that this required frequent scope adjustments due to shifting priorities. Additionally, these studies identified another source of environmental uncertainty driven by external factors such as market and technological turbulence. Rapid technological advancements and changing market conditions formed a significant source of uncertainty for the companies analyzed. These factors caused problems in predicting the future environment in which the project portfolio operates, thereby challenging its management.

Single projects
This category refers to uncertainties that arise within individual projects, which can subsequently impact the overall project portfolio. A significant source of uncertainty within this category is the variability of project estimates (Petit, 2012; Ward & Chapman, 2003). This variability can relate to project requirements such as time, budget, or resources and is often driven by factors such as a lack of clarity in project specifications, communication between stakeholders, or interdependencies between project activities. This source of uncertainty is challenging due to the unpredictability of the project environment. Additionally, project-specific risks pose another source of single-project uncertainty. These might include unplanned technical risks or project scope changes. Such risks are typically accounted for during portfolio planning but may also emerge unexpectedly during project execution (Jerbrant & Gustavsson, 2013; Korhonen et al., 2014; Ward & Chapman, 2003). Finally, unforeseen events represent another single-project source of uncertainty. These events could either directly disrupt the portfolio or have their impact cascaded through individual projects (Korhonen et al., 2014; Petit, 2012). As projects within the portfolio are interdependent, the impact of these uncertainties can lead to significant deviations from the planned schedule,

budget, or deliverables, potentially affecting the entire portfolio.

These examples demonstrate how different sources of uncertainty disrupt project portfolios. Table 2 provides an overview of the uncertainty categories, including sources from the studies and examples.

Table 2: Uncertainty categories, including sources of studies and examples

Uncertainty Category	**Example**	**Source**
Environmental		
Market and Technological Turbulence	Rapid technological advancements, changing market conditions	(Petit & Hobbs, 2010, p.735), (Petit, 2012, p.545), (Korhonen et al., 2014, p.22), (Voss & Kock, 2013, p.85)
External Factors	Regulatory changes, economic downturns	(Petit, 2012, p.735), (Petit, 2012, p.545), (Korhonen et al., 2014, p.22)
Market Turbulence and Competitive Pressure	Increased competition, new market entrants	(Petit, 2012, p.545), (Korhonen et al., 2014, p.22), (Voss & Kock, 2013, p.85)
Changing Customer Needs	Shifting consumer preferences, evolving client requirements	(Petit & Hobbs, 2010, p.734), (Petit, 2012, p.545), (Korhonen et al., 2014, p.22), (Voss & Kock, 2013, p.85)
Organizational Complexity		
Changes in Systems, Structures, and Activities	Implementation of new processes, restructuring	(Korhonen et al., 2014, p.22)
Portfolio Dynamics	Portfolio reconfiguration, shifting strategic goals	(Petit & Hobbs, 2010, p.734)
Resource Allocation and Inter-Project Dependencies	Conflicts in resource allocation, resource shortages	(Petit & Hobbs, 2010, p.735), (Korhonen et al., 2014, p.22)
Single Projects		
Variability in Project Estimates	Changes in time and budget estimates, underestimated complexity	(Petit, 2012, p.545), (Ward & Chapman, 2003, p.100)
Project-Specific Risks	Scope creep, technology risks	(Korhonen et al., 2014, p.22), (Ward & Chapman, 2003, p.99)
Unforeseen Events and Deviation Management	Unplanned technical issues, stakeholder conflicts	(Petit & Hobbs, 2010, p.735), (Korhonen et al., 2014, p.22), (Ward & Chapman, 2003, p.100)

Literature Findings on Dynamic Environment

- PPM can be challenging due to disruptions occurring in the dynamic environment. In literature, disruptions are commonly defined as unexpected events that interfere with normal operations. They disrupt PPM by for example delaying plans, escalating costs, and requiring strategic revisions. This creates pressure that requires adaptive responses to maintain strategic alignment.
- Uncertainty refers to the inherent unpredictability and lack of knowledge about future conditions that can affect project outcomes. Uncertainty encompasses factors that cannot be fully anticipated, and it often manifested in decision-making due to the unpredictability of disruptions.
- These disruptions can arise from three main uncertainty sources: environmental, organizational complexity, and single-project challenges. Each category demonstrates how uncertainties impact project portfolio from different perspectives, underscoring the need for tailored management to maintain portfolio stability and strategic alignment.
- PPM operates under varying conditions, shaped by different levels of **response time** and **impact**. Response time refers to how quickly an organization can identify and react to disruptions, while impact indicates the severity of these disruptions on organizational objectives. These two dimensions shape the applicability of different responses.

3.3 PPM in Dynamic Environments

For organizations to effectively manage disruptions in PPM, readiness for change is essential (Hanssen & Svejvig, 2023). The ability to adapt to shifting conditions, especially in environments characterized by high uncertainty, is critical for maintaining resilience (Mahmoudi & Alidoosti, 2022). As discussed, disruptions demand different management approaches based on specific conditions (time to respond and impact). This section explores the various capabilities organizations can leverage to manage disrupted project portfolios. It examines both dynamic and AHCs. By understanding key characteristics of both capabilities, this allows to identify how different approaches are used in next phases of this research.

3.3.1 Capabilities

To guide organizations in assessing and improving their PPM practices, Hanssen and Svejvig (2023) analyses the current state of organizations readiness to adapt. The authors encounter a trend in developing capabilities that enable organizations to cope with fast changing environments. Capabilities are often understood as 'routines' that allow organizations to deploy resources and make informed decisions under uncertain conditions. (Winter, 2003, p.991) defines an organizational capability as "a high-level routine (or collection of routines) that, together with its implementing input flows, confers upon an organization's management of a set of decision options for producing significant outputs of a particular type". Amit and Schoemaker (1993, p.35) similarly describe capabilities as "an organization's capacity to deploy resources, using organizational processes, to effect a desired end. They are information-based, tangible, or intangible processes

that are organization-specific and are developed over time through complex interactions among the organization's resources." Mahmoudi and Alidoosti (2022) states that organizations with well-developed capabilities can better navigate the unpredictable nature of disruptions, ensuring that their PPM practices remain flexible and resilient.

3.3.2 Dynamic Capabilities

Hanssen and Svejvig (2023) further highlight the evolution of capabilities through the development of 'dynamic' capabilities in organizations, emphasizing their role in adapting to fast-changing environments. By building dynamic capabilities (DCs) and fostering a readiness for change, organizations can better align their management strategies to the varying demands posed by disruptions. There are different interpretations of the concept of 'DCs' when considering the question of whether the development of DCs is effective for managing project portfolios in highly uncertain, fast-changing environments (Suddab et al., 2020). Some authors state that the development of DCs is crucial for organizations to adapt in environments characterized by fast-paced changes (Teece, 2007; Teece et al., 1997). Conversely, Eisenhardt and Martin (2000) contends that while DCs facilitate adaptation in stable environments, they are less effective in high-velocity contexts. For this research, the Teece perspective is considered the most appropriate, as it reinforces the idea that readiness for change is not just about immediate responses but about building sustained processes that allow for adaptability. Furthermore, this perspective aligns well with Schiphol's need to react continuously to shifting conditions and disruptions, enhancing its ability to adapt to new situations.

Teece (2007) developed a multi-level framework used to structure the micro-foundations of DCs. This framework has been applied in many studies and will be used in this research to gain a holistic understanding of the most commonly used DC approach, including its micro-foundations at different levels of PPM. Teece (2007) defined the first level of micro-foundations of DCs as the underlying elements that enable an organization to effectively sense, filter, and interpret uncertainties, opportunities, and threats, seize them by using decision-making based on selection rules and protocols, and reconfigure project portfolios to adapt to the changing environment. These first-level capabilities are conceived as more operational, leading to continuous reconfiguration and realignment of resources (Petit, 2012). The second-order capabilities lead to transformations, process improvements, and changes in other organizational aspects impacting PPM. Barbosa and Carvalho (2023b) investigated the use of DCs from a multilevel perspective, emphasizing the importance of applying DCs through sensing, seizing, and reconfiguration capabilities. To gain a deeper understanding of how DCs are applied through these capabilities, multiple studies are reviewed. This helps establish a solid theoretical foundation for the use and characteristics of DCs, which is essential for analyzing their application under varying conditions of disruption.

Sensing

Sensing capabilities are crucial for identifying and interpreting environmental changes, enabling organizations to respond effectively. Killen et al. (2008) advocate for defining specific roles within the PPM team to continuously monitor and react to emerging changes. These roles involve individuals or teams actively tracking customer needs, technological developments, and market trends, which allow the organization to proactively adapt its portfolio (Daniel & Daniel, 2018). Petit (2012) supports this by emphasizing the need for a system management group responsible for overseeing technological developments and conducting early-stage product demonstrations to

gather customer feedback, adjusting project plans accordingly. These strategies aim to increase an organization's responsiveness to external changes, which is essential for managing project portfolios in uncertain environments. Continuous monitoring capabilities, as suggested by Biedenbach and Müller (2012), include tracking new technologies, market shifts, and competitors' activities to identify potential opportunities and threats. This involves active environmental monitoring to guide decision-making. Petit and Hobbs (2010) highlights the importance of monitoring regulatory requirements and compliance needs to ensure alignment between project development and regulatory standards, especially in highly regulated environments. Additionally, Daniel and Daniel (2018) suggests that developing dynamic criteria for project prioritization and resource allocation is necessary to stay agile in changing environments, enabling organizations to balance risks and rewards effectively. By continuously using and refining sensing capabilities, organizations can stay ahead of disruptions, ensuring that their project portfolios remain agile and competitive.

Seizing

Seizing capabilities involve capturing the value of sensed opportunities. Biedenbach and Müller (2012) emphasize the importance of establishing flexible criteria for project prioritization when changes occur, ensuring projects align with strategic goals and add value to the organization. This dynamic capability enables organizations to adapt quickly based on new information. Similarly, Voss and Kock (2013) focuses on aligning project portfolios with market demands by adapting them to identified customer needs, ensuring relevance in competitive markets. Petit (2012) discusses the use of a centralized board that reviews and prioritizes project change requests based on impact and feasibility, reducing wasted effort and ensuring only critical changes are implemented. By strategically capturing emerging opportunities, organizations can ensure that their project portfolios consistently align with market demands and maximize value.

Reconfiguration

Several studies have identified reconfiguration capabilities as vital for managing project portfolios in dynamic environments. Killen et al. (2012) studied four portfolios over two years in organizations with established DCs and identified strategies like adding new projects, creating subportfolios, and terminating existing ones. Similarly, Petit and Hobbs (2010) emphasizes reconfiguring project portfolios to comply with regulatory changes by adjusting project compositions and reallocating resources. Daniel and Daniel (2018) also highlights the importance of stopping, postponing, or reconfiguring projects—including ongoing ones—based on their evolving value to the organization. Resource reallocation is another key aspect, with Killen et al. (2012) observing changes in financial and human resource allocations to maintain alignment with portfolio goals amid environmental changes. They further recommend using resource planning tools to support PPM. Biedenbach and Müller (2012) also underscores the role of resource allocation in enhancing project portfolio performance, finding that optimizing resource distribution in response to changing market conditions enhances responsiveness to new opportunities. Tools for resource planning are crucial, as discussed by Martinsuo et al. (2014), who emphasizes their role in helping managers identify opportunities within the organization and external environment. In line with this, Killen et al. (2008) and Petit (2012) suggest investing in computer applications that help align resource data for recurring forecasts. Both studies highlight the importance of regular reviews and data sharing across the organization to optimize PPM processes. Organizational structure also plays a significant role in reconfiguration capabilities. Killen et al. (2008) stresses the need to restructure organizations to elevate PPM activities, while Petit and Hobbs (2010) advocates regularly refining workflows to manage portfolios effectively. Clegg et al. (2018) concurs, suggesting that organiza-

tions continuously adapt their structures to support emerging strategies. Effective reconfiguration capabilities allow organizations to adjust their portfolios, ensure optimal resource allocation, and align with strategic goals.

Table 3: Dynamic Capabilities in PPM Literature

	Capability	Authors
Reconfiguration	Adding new projects, creating sub-portfolios, terminating projects	Killen et al., 2012
	Adjusting portfolios to comply with regulatory changes	Petit and Hobbs, 2010
	Stopping, postponing, reconfiguring projects	Daniel and Daniel, 2018
	Reallocating financial and human resources	Killen et al., 2012
	Optimizing resource distribution based on market trends	Biedenbach and Müller, 2012
	Using resource planning tools	Killen et al., 2008; Petit, 2012
	Refining organizational structure and workflows	Killen et al., 2008; Petit and Hobbs, 2010; Clegg et al., 2018
Sensing	Defining specific roles to monitor customer needs, technologies, and market trends	Killen et al., 2008; Daniel and Daniel, 2018
	Establishing a system management group for technological developments	Petit, 2012
	Continuous monitoring of technologies, market shifts, competitors, and regulatory requirements	Biedenbach and Müller, 2012; Petit and Hobbs, 2010; Daniel and Daniel, 2018
Seizing	Establishing flexible project prioritization criteria	Biedenbach and Müller, 2012
	Aligning the portfolio with customer needs and market demands	Voss and Kock, 2013
	Centralized board for reviewing and prioritizing project changes	Petit, 2012

3.3.3 Ad-Hoc capabilities

As mentioned in section 3.3.2, several studies suggest that developing DCs and processes for adapting to changes can create value and offer competitive advantages, especially in dynamic environments. However, some researchers question whether using DCs is always the best approach. Ad hoc approaches were studied as well, which are primarily characterized by their reactive and flexible decision-making capabilities. This approach is based on the tacit knowledge and quick judgment of experienced managers, making it highly effective in environments that demand rapid responses (Hepworth et al., 2017). Tacit knowledge is personal, experience-based

knowledge that is hard to express or formalize, often shared through social interactions or observation rather than documentation (Ahern et al., 2014). It includes skills, insights, and intuitions that individuals acquire over time. AHCs are less dependent on structured processes, allowing for immediate adjustments to unforeseen challenges without the long preparations typically required in more systematic approaches (Wang & Wang, 2017). The applicability of AHCs and DCs is heavily influenced by the level of environmental dynamism an organization encounters. AHCs are particularly useful in highly volatile and unpredictable settings, where the flexibility and low resource dependency allow organizations to respond swiftly and effectively without the constraints of predefined processes (Wang & Wang, 2017). In contrast, DCs are more appropriate in moderately dynamic environments, where changes are significant but occur with some level of predictability. These environments benefit from a structured approach that allows organizations to prepare and adapt without the constant urgency that necessitates an ad-hoc response (Ritala et al., 2016).

This section discussed the use of different capabilities for organizations to manage disruptions in PPM. The application of DCs is conceived as proactive and requires long-term development and structured processes. Decision-making is built on sensing and seizing capabilities. These capabilities enable organizations to systematically reconfigure and transform their operations and resources to adapt effectively to changing environments. In contrast, AHCs are primarily reactive, relying on the tacit knowledge of experienced managers to address immediate and unpredictable challenges. It is unstructured and improvisational, offering rapid, short-term solutions, though often resulting in temporary changes. Table 4 shows an overview of the key characteristics of both approaches.

Table 4: Key Characteristics of Ad Hoc vs. Dynamic Capabilities

Key Characteristic	Ad Hoc	Dynamic
Decision-making	Reactive	Proactive
Decision-making based on	Tacit knowledge of experienced managers	Knowledge by sensing and seizing capabilities
Decision-making processes	Unstructured and improvisational	Structured and formalized
Preparation time	Short	Long
Change	Temporary	Reconfiguration

3.3.4 Hybrid Approach

Hepworth et al. (2017), Ritala et al. (2016), and Wang and Wang (2017) collectively suggest that ad hoc approaches could complement DCs in complex environments. Ritala et al. (2016) highlight the need for hybrid approaches, combining ad hoc problem-solving with DCs, which can enhance adaptability and flexibility. Wang and Wang (2017) support this by suggesting that integrating DCs and ad hoc processes could provide a more holistic approach to strategic change. Jerbrant and Gustavsson (2013) emphasizes the importance of balancing flexibility and structure, highlighting that effective portfolio management requires integrating improvisational practices with more formalized DCs to manage uncertainty. Integrating both AHCs and DCs can potentially provide positive outcomes, particularly when problems within the project portfolio are complex and can be segmented into familiar and unfamiliar categories. A hybrid approach enables organizations to use structured DCs to manage predictable aspects of their projects while leveraging the agility of AHCs for unexpected or unique challenges (Jerbrant & Gustavsson, 2013). This could allow for

greater flexibility and responsiveness and also provide a more comprehensive approach to resource allocation and decision-making.

Literature Findings on PPM in Dynamic Environments

- The importance of developing capabilities that help organizations cope with rapid changes and disruptions is emphasized. Capabilities are defined as high-level routines that enable organizations to deploy resources and make informed decisions under uncertain conditions.
- **Ad-Hoc Capabilities**: These refer to immediate, flexible, and reactive responses that rely on intuition and experience, rather than formalized processes. They are typically temporary and do not require significant changes to the project portfolio.
- **Dynamic Capabilities**: These capabilities involve a long preparation time, structured decision-making, and routines to sense, seize, reconfigure, and transform the project portfolio strategically. They are categorized into:
  - **Sensing capabilities**: Organizational processes and tools that allow an organization to detect, monitor, and interpret changes, trends, and signals in both the internal and external environment.
  - **Seizing capabilities**: Organizational processes and actions that translate insights from sensing capabilities into concrete actions aimed at capturing opportunities.
  - **Reconfiguration capabilities**: Organizational processes that enable organizations to adjust structures and adapt strategies to maintain alignment with changing conditions.
- Integrating ad hoc methods with dynamic capabilities offers a hybrid approach that enhances flexibility and adaptability in managing project portfolios under uncertainty. Ad-hoc responses provide agility for unforeseen challenges, while dynamic capabilities ensure strategic, long-term planning. However, further research is needed to explore this approach's practical application fully.

4 Background and Context Schiphol Airport

In project portfolio management (PPM), mission, vision, goals, and objectives form the hierarchical structure that aligns projects with an organization's overarching strategy. PPM structure at Schiphol is designed to strategically align projects with the airport's long-term vision while ensuring adaptability and efficient resource management. Schiphol divides it's PPM process into two phases: strategic and tactical phase.

4.1 Strategic phase

Schiphol's strategic phase establishes the foundational direction for its project portfolio by aligning it with the organization's mission, which defines its core purpose and reason for existence. The mission acts as the cornerstone for all strategic decisions, including those made within the PPM framework, ensuring that the projects supports Schiphol's overarching portfolio goals.

Schiphol's mission: *"Royal Schiphol Group exists to connect your world, by orchestrating inspiring journeys and building connections for passengers and other stakeholders. As part of this ambition, we are transitioning into an airport that will act as a front runner in sustainability."*

To guide its mission and provide long-term direction, Schiphol developed a 'Masterplan,' articulating a vision for 2050. To ensure this vision is implemented in a SMART (specific, measurable, achievable, relevant, and time-bound) manner, Schiphol identified six strategic pillars: Quality of Network, Quality of Life, Quality of Work, Quality of Service, Safety, and Robust Organization. These pillars are supported by Total Performance Indicators (TPIs), which measure progress through metrics such as the number of intercontinental destinations (Quality of Network), CO2 reduction and reputation score (Quality of Life), employee satisfaction (Quality of Work), on-time performance and NPS (Quality of Service), safety performance (Safety), and return on equity (Robust Organization). To bridge the gap between the long-term vision of the Masterplan and actionable projects, Schiphol created a 10-year 'Midterm Plan' (MTP), which defines strategic priorities and goals for the next decade. For instance, the MTP outlines steps to achieve Schiphol's ambition of becoming the world's most sustainable airport, including operating zero-emissions and zero-waste airports by 2030, contributing 14% sustainable aviation fuel by 2030, and improving the balance between communities and airports through reduced noise and improved air quality. To operationalize these goals, Schiphol maintains a Total Project List (TPL), which includes all initiatives, projects, and programs to be executed within five years. This list is structured into four spatially focused programs—Terminal, Airside, Baggage, and Landside—to ensure spatial and temporal feasibility in delivering the airport's vision.

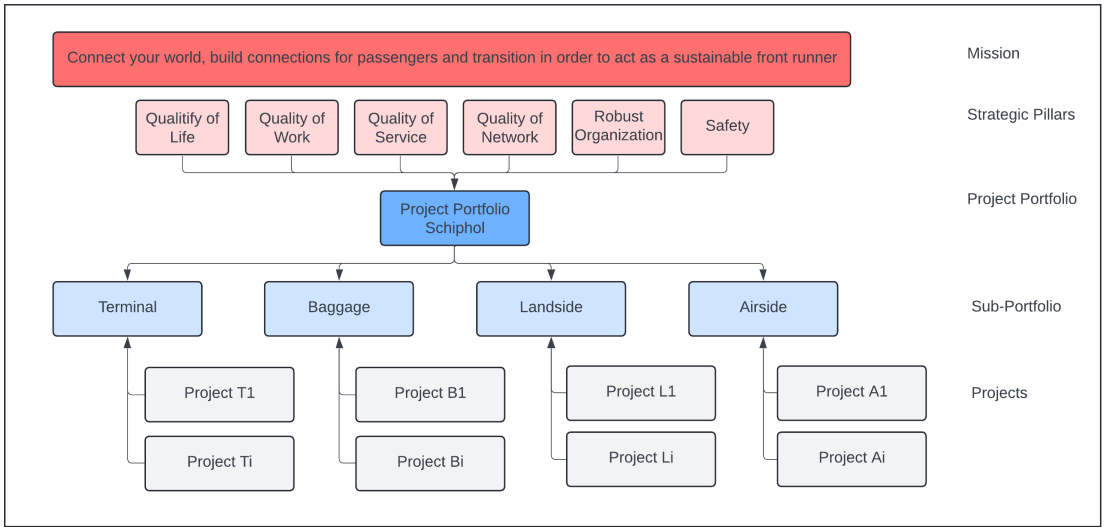


Figure 5: PPM structure Schiphol, source: author

4.2 Tactical Phase

This page is intentionally left blank.

5 Disruptions and Capabilities applied at Schiphol Airport

5.1 Data Collection and Analysis round 1

As mentioned in Section 2, this research consists of two rounds of interviews. The first round aims to collect data on how disruptions impact Schiphol's project portfolio and the capabilities (both ad-hoc and dynamic) used to address these disruptions. A total of 11 semi-structured interviews were conducted for this round. The second round involves 4 additional semi-structured interviews, aimed at exploring how both ad-hoc and dynamic capabilities were used in a combined approach.

Table 5 provides an overview of the interview participant sample for this research. The participants represent a broad range of roles, from high-portfolio-level decision-makers (e.g., Program Lead, Cluster Lead, Airport Development Program Owner) to low-portfolio-level participants (e.g., Project Manager, Work Security Advisor, Main Contractor). This diversity ensures insights are gathered from strategic, tactical, and operational levels, offering a comprehensive understanding of the disruptions and capabilities applied at Schiphol. For the follow-up interviews, specific decision-makers mentioned during the first round were selected based on their involvement in the decision-making process during the disruptions.

Table 5: Participants of the Interviews by Role and Round

Role	Number of Participants	Round(s) of Interview
Program Lead	1	Round 1
Airport Development Programme Owner	1	Round 1
Cluster Lead	1	Round 1 and 2
Cluster Manager	1	Round 1
Project Lead	1	Round 1
Senior Project Manager	1	Round 1
Project Manager	1	Round 1 and 2
Project Client	1	Round 1 and 2
Work Advisor	1	Round 1
Work Security Advisor	1	Round 1
Resource Coordinator	1	Round 1 and 2
Main Contractor	1	Round 1
Reliability Engineer	1	Round 1
Manager Realisation	1	Round 2

The method used to analyze the data obtained from the interviews is explained in Section 2. After completing steps 1–3, the initial coding aimed to categorize interview phrases into components of the theoretical framework in order to identify patterns. This included 'Capabilities,' 'Conditions,' and 'Uncertainty Sources.' As the literature study provided insight into classifications of these labels, the second round of labeling involved assigning terms related to the determined characteristics of AHCs and DCs, different sources of uncertainties, impact levels, and response time levels. After this was done for all 11 interviews, the initial coding labels and second round labels were merged to identify patterns and themes. These themes led to the identification of different AHCs and DCs, as well as various disruptions, categorized according to the sources of uncertainty. Finally, labels referring to time and impact-specific indications were used to determine different

impact levels and response time levels, which were then used for selecting disruptions for further analysis. Overall, data from the literature study and the data collected through semi-structured interviews were used in a qualitative analysis to identify AHCs, DCs, and disruptions (including impact levels and response time) at Schiphol Airport. These insights were then used to select five disruptions for further analysis.

5.2 Disruptions at Schiphol

Key Reader Instruction

This section elaborates on the disruptions identified at Schiphol Airport through Interview Round 1, categorized into three primary sources:

- **Environmental Uncertainties:** External, dynamic, and unpredictable factors affecting the broader operating environment.
- **Organizational Complexities:** Internal interdependencies, structural adjustments, and competing priorities that require portfolio adaptation.
- **Single-Project:** Project-specific, localized disruptions with potential ripple effects across the portfolio.

5.2.1 Single Project

Three disruptions from single-project uncertainty were identified: variability in project estimates, unforeseen weather events and unforeseen contamination.

Variability in Project Estimates

This page is intentionally left blank.

Unforeseen events
Unforeseen events significantly disrupt individual projects within Schiphol's portfolio. Two types have been identified: adverse weather conditions and unexpected soil discoveries. Both have substantial impacts on project planning, resources, and timelines.

Adverse Weather Conditions
Adverse weather conditions are a recurring risk in runway maintenance projects, often causing delays and operational challenges. As noted in Interview 1.12.85, "*Every year, we deal with projects that are delayed due to adverse weather conditions.*" Severe weather, such as prolonged rainfall, can hinder critical tasks like applying runway markings, leading to project overruns despite tight schedules that account for some weather risks. For instance, a maintenance project on Runway 1860 experienced significant delays due to rain, which triggered cascading effects across the broader project portfolio. As described in Interview 5.50, "*Bad weather conditions caused the project to be delivered later than planned. The adjustment in the Integrated Project Planning (IPW[2]) subsequently triggered a chain reaction, delaying the start of other projects.*" Delays in critical infrastructure, such as runways, exacerbate these issues, causing operational inefficiencies, increased congestion, and financial impacts. Interview 23.12.111 highlights the consequences: "*If a runway is not ready, more flights will need to be accommodated elsewhere. This can lead to increased congestion and delays, potentially causing financial impacts as well.*"

Unexpected Soil Discoveries
Soil discoveries, such as contamination or unrecorded underground infrastructure, also significantly disrupt project timelines. These findings often require immediate adjustments to project plans and additional resources, leading to delays and cost overruns. One example is the unexpected discovery of soil contamination during an investigation: "*We encountered glycol contamination. It had to be remediated, and a plan approved by the regulatory authority. Normally, this procedure takes eight weeks, but it wasn't feasible within the planned start time.*" (Interview 3.10). Similarly, unrecorded underground infrastructure can force major changes to project execution: "*Discoveries related to underground cables, pipelines require executing plans in more phases, extending project timelines.*" (Interview 1.3.20). These unexpected findings increase demand for resources, such as additional scheduling or security supervision, and often extend project timelines.

Table 6: Single Project Uncertainty and Disruptions

Disruption	Phrases
Variability in Project Estimates	Table 31, Appendix A
Unforeseen Event - Weather	Table 32, 33, and 34, Appendix A
Unforeseen Event - Soil Discovery	Table 35, Appendix A

5.2.2 Organizational Complexity

Five disruptions from organizational complexity were identified: scarce resources (CSHI, Security Lanes and Personnel), Portfolio Dynamics and Strategic shifts.

[2]Tool that Schiphol uses to align planning, resources, and stakeholder collaboration

Scarce Resources

Resource scarcity, particularly in skilled labor and operational roles, has been a recurring disruption for Schiphol's project portfolio. These constraints—amplified by external factors like the COVID-19 pandemic and ongoing labor market challenges—affect project timelines, create bottlenecks, and increase operational uncertainty.

Scarce Resource: CSHI

This part is intentionally left blank.

Scarce Resource: Security Personnel

Security personnel shortages, exacerbated by Schiphol's downsizing during the COVID-19 pandemic, caused widespread disruptions across passenger operations and project execution. Following 2020 budget cuts, many staff were laid off and not rehired due to aviation's perceived instability. When passenger numbers surged to 5.2 million in June 2022, the airport faced severe bottlenecks, with long queues leading to 15% of flights canceled, 83% delayed, and reputation damage from negative media coverage and a drop in customer satisfaction (Group, 2022; Royal Schiphol Group, 2023; Strategy&, 2023). The shortages also impacted Airside operations, where security staff managed restricted access. Reassignments to maintain these checkpoints caused cascading delays, including up to 3-hour waits for vehicles and personnel, which disrupted ongoing and planned projects: *"If security personnel are at checkpoints, they can't process passengers"* (Interview 20.2.5). Overall, the impact of the security resource was significant:"*During the 2022 summer, with all the security shortages and long queues, everyone suddenly started flying again. That turned out to be the worst summer Schiphol had ever experienced*"(20.2.5).

Scarce Resource: Security Lanes

This part is intentionally left blank.

Portfolio Dynamics
Portfolio dynamics significantly impact Schiphol's ability to manage its project portfolio. The addition or reprioritization of projects introduces an additional layer of unpredictability that requires adjustment. High-value initiatives may be delayed or cause lower-priority projects to be canceled: "Adding projects might require dropping others planned for the next five years" (Interview 2.18.77). Interviews mention one example where an Airside project, initially kept out of the 2026 portfolio, faced reconsideration during reviews, leading to its reinstatement into the portfolio. The decision-making process spanned over three months, disrupting planning and resource allocation. This delay highlighted the cascading effects of portfolio adjustments, particularly when reviews and decisions extend beyond expected timelines.

Strategic Shifts
Strategic shifts at Schiphol, driven by executive directives, regulatory demands, or external pressures, significantly disrupt the project portfolio through sudden reprioritizations and resource reallocations. Poor air quality at Schiphol's Airside platform, caused by emissions from Auxiliary Power Units (APUs) and diesel engines, exemplifies such disruptions. Regulatory intervention from the Human Environment and Transport Inspectorate (ILT) revealed excessive APU use, mandating an urgent action plan to improve working conditions by March 2023. Non-compliance risked penalties of €50,000 per violation and the closure of critical airport sections, threatening operational capacity: "That would have meant shutting down part of our airport" (Interview 20.18.58). These adjustments created bottlenecks, reducing gate availability and limiting the number of aircraft that could be serviced, thereby impacting flight schedules and overall operational efficiency.

This part is intentionally left blank.

Table 7: Organizational Complexity and Disruptions

Disruption	**Phrases**
Strategic Shifts	Table 36, 37 and 38, Appendix A
Portfolio Dynamics	Table 39, Appendix A
Resource Shortage - CSHI Personnel	Table 40, Appendix A
Resource Shortage - Security Personnel	Table 41, and 42, Appendix A
Resource Shortage - Lane Capacity	Table 43, 44, and 45, Appendix A

5.2.3 Environmental Uncertainty

Three disruptions stemming from environmental uncertainty were identified: external factors (COVID-19 and Ukraine War) and changing customer needs.

External Factor

External Factor: COVID-19

The COVID-19 pandemic severely disrupted Schiphol Airport, with passenger numbers dropping by 70.9% compared to 2019, leading to a dramatic decline in daily flights from 1,400 to fewer than 200 during the lockdown (Figure 19, Appendix C.3). This caused a shift from a €355 million profit in 2019 to a €563 million loss in 2020 (Figure 20, Appendix C.3). Interviewees highlighted the COVID-19 crisis as the most disruptive event: "In the past five years, both global and national events have impacted our project portfolio. The most obvious and impactful of these was the COVID-19 crisis." To respond, Schiphol reduced its project budget from €1 billion to €800 million over two years, focusing on cutting cash outflows by 20%. This rapid reconfiguration, occurring between March and June 2020, involved urgent decisions amidst severe workforce shortages and resource constraints, emphasizing the need for swift adaptation to an unprecedented situation.

External Factor: Ukraine War

The war in Ukraine offers another example of how external factors strain project portfolios. Disrupted supply chains and increased costs for raw materials necessitated constant reassessments of financial planning and project budgets. Furthermore, the war's impact on oil and gas prices significantly drove up material costs, challenging project viability and requiring adaptability in logistical arrangements. "*The war in Ukraine broke out unexpectedly between Russia and Ukraine, causing major disruptions for suppliers. Delivery times became uncertain, and logistical routes were no longer reliable. This also affected prices; oil and gas became extremely expensive, which translated into higher costs for raw materials. As a result, contractors had to adjust their prices, creating significant uncertainty for our project portfolio.*" (Interview 8.3.26)

Changing Customer Needs

Changing customer needs, particularly from airlines, introduced additional environmental uncertainty at Schiphol. Airlines strategically align with Schiphol when making major decisions, such as purchasing larger aircraft, which require significant adjustments to infrastructure. For instance, when airlines acquire larger planes, Schiphol must ensure there are sufficient parking spaces, compatible taxiways, and operational facilities to accommodate them. These adjustments are not short-term considerations; aircraft remain in use for approximately 25 years, and corresponding infrastructure changes, like terminals or runways, often have lifespans of 50 and 15 years, respectively. This dynamic requires Schiphol to prepare for varying levels of passenger and fleet growth. However, unexpected shifts in customer needs can disrupt long-term plans and require rapid adjustments. The long-term nature of infrastructure investments means that sudden changes, such as unexpected fleet upgrades by airlines, require Schiphol to proactively revise project priorities. "*We know which planes are coming because airlines, our largest customers, strategically coordinate with us. If they buy larger aircraft, we must ensure there are enough parking spaces.*" (Interview 2.9.44)

Table 8: Environmental Uncertainty and Disruptions

Disruption	Phrases
External Factors - COVID-19	Table 46, 47, and 48, Appendix A
External Factors - War in Ukraine	Table 49, Appendix A
Changing Customer Needs	Table 50, Appendix A

5.2.4 Impact and Response time

The goal of this section is to provide a clear understanding of the conditions under which the disruptions impact Schiphol Airport. Each disruption was analyzed for impact and response time, focusing exclusively on the information available in the interview phrases. Where no explicit timing or impact was stated, similar disruptions were used to draw logical conclusions based on context. Impact refers to the degree of disruption caused to Schiphol's operations, project portfolio, or strategic objectives. Response time refers to the time available between detecting the disruption and when the impact of the disruption becomes visible.

Each phrase was analyzed to extract information about the disruption's impact and response time. Specific phrases like "immediate fixes," "within two months," or "15-year runway planning" were directly tied to their respective timing scales. For ambiguous cases, similar disruptions or contextual information (e.g., complexity, scope) informed categorization. For instance, resource shortages requiring year-long fixes were categorized as mid-term, while project shifts responding to weather changes fell under immediate. This resulted in a five-point time and impact scale as shown in Tables 9 and 10. The phrases are categorized for each disruption and shown in Tables 51 - 59, Appendix A.

Table 9: Impact Levels

Level	Description
High	Portfolio-wide disruption directly affecting the airport's operationality.
Medium-High	Significant disruptions that create delays for multiple projects across the portfolio.
Medium	Moderate disruptions without portfolio-wide implications.
Medium-Low	Minor disruptions without portfolio-wide implications.
Low	Small disruptions contained within one independent project.

Table 10: Response Times

Response Time	Description
Immediate	Detected during the execution phase or with no lead time before impact.
Short-Term	Detected within up to 2 months before impact.
Mid-Term	Detected more than 2 months and up to 6 months before impact.
Intermediate-Term	Detected more than 6 months and up to 1 year before impact.
Long-Term	Detected more than 1 year before impact.

The response time and impact levels identified are visualized in a graph presented in Figure 6. The X-axis represents the impact level, ranging from low to high, while the Y-axis denotes the response time, spanning from immediate to long-term. These insights will be used for selecting the disruptions for further analysis.

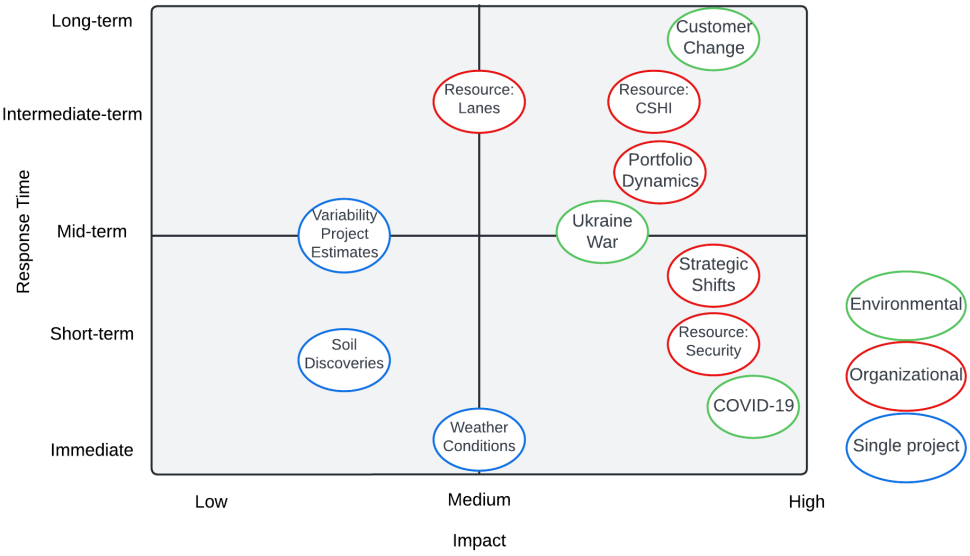


Figure 6: Urgency Matrix, source: author

Appendix A, Table 60, show an overview of the disruption's impact levels and response times including explanation.

5.3 Capabilities applied at Schiphol Airport

Key Reader Instruction

This section elaborates on the capabilities applied at Schiphol Airport to manage disruptions, focusing on two key types:

- **Dynamic Capabilities:** Long-term, structured approaches to sense, seize, and reconfigure the project portfolio strategically.
- **Ad-Hoc Capabilities:** Immediate, flexible, and reactive responses that rely on intuition and experience, rather than formalized processes.

The data analysis of the interviews conducted in round 1, resulted in 24 different capabilities identified. The subsections describe AHC's (3), and DC's (21). For DC's, subcategories (sensing, seizing and reconfiguration) are (**bold**) and specific capabilities are (*italics*).

5.3.1 Dynamic Capabilities

This research identified 21 distinct dynamic capabilities (DCs).

Dynamic Sensing Capabilities Three key dynamic sensing capabilities were identified: Tracking Resource Demand and Supply by Resource Coordinator, Explicit Knowledge Gathering, and Tracking Operational and Legal Compliance. This section elaborates on their application at Schiphol.

Tracking Resource Demand and Supply by Resource Coordinator
Schiphol actively tracks the demand and supply of human resources across the entire project portfolio to assess feasibility and flag potential resource gaps early in the process. This proactive approach allows Schiphol to make informed adjustments and avoid bottlenecks by ensuring resources align with project demands. This is achieved through the establishment of the role of a Resource Coordinator. This role is pivotal in managing Schiphol's critical resources for Airside projects, ensuring demand and supply are balanced over a two-year horizon. The focus is on four essential resources: CSHI (Critical Systems Health Inspection) specialists, ASE supervisors, security personnel, and physical lane capacity for construction traffic. Table 11 provides an overview of the capabilities of this sensing mechanism.

Table 11: Tracking Resource Demand and Supply by Resource Coordinator

Mechanism	Details
Resource Coordinator	Established role to identify and address resource supply and demand across the portfolio
Interviews	3.23, 4.8.79, 10.9.22, 1.10.72, 22.2.9, 6.6.25 (Table 61, Appendix B)

Explicit knowledge gathering
Schiphol employs advanced sensing capabilities to gather explicit knowledge about resource availability, enabling more effective resource management. As highlighted in Interview 4.40.1, "*This helps us make proactive decisions and allocate our resources more efficiently.*" Forecast simulation models predict resource demand and identify potential bottlenecks, such as security lane

capacity during peak project periods at Airside. These models provide a dynamic, data-driven view of resource fluctuations: "*This allows us to address challenges before they become significant problems*" (Interview 4.41.1). To gain this explicit knowledge, Schiphol integrates live monitoring to validate and refine forecasts. For example, real-time data on security lane capacity and processing times is collected at checkpoints, ensuring forecast accuracy and detecting inefficiencies. Additionally, the number of supervisors deployed for projects is monitored and compared to forecasts, identifying over-allocations that indicate inefficiencies in resource planning. This creates a continuous feedback loop that improves resource management by validating assumptions and optimizing allocation: "*It gives us the opportunity to adjust and make better use of scarce resources.*" (Interview 4.41.2). Table 12 provides an overview of the abilities of such a sensing capability.

Table 12: Explicit Knowledge Gathering

Mechanism	Details
Explicit Knowledge Gathering	Schiphol gathers explicit knowledge through forecast simulation models and live monitoring systems.
Interviews	22.3.12, 4.40.1, 4.40.2, 4.40.3 (Table 62, Appendix B)

Tracking Operational and Legal Compliance

Schiphol operates under strict legal and operational constraints, necessitating proactive planning and continuous assessment to ensure compliance and efficiency. Legal requirements, such as adherence to EASA (European Union Aviation Safety Agency) regulations[3], mandate high safety, operational, and environmental standards. Non-compliance risks, including fines or closures, are mitigated through ongoing monitoring and alignment with regulatory standards. Operational constraints require early planning to maintain flow, capacity, and safety. For instance, Schiphol limits the number of VOPS (Vehicle and Operational Parking Spaces) that can be out of operation at any time, minimizing impacts on on-time performance (OTP) and operations: "*It has been agreed with various stakeholders that you can only take a maximum of four VOPS out of operation during this period*" (Interview 11.16.30). During large-scale projects, temporary measures, such as establishing alternative VOPS or taxi routes, help maintain continuity and reduce disruptions. By integrating these legal and operational considerations into project portfolio management, Schiphol aims to balance regulatory adherence with operational efficiency to minimize disruptions and maintain safety standards.

Table 13: Tracking Operational and Legal Compliance

Mechanism	Details
Tracking Operational and Legal Compliance	Process that tracks operational and legal requirements to ensure compliance.
Interviews	11.16.30, 10.12.34 (Table 63, Appendix B)

[3]Encompasses all aspects of aviation safety, ensuring compliance with the applicable Standards and Recommended Practices.

Overview Dynamic Sensing Capabilities

This subsection elaborated on the dynamic sensing capabilities applied at Schiphol Airport to manage disruptions, focusing on:

- **Sensing capabilities (DC)** include Tracking Resource Demand and Supply by Resource Coordinator, Explicit Knowledge Gathering using Forecasting Models, and Tracking Operational and Legal Compliance.

Dynamic Seizing capabilities

A seizing capability refers to the processes, tools, or structures that enable an organization to capitalize on identified opportunities or address disruptions effectively. Based on the analysis, this research identified six different dynamic seizing capabilities. This section elaborates on its application at Schiphol, and how it relates to the sensing capabilities.

Central Planning Tool

Schiphol uses dynamic capabilities to manage resource constraints, notably through the Integrale Planning Werken (IPW) tool, which supports long-term planning and oversight. The IPW integrates resource, operational, legal, and customer requirements into a cohesive system, allowing Schiphol to adapt to disruptions and shifting priorities. It plays a key role in assessing the impact of project decisions on the broader portfolio: "If the projects had gone ahead, it would likely have impacted other projects, necessitating changes to the IPW" (Interview 20.7.23). This proactive approach ensures that project execution does not compromise overall feasibility. Collaboration between the IPW planner, Resource Coordinator, and project managers further strengthens this process: "We are frequently in contact with the IPW planner who creates the IPW, and the Resource Coordinator stays well-informed because they have regular communication" (Interview 20.7.23). By using tools like the IPW, Schiphol aims to manage project adjustments and disruptions. Table 14 provides an overview of this seizing capability.

Table 14: Central Planning Tool: Integrated Planning Workspace (IPW)

Mechanism	Details
Integrated Planning Workspace (IPW)	The IPW integrates resource, operational, legal, and customer requirements into a cohesive planning system.
Interviews	7.18.85, 20.7.23 (Table 64, Appendix B)

Airport Development Team

To stay competitive and respond to evolving customer needs, Schiphol actively monitors technological advancements both internally and externally. The Airport Development Team (ADT) aligns strategy, stakeholder needs, and operational demands with market and technological trends. By studying market developments and project-specific needs, the ADT anticipates challenges and opportunities to future-proof Schiphol's infrastructure. They translate these insights into area visions, roadmaps, and development portfolios that guide the airport's growth. Engaging stakeholders to define project value cases ensures alignment with strategic objectives. By updating the Medium Term Plan (MTP) periodically, the team adapts to shifting demands and regulatory requirements. For example, sustainability is integrated into planning to meet long-term environmental goals. Through such capabilities, the ADT aims to remain competitive by incorporating market insights, stakeholder needs, and sustainability objectives into forward-thinking, cohesive

plans. Table 15 provides an overview of this seizing capability.

Table 15: Airport Development Team

Mechanism	Details
Airport Development Team	Monitor emerging trends.
Interviews	Airport Development Team Insights: Figure 21

Capital Life Cycle Process (CLP)

This part is intentionally left blank.

Link to Sensing capabilities
Schiphol's sensing capabilities, including resource, compliance, and trend monitoring, inform the CLP. The Resource Coordinator identifies gaps early, ensuring feasibility in decision-gate evaluations. Legal and operational requirements, such as VOPS limits and parking needs, ensure compliance. These insights help prioritize initiatives aligned with strategic goals, minimizing disruptions. Table 16 provides an overview of this seizing capability.

Table 16: Capital Lifecycle Process (CLP)

Mechanism	Details
CLP	The CLP is a structured decision-making process at Schiphol that evaluates and prioritizes investment initiatives.
Interviews	20.20.64, 2.8.41, 1.1.6, 2.1.3, 2.2.11, 2.3.15, 2.5.26 (Table 65, Appendix B)

Escalation Process through Project Portfolio Boards

This part is intentionally left blank.

Link to Sensing capabilities
Schiphol's escalation process is linked to its sensing capabilities. Real-time insights from the Resource Coordinator detect resource disruptions (e.g., CSHI or security shortages), triggering escalation to the relevant board. The IPW links sensing and seizing capabilities by updating project data on disruptions or new resource needs, guiding escalation levels, such as when VOPS limits are exceeded. Table 17 provides an overview of this seizing capability.

Table 17: Escalation Process through Project Portfolio Boards

Mechanism	Details
Escalation Process	A structured decision-making process to escalate disruptions to the appropriate decision-making levels.
Interviews	3.4, 3.8, 4.5.40, 8.8.61, 11.19.37 (Table 66, Appendix B)

Scenario Planning based on Predetermined Prioritization Criteria
Schiphol's scenario-based decision-making reduces reliance on ad hoc actions, as highlighted in Interview 3.34: "We want to avoid ad hoc actions as much as possible. In the past, we relied on them more often, but now we build scenarios." These scenarios are based on analyses of constraints like resource limitations, regulatory requirements, and project interdependencies. For instance, during the 2022 security capacity issue, project priorities were set by evaluating fixed capacity and operational needs: "This allowed us to generate and prioritize project combinations based on constraints like regulations and dependencies" (Interview 4.7.62). Each scenario includes a preferred option, following a standardized methodology: "You must present a scenario analysis with a preferred option. That is a standard method" (Interview 5.55). This ensures decisions align with strategic goals while addressing operational challenges. Scenarios also clarify impacts: "The scenarios calculated with operations are well-developed, providing better insight into the impact of decisions" (Interview 23.9.77).

This part is intentionally left blank.

Link to Sensing capabilities
Schiphol's sensing capabilities drive scenario analysis with real-time data. The Resource Coordinator identifies resource gaps, feeding insights into scenario planning for adjustments like rescheduling or resource reallocation. The IPW tool dynamically updates project dependencies and needs, while the Airport Development Team identifies trends to guide long-term scenarios. This integration aims to ensure proactive, aligned responses. Table 18 provides an overview of this seizing capability.

Table 18: Scenario Analysis based on Predetermined Prioritization Criteria

Mechanism	Details
Scenario analysis	Schiphol consistently develops scenarios that are used for decision-making.
Interviews	3.34, 4.7.62, 5.55, 23.2.11, 23.9.77, (Table 67, Appendix B)

Lessons Learned
Schiphol uses lessons learned to adapt strategies and improve project management. By documenting issues and analyzing root causes, the organization identifies risks and integrates preventive measures into future planning. Each project tracks problems like resource shortages and determines ways to avoid them: "If there's an issue, like a resource shortage, we analyze it and determine how to avoid it in the future" (Interview 3.42). Lessons learned are reviewed at project completion and shared across teams, promoting knowledge transfer and preventing repeat mistakes. This process informs decisions with insights from past projects, benchmarks, and market trends: "We are a risk-driven organization that shapes policy and strategy based on lessons learned" (Interview 8.7.48). Standardized reports ensure consistent documentation, creating a feedback loop that strengthens processes and enhances efficiency.

Link to Sensing capabilities
Schiphol incorporates lessons learned into its sensing capabilities to proactively manage disruptions. Standardized reports identify patterns, refine tools like the IPW, and anticipate challenges such as resource shortages. Shared insights drive continuous improvement, enabling early disruption detection and data-driven adjustments. Table 19 provides an overview of this seizing capability.

Table 19: Lessons Learned

Mechanism	Details
Lessons Learned	Schiphol systematically documents and shares lessons learned from completed projects.
Interviews	3.42, 8.7.48, 5.60 (Table 68, Appendix B)

Overview Dynamic Seizing Capabilities

This subsection elaborated on the dynamic seizing capabilities applied at Schiphol Airport to manage disruptions, focusing on:

- **Seizing capabilities (DC)** involve tools, roles and processes such as the Central Planning Tool (CPT), the Airport Development Team (ADT), the Capital Life Cycle Process (CLP), escalation processes via PPM boards, scenario analysis informed by predetermined prioritization, and lessons learned.

Dynamic Reconfiguration capabilities

A reconfiguration capability refers to the processes, tools, or systems that enable an organization to adapt and realign its resources, structures, or strategies in response to evolving conditions or disruptions. Based on the analysis, this research identified 8 different dynamic reconfiguration capabilities: Adjust Planning, Reallocate Resources, Collaboration with Contractors, Planning Buffers and Margins, Workforce Optimization, Terminate or Postpone Projects, Add Project to Portfolio, and Acceptance of Risk as a Collective Decision. This section elaborates on its application at Schiphol.

Adjust Planning

Schiphol utilizes reconfiguration capabilities to address constraints by adjusting project timelines and shifting workloads to reduce bottlenecks. This involves collaboration across stakeholders to identify high-demand periods and optimize resource allocation. For example, rescheduling projects from peak to low-peak periods reduces pressure on resources like security checkpoints. As noted in Interview 3.23, "We come together to discuss possibilities, such as shifting projects or adjusting schedules." This approach ensures better coordination and minimizes disruptions while maintaining portfolio progress. Table 20 provides an overview of this reconfiguration capability.

Table 20: Adjust Planning

Mechanism	Details
Adjust Planning	Reconfigure project and portfolio timelines.
Interviews	3.23, 19.80, 4.9.96, 4.12.119, 11.10.24 (Table 69, Appendix B)

Reallocate Resources

Schiphol addresses resource constraints by reallocating resources between projects, redistributing personnel or equipment to manage immediate shortages. This method often involves intuitive decision-making based on urgency and project needs. For smaller gaps, minor adjustments can be made, as noted in Interview 4.12.119: "There are intuitive margins on how much we can accommodate by tweaking schedules or rosters." For larger gaps, projects may be scaled down or delayed to prioritize critical resources: "If we need more switch capacity (CSHI), we determine which projects to scale down and plan weeks ahead" (Interview 3.15). Table 21 provides an overview of this reconfiguration capability.

Table 21: Reallocate Resources

Mechanism	Details
Reallocate Resources	Redistributing personnel or equipment across projects.
Interviews	3.34, 4.12.119, 3.15, 10.4.10 (Table 70, Appendix B)

Collaboration with Contractors

This part is intentionally left blank.

Table 22: Collaboration with Contractors

Mechanism	Details
Collaboration with Contractors	Collaborate with external contractors to bridge resource gaps through their problem-solving capabilities.
Interviews	4.12.119, 3.23, 3.15 (Table 71, Appendix B)

Planning Buffers and Margins

Schiphol uses margins and buffers as proactive measures to manage disruptions in its project portfolio. Buffer planning creates gaps between projects to minimize interdependencies and avoid cascading delays. As noted in Interview 2.15.63, "You can take control measures by planning some space between projects or making them less dependent on one another." Contractors are also required to include margins in their resource calculations to absorb disruptions like illness or leave, ensuring flexibility in resource availability: "They also include margins for illness and leave in their calculations" (Interview 4.10.102). This approach aims to maintain project schedules and prevent minor issues from escalating into significant delays. Table 23 provides an overview of this reconfiguration capability.

Table 23: Buffer Planning and Margins

Mechanism	Details
Planning Buffers and Margins	Plan in buffer and resource margins between projects.
Interviews	2.15.63, 4.10.102 (Table 72, Appendix B)

Workforce Optimization

Schiphol aims to ensure workforce stability through proactive and reactive measures to address labor shortages and maintain project continuity. Proactively, Schiphol improves worker well-being by involving employees in planning, upgrading conditions, and collaborating with educational institutions to train staff: "We decided to partner with an educational institution to train people ourselves" (Interview 7.14.68). Reactively, it launches recruitment campaigns and renegotiates collective labor agreements (CAO) to fill immediate gaps, such as the post-COVID security personnel drive: "We launched a large campaign with suppliers to improve conditions and attract workers" (Interview 4.20.167). This approach aims to balance immediate needs with long-term workforce development. Table 24 provides an overview of this reconfiguration capability.

Table 24: Workforce Optimization

Mechanism	Details
Workforce Optimization	Schiphol implements strategies to enhance workforce availability.
Interviews	8.10.83, 7.14.68, 4.20.167 (Table 73, Appendix B)

Terminate or Postpone Projects
In response to resource constraints, timing issues, or external disruptions, Schiphol may postpone or terminate projects.

This part is intentionally left blank.

Postponing projects helps conserve resources during uncertainty, like when a security personnel shortage led to the delay of a project to prevent strain on resources: "We decided not to proceed with project 'Yankee', as it would have overburdened resources" (Interview 7.10.44). However, reduced activity periods also present opportunities to advance difficult-to-execute projects, such as those in hard-to-access areas: "We brought forward projects that were hard to access otherwise, using the reduced activity as an opportunity" (Interview 7.10.44). These adjustments aim to align operational, financial, and strategic needs. Table 25 provides an overview of this reconfiguration capability.

Table 25: Terminate, Postpone, or Prioritize Projects

Mechanism	Details
Terminate, Postpone or Prioritize Projects	Schiphol adapts its project portfolio by terminating, postponing, or reprioritizing initiatives.
Interviews	7.10.44, 2.12.53, 9.5.29 (Table 74, Appendix B)

Add Project to Portfolio
Schiphol adds new projects to the portfolio to address emerging needs or capture unforeseen opportunities, requiring reprioritization to align with strategic objectives and resources. For instance, regulatory demands like labor inspections prompted the prioritization of compliance projects: "A new project was started to meet labor inspection requirements, added to the portfolio at the expense of less urgent projects" (Interview 9.5.29).

This part is intentionally left blank.

Adding projects aims to ensure that critical requirements are met and unforeseen disruptions are addressed. Table 26 provides an overview of this reconfiguration capability.

Table 26: Add Projects to the Portfolio

Mechanism	Details
Add Project to Portfolio	Incorporates new projects into the portfolio.
Interviews	2.11.50, 2.12.53, 9.5.29 (Table 75, Appendix B)

Acceptance of Risk as a Collective Decision

This part is intentionally left blank.

Table 27: Acceptance of Risk as a Collective Decision

Mechanism	Details
Acceptance of Risk	A deliberate choice of risk acceptance.
Interviews	6.60, 5.50, 4.24.185, 11.10.24, 7.13.59, 1.12.85, 3.19 (Table 76, Appendix B)

Overview Dynamic Reconfiguration Capabilities

This subsection elaborated on the dynamic reconfiguration capabilities applied at Schiphol Airport to manage disruptions, focusing on:

- **Reconfiguration capabilities (DC)** encompass adjusting planning, reallocating resources, collaborating with contractors, implementing planning buffers and margins, optimizing workforce strategies, terminating or postponing projects, adding new projects to the portfolio, and collectively accepting risk as part of strategic decision-making.

5.3.2 Ad-Hoc Capabilities

As mentioned in Section 3.3.3, AHCs involve short preparation time, an unstructured and improvised decision-making process based on the tacit knowledge of experienced managers. Based on the analysis, this research identified 2 different AHCs: Ad-hoc Data Gathering and Improvised Solutions. This section elaborates on these AHCs.

Ad-hoc data gathering

Schiphol employs ad-hoc data-gathering capabilities to quickly collect relevant, context-specific information to address immediate challenges or disruptions. Resource demand and supply information is gathered by consulting project managers and contractors, with the resource coordinator analyzing weekly data to compare project needs with availability. For instance, tracking security lane access demand against supply enables early identification of gaps, allowing Schiphol to prepare for peaks without committing to long-term overstaffing. This process involves both tacit and explicit knowledge. Tacit knowledge, being informal and experience-based, is retained within individuals and shared through direct collaboration.

This part is intentionally left blank.

Informal discussions also play a role, as highlighted in Interview 1.7.45: "People discuss among themselves, call each other: 'How can we fix this in the best interest of the airport?'" Table 28 provides an overview of this reconfiguration capability.

Table 28: Ad-hoc data Gathering

Mechanism	Details
Ad-hoc data Gathering	Informal process leveraging interpersonal communication and unstructured decision-making to gather individual expertise and intuition.
Interviews	1.11.77, 5.60, 5.44, 1.14.97, 1.15.104, 1.8.53, 1.7.45, 15.104, 3.15, 5.37 (Table 77, Appendix B)

Improvised Solutions
Schiphol employs improvised solutions to address disruptions when predetermined plans prove insufficient. These ad-hoc capabilities aim to minimize the impact of unforeseen challenges. For instance, during adverse weather, a temporary tent allowed construction to proceed (Interview 5.50). Similarly, limited security lane capacity prompted the creation of a secured depot at Schiphol Zuidoost, streamlining material inspection and transport (Interview 6.28). Schiphol also transfers disruption management to contractors, such as by rescheduling work to weekends in exchange for reduced weekday demands (Interview 4.3.23). These flexible, improvised solutions mitigate disruptions while maintaining project and operational continuity. Table 78 provides an overview of this reconfiguration capability.

Table 29: Improvised Solutions

Mechanism	Details
Improvised Solutions	Schiphol employs improvised and immediate measures to address disruptions.
Interviews	5.50, 6.28, 4.3.23, 9.8.48 (Table 78, Appendix B)

Overview Ad-Hoc Capabilities

This subsection elaborated on the ad-hoc capabilities applied at Schiphol Airport to manage disruptions, focusing on:

- **Ad-hoc data gathering**: Rapid collection of information to understand and address disruptions.
- **Improvised solutions**: Developing creative, situation-specific responses to manage and mitigate immediate challenges.

5.4 Disruptions selected for further analysis

This section will further elaborate on the disruptions selected for inclusion in the subsequent analysis phase of this research.

To ensure that the selected disruptions are relevant and representative of the research objectives, the selection process was guided by a set of criteria focused on impact, response time, and uncertainty sources. Disruptions were chosen from each of the three uncertainty categories—organizational complexity, single-project disruptions, and environmental disruptions—to provide a comprehensive understanding of the various challenges faced by the organization. As highlighted in Interview 2.7.37: "In the define phase, it is often challenging to improvise, as the focus is on proactively considering potential scenarios. On the other hand, the improvised, reactive approach is more suited to the tactical phase." Therefore, disruptions requiring a short response time and medium to high impact were prioritized, as these scenarios offer opportunities to examine the use of both ad-hoc capabilities (AHCs) and dynamic capabilities (DCs). Disruptions with long-term effects or low impact, which do not trigger immediate or high-pressure decision-making, were excluded to focus on cases requiring both reactive and proactive responses. Environmental disruptions like changes in customer needs were excluded due to their long-term nature, while COVID-19 was selected due to its short-term detection and high impact. For single-project disruptions, unforeseen weather conditions were prioritized over unexpected soil discoveries or project estimate variability, given their medium-high impact and immediate response requirements. Within organizational complexity, strategic shifts and security personnel shortages were selected based on their positioning in the high-impact, short-response quadrant of the urgency matrix. Finally, security lane shortages, identified a year before impact with delayed proactive actions, were included for their potential to involve AHCs in managing the disruption. The five disruptions selected for further analysis are COVID-19, unforeseen weather conditions, strategic shifts, security personnel shortages, and security lane shortages. Figure 5.4 shows an overview of the selected cases in the urgency matrix.

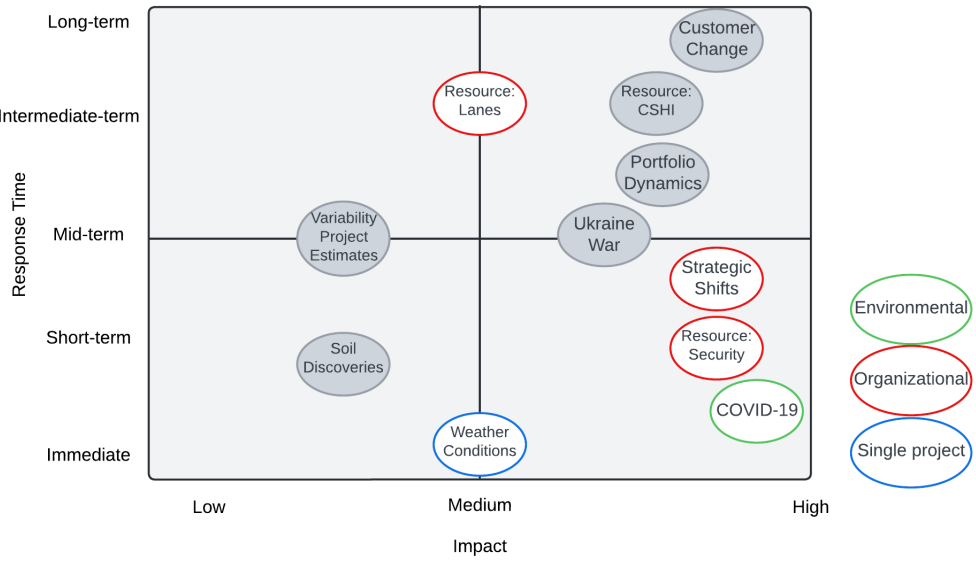


Figure 7: Selected Disruptions, source: author

6 Hybrid approach applied at Schiphol Airport

Key Reader Instruction

- **Objective:** This section delves into the combined application of dynamic and ad-hoc capabilities at Schiphol Airport to manage disruptions. By analyzing the disruptions selected in Section 5.4, it illustrates how these capabilities were employed to address uncertainties.
- **Structure:** The section begins with an overview of the data collection and analysis methods employed for this part of the study. This is followed by detailed subsections dedicated to each selected disruption. Each subsection highlights the interplay between dynamic and ad-hoc capabilities (**bold**, and *italics* for specific capabilities).
- **Conditions:** The section concludes with a examination of the relationship between disruption impact, response time, and the use of dynamic and ad-hoc capabilities.

6.1 Data Collection and Analysis round 2

As mentioned in Section 5.1, the second round involves 4 semi-structured interviews, aimed at exploring how different AHCs and DCs were used in a combined approach. In the second round of interviews, themes identified in the first round were applied to label specific disruption conditions and classify their sources of uncertainty. This enabled categorization by type, response time, and patterns. The analysis then linked AHCs and DCs to these disruptions, exploring their application across different conditions. Disruption conditions were further analyzed by impact levels and response times, contextualized within uncertainty classifications. Finally, overarching themes demonstrated how a hybrid approach, combining AHCs and DCs, was employed to address disruptions. Each disruption follows a consistent structure: it begins with the context and impact of the disruption, followed by an analysis of dynamic and AHCs used to manage the disruption, supported by phrases from interviews and relevant documents.

6.2 Disruption 1: External Factors: COVID-19

Recap disruption: COVID-19

- **Introduction:** The COVID-19 pandemic led to severe disruptions at Schiphol Airport, resulting in massive reductions in air traffic and financial losses. This external disruption triggered urgent adjustments to the project portfolio, workforce, and operation of the Airport.
- **Impact Level:** High - Extensive portfolio reductions, inability to operate, workforce downsizing, and canceled projects demonstrate a significant portfolio-wide impact.
- **Response Time:** Short-Term - Actions were implemented urgently within two months to manage the disruption.

Tables 79 80 and 81, Appendix C.3 show an overview of the phrases from the interviews related to the management of the COVID-19 disruption.

Dynamic Capabilities

Reconfiguration Capability: Project Postponement/Termination

During the pandemic, the Executive Team (ET) established a maximum budget threshold to reduce the overall project portfolio and align expenditure with available financial resources. Each program (Airside) was given specific reduction targets and tasked with identifying adjustments to meet these goals. These proposed adjustments were then presented to the ET for approval. Schiphol postponed or terminated non-essential projects, particularly those focused on renewal, innovation, and expansion. Essential projects, such as those related to safety, regulatory compliance, and permits, were prioritized and allowed to proceed. This approach aimed to align resource allocation and project planning to address the financial challenges posed by the pandemic.

Seizing Capability: CLP using Scenario analysis based on Value Impact Criteria

This part is intentionally left blank.

Ad-hoc Capabilities

Ad-Hoc data gathering

During the pandemic, uncertainty about its duration and impact made decision-making difficult, as there was limited information to prioritize projects and adjust the portfolio. Interview 23.8.68 stated: "We had no idea how long this situation would last, making planning difficult." Therefore, Schiphol relied on ad-hoc data collection, often drawing on tacit knowledge from project managers and contractors.

This part is intentionally left blank.

While this ad-hoc capability helped manage disruptions, the lack of proactive information highlighted the need for better portfolio management systems that could provide information without relying on retroactive data collection.

Conclusion Schiphol's Response to COVID-19

Schiphol's response to COVID-19 combined dynamic capabilities (DCs) and ad-hoc problem-solving (AHCs). Reactive ad-hoc data gathering filled the lack of proactive dynamic sensing capabilities. This data was used to support dynamic seizing capabilities like scenario planning to prioritize projects. Dynamic reconfiguration capabilities then adjusted the portfolio by postponing or terminating non-essential projects to align with limited resources, ensuring critical operations continued. This demonstrates the application of an hybrid approach in managing disruptions where AHC's are used to inform DC's.

Figure 8 shows an overview of each capabilities applied during management of the COVID-19 disruption.

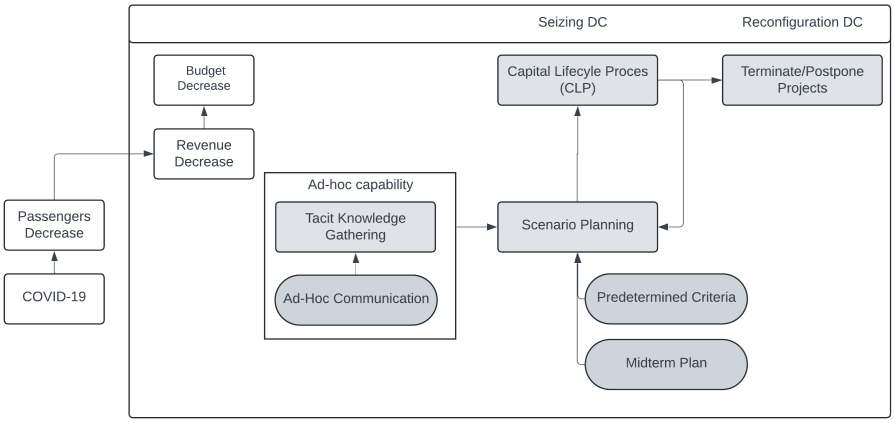


Figure 8: Case 1: COVID-19: Sensing, Seizing, and Reconfiguration mechanisms. Source: author

6.3 Disruption 2: Resource shortage - Security Personnel

Recap disruption: Security Personnel Shortage

- **Introduction:** In response to a budget cut in 2020, Schiphol significantly reduced its security personnel. By June 2022, the airport experienced a surge in passenger numbers, exposing resource shortages both on Airside projects and public-facing services such as Terminals.
- **Impact Level:** High - Insufficient capacity caused project halts, canceled flights, and widespread delays, severely impacting operations.
- **Response Time:** Short-Term - Persistent issues over the summer required urgent and immediate management.

Tables 82, 83 and 84, Appendix C.4 show an overview of the phrases from the interviews related to the management of the security personnel shortage.

Dynamic Capabilities

Reconfiguration Capability: Workforce Optimization

To address these resource shortages and operational challenges, Schiphol deployed several reconfiguration capabilities. For instance, workforce optimization focused on preventing further resource strains by enhancing recruitment efforts and improving working conditions. This included launching a large-scale recruitment campaign, improving collective labor agreements (CAO), increasing pay, and creating better resting areas for staff. Schiphol also prioritized human-centric planning, reducing pressure on workers by involving them in the planning process and minimizing excessive workloads.

Reconfiguration Capability: Project Postponement

This part is intentionally left blank.

Sensing Capability: Tracking Human Resource Demand and Supply

This part is intentionally left blank.

Seizing Capability: Escalation process using Scenario Planning based on Predetermined Prioritization Criteria

Despite the disruption being identified well in advance, the decision to address it was made only days before execution. Initially, the issue was escalated from the Project level to the Airside board, which attempted to mitigate the disruption through adjustments to planning, resource allocation, and scheduling. Given the impact on multiple projects, it was then escalated to the Executive Team (ET), who convened a formal meeting three days before the project start and decided to cancel it. The ET's decision was based on scenario analyses prepared by the Airside Board. According to Interview 12.13, an issue report was compiled, outlining the disruption, its causes, potential solutions, and associated risks. The first step was creating an overview of projects requiring security personnel, highlighting discrepancies between the required and available resources. Several project scenarios were then evaluated to find the best configuration that minimized discrepancies. Each scenario was analyzed based on predetermined criteria, including increased costs (e.g., additional design, asset malfunctions), regulatory non-compliance (such as exceeding asset durability), resource shortages (potential bottlenecks from project delays), and interdependencies between projects (where one project's output was critical for another).

Ad-hoc capabilities

Tacit Knowledge Gathering

While resource demand and supply were proactively gathered by the resource coordinator, tacit knowledge—such as the experience of project managers—was gathered in a reactive, ad-hoc manner. By leveraging this combined expertise and providing detailed project information about potential postponement risks, Schiphol was able to evaluate various project combinations and assess risks. Ultimately, this informed approach was used to make the decision: *"Eventually, the decision was based on our expert judgment"* (Interview 20.14.46).

Conclusion Schiphol's Response to the security personnel shortage

Proactive resource tracking (sensing DC) identified constraints, while recruitment and improved working conditions (reconfiguration DC) aimed to rebuild the workforce. With limited short-term improvements, a structured escalation process (seizing DC) brought the issue to the Executive Team, where scenario planning (seizing DC) evaluated trade-offs. Tacit knowledge gathering (AHC) informed these scenarios, leading to decisions such as postponing Yankee 22 (reconfiguration DC). This illustrates the hybrid approach of using AHCs to inform DCs in managing disruptions.

Figure 9 shows an overview of each capabilities applied during management of the security personnel shortage.

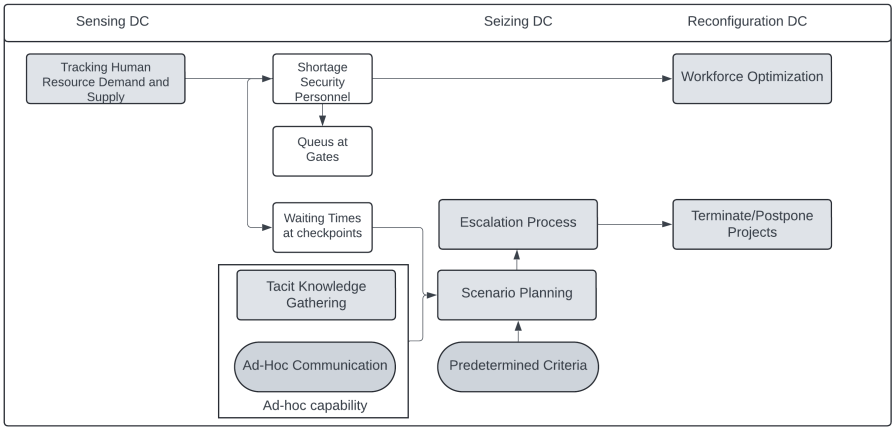


Figure 9: Case 2: Yankee: Sensing, Seizing, and Reconfiguration mechanisms. Source: author

6.4 Disruption 3: Resource shortage - Security Lanes

Recap disruption: Security Lane Shortage

- **Introduction:** In 2024, Schiphol faced security lane capacity constraints at Airside checkpoints, which caused significant delays in construction vehicle traffic. Unlike personnel shortages, this disruption was due to insufficient physical lanes.
- **Impact Level:** Medium - Capacity constraints affected multiple projects within the Airside cluster but remained contained within the area.
- **Response Time:** Intermediate-Term - Insights into capacity constraints were visible a year before the impact, indicating a long-term response.

Tables 85, 86, and 87, Appendix C.5 show an overview of the phrases from the interviews related to the capabilities applied during the security lane shortage.

Dynamic Capabilities

Reconfiguration Capability: Project Postponement

The project team and contractors were engaged to explore whether rescheduling activities could mitigate the capacity issue. However, due to time constraints, the discussions were brief: "The project team aimed to determine whether we had truly done everything possible to mitigate the impact. It turned out to be the case; everybody confirmed that all possible measures had been taken." The project manager and resource coordinator then explored other solutions: "We considered removing a project, but we needed to determine which project that would be and what the consequences would be" (Interview 21.2.16).

This part is intentionally left blank.

Seizing Capability: Escalation process using Scenario Analysis

This part is intentionally left blank.

Sensing Capability: Tracking Demand and Supply and Explicit knowledge gathering

The security lane shortage was proactively detected: "I think the situation was predicted somewhat earlier; I believe we already had the insight at the end of last year that peaks were coming and that capacity would not be sufficient" (Interview 22.2.15). The resource coordinator proactively provided insights by gathering explicit knowledge: "Based on the information provided by the Resource Coordinator, we saw a peak emerging at the Lanes" (Interview 22.2.9). Forecasting simulation models were used to predict peak fluctuations.

This part is intentionally left blank.

Ad-hoc Capabilities

Improvised solution

This part is intentionally left blank.

Conclusion Schiphol's Response to the security lane shortage

Proactive explicit knowledge gathering (sensing DC) identified capacity peaks early, providing actionable insights. Improvised solutions (AHC) were implemented as rescheduling activities could not mitigate the capacity issue. Ultimately, the portfolio was reconfigured by postponing the project. This decision was made through structured escalation (seizing DC) to the Airside Board, where scenario planning and standardized criteria (seizing DC) informed strategic trade-offs. This approach illustrates the integration of proactive sensing into both improvised (ad-hoc) and formalized escalation (dynamic) processes, demonstrating a hybrid use.

Figure 10 shows an overview of each capabilities applied during management of the security lane shortage.

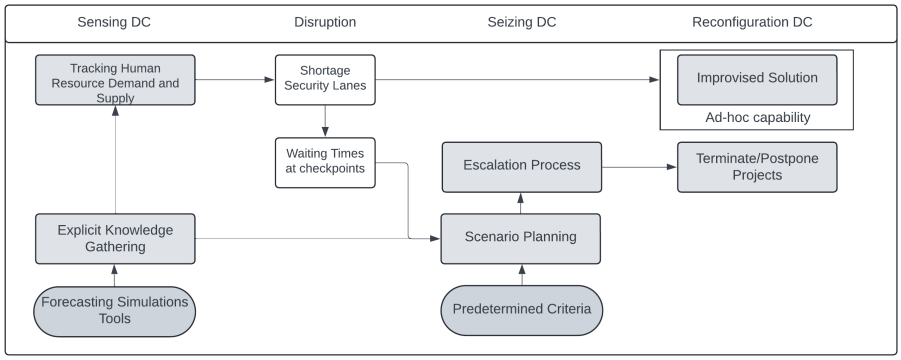


Figure 10: Case 3: Echo-24: Sensing, Seizing, and Reconfiguration mechanisms. Source: author

6.5 Disruption 4: Strategic Shift

Recap disruption: Strategic Shift

- **Introduction:** Between October 2021 and July 2022, poor air quality at Schiphol's Airside platform, caused by emissions from Auxiliary Power Units (APUs) and diesel engines, led to regulatory intervention by the ILT. The mandate required an action plan to improve working conditions.
- **Impact Level:** High - Resource reallocation and project delays threatened operational shutdown, indicating a critical impact on the portfolio.
- **Response Time:** Mid-Term - The process to implement changes and adapt to the shifts took approximately six months.

Tables 88, 89, and 90, Appendix C.6 show an overview of the phrases from the interviews related to the management of the strategic shift.

Dynamic Capabilities

Reconfiguration Capability: Add PCA Project to Portfolio

To meet regulatory deadlines, Schiphol fast-tracked infrastructure projects like the installation of

PCA units, which created significant challenges. These urgent directives required immediate organizational response, resulting in disruptions elsewhere in the portfolio. As one interview noted: *"Certain facilities had to be delivered earlier than planned, causing disruptions in other parts of the portfolio, requiring a fresh look at the schedule, coordination with contractors, and accounting for dependencies. The impact can be significant, but that's how it works."* (Interview 23.14.128). To manage this, projects like PCA units were prioritized as "urgent matters" (Interview 9.4.23), allowing Schiphol to meet regulatory requirements.

Seizing Capability: Accelerated CLP

This part is intentionally left blank.

Seizing Capability: Scenario Planning

Initially, the project team presented proposals through formal channels, including a memo prepared in 2023 outlining options, trade-offs, and associated risks. This memo formed the basis for the funding request to the board. The scenarios addressed compliance risks and operational challenges, evaluating potential risks, costs, and timelines. After escalating the memo to the Executive Team, a solution was chosen based on an acceptable risk profile, enabling Schiphol to avoid the slow pace of traditional timelines.

Sensing Capability: Proactive Tracking of Legal Compliance
During the PCA unit procurement process, Schiphol faced a conflict between regulatory deadlines and formal procurement requirements. Since the project budget exceeded procurement thresholds, Schiphol was obligated to follow European tendering regulations. However, the labor inspectorate's strict deadlines conflicted with the lengthy European tendering process. Through proactive tracking of legal requirements, Schiphol identified the conflict between the tendering laws and the labor inspectorate's deadlines. This early detection allowed Schiphol to assess the feasibility of compliance, evaluate operational risks from missed deadlines, and take corrective actions to ensure adherence to regulations while managing the project timeline.

Ad-hoc Capabilities
Improvised Solution and Ad-hoc data gathering

This part is intentionally left blank.

Conclusion Schiphol's Response to the strategic shift

Proactive legal tracking (sensing DC) identified conflicts between European procurement laws and ILT deadlines. Improvised procurement solutions (AHC) leveraged contractor agreements to bypass tender delays while adhering to legal frameworks. Besides that, the CLP process was accelerated (seizing DC), combining all steps into a single approval cycle. Ad hoc explicit and tacit data gathering (AHC) was used for scenario analysis (seizing DC) to evaluate compliance risks, costs, and operational disruptions. This approach illustrates the integration of proactive, dynamic sensing into both improvised solutions (AHC) and formalized decision-making (DC), demonstrating a hybrid approach to manage strategic shifts.

Figure 11 shows an overview of each capabilities applied during management of the strategic shift.

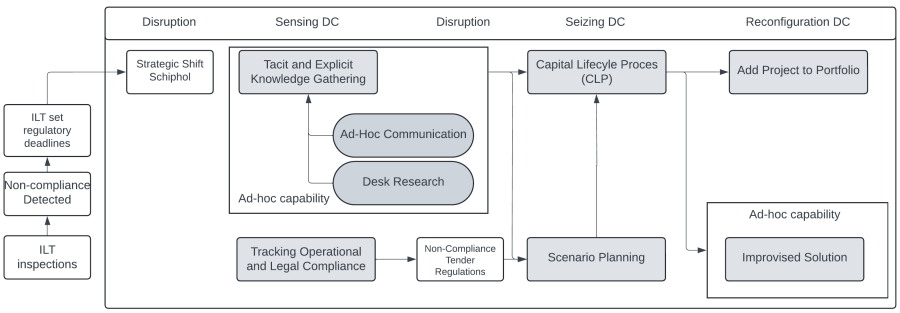


Figure 11: Case 4: PCA: Sensing, Seizing, and Reconfiguration mechanisms. Source: author

6.6 Disruption 5: Unforeseen Event - Weather Conditions

Recap disruption: Unforeseen Weather Conditions

- **Introduction:** Unforeseen weather conditions, particularly prolonged rain, severely hindered critical tasks like runway maintenance.
- **Impact Level:** Medium-High - Cascading delays across multiple projects due to weather disruptions were significant but contained within the Airside cluster.
- **Response Time:** Immediate - Unpredictable weather necessitated immediate responses during execution.

Tables 91, 92, 93, Appendix C.7 show an overview of the phrases from the interviews related to the management of the unforeseen weather conditions.

Dynamic Capabilities

Reconfiguration Capability: Adjust Planning and Allocate Resources

In response to the unforeseen weather conditions, decision-makers revisited the initial goals: *"The focus was placed on everything necessary to get the runway operational. From that focus, further considerations were made, and scenarios were mapped out"* (Interview 23.11.101). Additionally, resources were reallocated, allowing the team to prioritize essential tasks and resources for successful execution: *"By rescheduling the project and all required resources, project management ensured that there was no impact on the portfolio"* (Interview 23.11.97). The reconfiguration process had a significant impact on the people involved: *"It required a lot of people to work extremely hard to meet the goals"* (Interview 23.11.97).

Seizing Capability: Building in Buffers

When the detailed, high-level planning of projects is made, weather risks are taken into account. Schiphol actively identified specific tasks that could be affected by poor conditions, such as runway maintenance activities requiring dry weather, and adjusted schedules accordingly to mitigate potential disruptions. For instance, maintenance activities are scheduled during periods with historically better weather conditions, such as starting in January and aiming to conclude by late spring, when the weather is typically more predictable. Also, for runway projects, a buffer for delays is always included to avoid projects being affected by bad weather. However, while risks were identified in advance and actions were taken, the extreme nature of the actual weather exceeded expectations.

Ad-hoc Capabilities

Ad-hoc data gathering

This part is intentionally left blank.

Conclusion Schiphol's Response to the unforeseen weather conditions

While weather-related forecasting simulations (sensing DC) are used to build in buffers (seizing DC), the disruption exceeded contingencies. To mitigate delays, the project team employed ad-hoc data gathering (AHC) to assess the situation. This information was used to prioritize critical tasks, reallocate resources, and revise schedules collaboratively (reconfiguration DC). These improvised efforts ensured the runway became operational on time with minimal portfolio impact. This approach illustrates the integration of proactive, dynamic sensing and seizing capabilities (DC) and ad-hoc data gathering (AHC), demonstrating a hybrid approach to manage unforeseen weather events.

Figure 12 shows an overview of each capabilities applied during management of the unforeseen weather conditions.

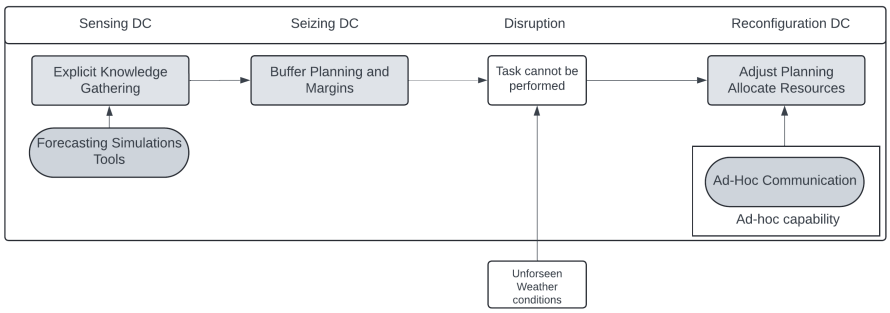


Figure 12: Case 5: Unforeseen Weather Conditions: Sensing, Seizing, and Reconfiguration mechanisms. Source: author

6.7 Hybrid Approach Types

The case study of Schiphol illustrates two types of hybrid approaches in managing disruptions, where ad-hoc capabilities (AHCs) and dynamic capabilities (DCs) are applied.

6.7.1 Type 1: Improvised Solutions (Ad-Hoc Capability) Complement Dynamic Capabilities

The first interplay is particularly evident in the management of two disruptions: security lane shortages and strategic shifts. In each of these disruptions, Schiphol initially employed **dynamic capabilities**, but when these proved insufficient, **ad-hoc problem-solving** approaches were deployed as complementary solutions.

- **Security Lanes Shortage:** Initially, Schiphol used dynamic capabilities (DC) by adjusting the planning, which included forecasting and resource tracking. However, when these measures did not resolve the shortage entirely, improvised solutions (AHC) were implemented. An improvised solutions (storage depot) was applied to resolve security lane shortages This highlights how AHCs act as a contingency when DCs are inadequate.
- **Strategic Shifts:** Here, Schiphol relied on integrating the PCA project into the portfolio, using structured processes like the CLP framework (seizing DC). However, the European tendering process risked delaying compliance with regulatory deadlines. *This part is intentionally left blank*.

Conclusion on Hybrid Approach Type 1

Improvised solutions (AHCs) complement dynamic capabilities (DCs) when DCs are insufficient, acting as contingency measures to address challenges and provide flexible, ad-hoc responses when structured approaches are inadequate.

6.7.2 Type 2: Dynamic Capabilities Complement Ad-Hoc Data Gathering

The second interplay is particularly evident in the management of four disruptions: COVID-19, security personnel shortages, unforeseen weather conditions and strategic shifts. Each of these disruptions illustrates how **ad-hoc data gathering** informs **dynamic capabilities** in the management of disruptions.

- **COVID-19:** During the pandemic, there was limited information available. Therefore, Schiphol relied on reactive ad-hoc data collection (AHC), often drawing on tacit knowledge from project managers and contractors. This was used to prioritize projects and adjust the portfolio (reconfiguration DCs).
- **Security Personnel Shortage:** While resource demand and supply were proactively gathered by the resource coordinator (sensing DCs), tacit knowledge—such as the experience of project managers—was gathered in a reactive, ad-hoc manner (AHC) to inform scenario planning (seizing DC) for project postponement (reconfiguration DC).
- **Unforeseen Weather Conditions:** Schiphol required immediate, ad-hoc data gathering (AHC) to prioritize critical tasks, reallocate resources, and revise schedules collaboratively (reconfiguration DCs).

- **Strategic Shift:** Ad hoc explicit and tacit data gathering (AHC) was used for scenario analysis (seizing DC) to evaluate compliance risks, costs, and operational disruptions.

Conclusion on Hybrid Approach Type 2

Ad-hoc data gathering complements dynamic capabilities by providing reactive, situational insights that inform decision-making, helping to adjust plans, prioritize actions, and reallocate resources during disruptions.

6.8 Capabilities applied under different conditions

This section highlights the relationship between disruption impact, response time, and capability application, emphasizing how these capabilities complement each other under different conditions.

6.8.1 Impact

AHCs are typically sufficient for localized disruptions contained within a program or cluster, as they address issues without requiring extensive portfolio-wide coordination. For instance, the security lane shortage affected multiple Airside projects but did not threaten overall airport operations. AHCs, like adjusting schedules, were attempted but proved insufficient. Similarly, weather-related disruptions impacted several Airside projects but were successfully managed through ad-hoc resource reallocation and planning adjustments. In such cases, decisions remain at the program level due to the contained impact. Conversely, DCs are essential when disruptions threaten airport-wide operations or the entire portfolio. These structured approaches ensure coordinated responses to systemic challenges. For example, the pandemic required realigning the portfolio through Executive Team (ET) decisions to maintain operational continuity. Similarly, the security personnel shortage and the labor inspectorate's mandates, both with portfolio-wide implications, necessitated structured escalation and reconfiguration processes to prioritize operations and prevent shutdowns.

Conclusion on link between impact and capabilities

AHCs are commonly applied for localized disruptions that can be managed within a specific program or area. However, when disruptions affect broader operations or the entire portfolio, DCs are essential for coordinated, systemic responses.

6.8.2 Time to respond

The relationship between response time and the use of dynamic and AHC's highlights a key aspect of disruption management: late responding to disruptions limits the effectiveness of DC's, increasing reliance on AHC's. In Schiphol's security personnel and lane shortages, the disruptions were identified early, but delayed action hindered the use of DC's like workforce optimization and structured resource reallocation. Recruiting and training staff, for instance, required long lead times, making it unfeasible closer to execution. Similarly, late-stage planning adjustments for security lanes were constrained by the schedule's complexity, reducing flexibility. Moreover,

regarding the unforeseen weather conditions, the sudden impact left no opportunity for proactive DC's. Without early sensing mechanisms to anticipate severe weather, Schiphol had to rely entirely on reactive ad-hoc data gathering and decision-making to adjust resources and schedules. The strategic shift further illustrates the risks of late-stage decision-making. Adding a project to the portfolio late in the planning process caused ripple effects, requiring last-minute adjustments and improvised solutions. These disruptions increased the complexity of structured portfolio adjustments, increasing their impact on other projects.

Conclusion on Link between response time and capabilities

Delayed responses reduce the effectiveness of dynamic capabilities (DCs), increasing dependence on ad-hoc capabilities (AHCs). Early identification of disruptions is less effective without timely action, leading to greater reliance on reactive, improvised solutions.

7 Expert Judgment

Key Readers Instructions Expert Judgment

Goal: The expert judgment session aimed to assess the applicability and relevance of the hybrid approach combining dynamic and ad-hoc capabilities. This is done by gathering expert perspectives on the study's conclusions and evaluate the practical implications.

Participants: Seven professionals from the infrastructure sector, with roles in project management and contract advising, shared insights based on their expertise.

Assessment: Participants evaluated five predefined statements about the hybrid approach on a 5-point Likert scale (Strongly Disagree - Strongly Agree).

Follow-up Discussions: Qualitative discussions followed, where participants provided examples or elaborated on their responses. These discussions can be found in Appendix D.

7.1 Findings

Statement	Project Level	Portfolio Level
1. Predefined strategies and ad-hoc problem solving	4.3	2.0
2. Proactive monitoring for ad-hoc problem solving	2.9	1.8
3. Ad-hoc problem solving supplements structured methods	4.4	5.0
4. Lessons from ad-hoc integrated into structure	2.4	2.5
5. Urgency and method selection	4.3	3.3

Table 30: Expert Judgement Score Summary (5-point Likert Scale)

Statement 1

The results of the expert judgment session indicate that participants strongly recognize that decisions are guided by both predefined strategies and ad-hoc problem solving when disruptions occur at a project level. However, at a portfolio level this is not recognized. A participant mentions an example during the occurrence of a design issue at the Afsluitdijk project. A predefined issue- and change-management process was used to address disruptions inherent to the project. However, when a design issue arose due to previously missed boundary conditions, an ad-hoc task force was established. This team revised the design assumptions and escalated the matter to senior management for resolution, combining structured and ad-hoc approaches. Another participant mentions and example where changes in the contract required a structured administrative process involving formal reviews and agreements. Simultaneously, ad-hoc problem-solving occurred on-site to address immediate technical issues and come up with ad-hoc solutions, ensuring the project's progress while the formal process continued.

Statement 2

The results of the expert judgment session indicate that participants, both at a project and portfolio level, are neutral regarding the use of proactively monitored information, such as resource demands and market trends, to inform improvised, ad-hoc solutions. However, two participants provided examples. Financial information, such as the status of expenditures, is regularly collected. This data is used for ad-hoc actions, such as following up with suppliers to inquire about

missing invoices or resolving delays in payments. Besides that, risk dossier are maintained, which includes adaptive measures. Ad-hoc decision-making often occurs regarding the implementation of these measures, especially for risks that are difficult to define precisely. This process relies heavily on tacit knowledge of decision makers to decide whether and how to apply a corrective action effectively.

Statement 3
The results of the expert judgment session indicate that participants, both at project and portfolio level, recognize the use of ad-hoc problem solving to address shortcomings in formalized decision-making processes. One participant mentions when unexpected issues, such as unforeseen conditions in the ground, hinder project progress, following the formal change process would take too long. Ad-hoc collaboration with project management allows work to be continued, mitigating delay-related costs. Another example that was mentioned relates to the taskforce at the Afsluitdijk project. Here, structured design methods proved insufficient to address disruptions caused by significant changes to design principles during the project. A taskforce was introduced as an ad-hoc measure to support and supplement the formalized process, allowing the project to continue without prolonged delays.

Statement 4
The results of the expert judgment session indicate that participants, both at portfolio and project level, do not recognize that their teams modify formalized decision-making approaches based on what has been learned from ad-hoc problem solving. However, one participant mentions an example where throughout the project, various 'detour' routes and temporary traffic measures were applied ad hoc due to safety inspections and complaints from residents. These adjustments ensured that work could continue without unnecessary delays or safety risks. From these ad-hoc adjustments, a new structured process was established to manage such changes in the future. This process incorporates insights from ad hoc measures, ensuring improved management of similar situations in subsequent projects.

Statement 5
The results of the expert judgment session indicate that participants, both at portfolio and project level, recognize that the application of defined and ad-hoc problem solving depend greatly on the urgency of of the disruption. One participant mentions that a number of infrastructural objects were found at the construction site that caused the safety was to be at immediate risk. Although regular management of such occurrences would have gone through a formal procurement process, the urgency of the situation required bypassing these procedures. Immediate action was undertaken to address the safety issue as quickly as possible. Besides that, the examples previously mentioned related to Afsluitdijk illustrate this as well. A major design change had to be addressed outside the regular decision-making process to avoid disrupting the established procedures. This allowed the team to focus entirely on the redesign and ensure faster progress. Similarly, a significant change in scope and budget was managed directly with management outside the standard process due to its high urgency and the clear mandate to act quickly. This approach prioritized decision-making to address the issue effectively.

7.2 Compared with Study Findings

Alignment with findings

The expert feedback supports the application of the hybrid approach in managing disruptions, especially at the project level. Participants acknowledged that predefined strategies often require ad-hoc problem-solving for urgent or unforeseen challenges. Examples such as the Afsluitdijk task force and safety risks confirm that ad-hoc solutions complement dynamic capabilities when structured processes alone are insufficient. This reinforces the conclusions in Hybrid Approach Type 1, where improvised solutions act as contingency measures to address lacks in dynamic capabilities. The influence of urgency, as highlighted in the session, directly aligns with the findings on the link between response time and capabilities. Experts noted that urgent disruptions require bypassing formal procedures, emphasizing the critical role of ad-hoc actions in managing immediate challenges, such as safety risks or critical design changes. This recognizes the observation that delayed responses increase reliance on ad-hoc capabilities.

Divergences

However, there was limited recognition of the hybrid approach's application at the portfolio level. While Type 2 suggests ad-hoc data gathering can inform dynamic capabilities for broader disruptions, the session revealed neutrality regarding the proactive use of monitored information for ad-hoc responses. This indicates a gap in integrating tacit knowledge consistently into structured processes at the portfolio level. One refinement proposed by experts involves better incorporating lessons learned from ad-hoc problem-solving into formalized decision-making frameworks. For example, ad-hoc traffic measures informed the creation of a structured process for managing future safety inspections, suggesting opportunities to institutionalize ad-hoc insights.

Credibility

The expert session adds credibility to the research by confirming key aspects of the hybrid approach, particularly its practicality in addressing urgent, project-level disruptions. However, the limited recognition on portfolio-level applications and proactive measures suggests that the framework could benefit from added context-specific considerations, such as mechanisms for embedding ad-hoc insights into dynamic capabilities and fostering stronger integration across project and portfolio levels.

Conclusion Expert Judgment

The expert judgment session confirms the hybrid approach's application at the project level, where ad-hoc solutions complement dynamic capabilities. However, it highlights a gap in applying this approach at the portfolio level, with limited integration of ad-hoc insights into formal processes. Experts suggest enhancing its PPM approach by incorporating lessons learned from ad-hoc problem-solving into structured, dynamic decision-making. This feedback strengthens the research by recognizing key findings and identifying areas for refinement.

8 Discussion

This section contextualizes the findings within the literature reviewed in Section 3, offering a deeper interpretation of their implications. It focuses on linking the results to existing literature, particularly examining the hybrid use of dynamic and ad-hoc capabilities in managing disruptions. Drawing on the findings from Sections 5 and 6, the discussion begins with discussing the application of the two types of hybrid approaches and continues with these capabilities under varying levels of impact and response time.

8.1 Dynamic Capabilities and Ad-Hoc Problem-Solving

Literature emphasizes the importance of using different management approaches to address varying challenges, often by breaking problems into sub-problems that can be managed through different strategies (Jerbrant & Gustavsson, 2013). Moreover, Jerbrant and Gustavsson (2013) and Wang and Wang (2017) highlight the importance of integrating improvisational practices with DCs to manage uncertainty. This is evident in Schiphol's response to disruptions, where ad-hoc problem-solving played a crucial role when reconfiguration capabilities were constrained.

This part is intentionally left blank.

Academic Contribution: DCs and ad-hoc problem solving

- This study expands the literature by providing empirical evidence that ad-hoc capabilities are not just complementary but essential problem-solving capabilities in high-uncertainty environments, addressing immediate challenges and enhancing dynamic seizing and reconfiguration capabilities when they fall short.

8.2 Ad-Hoc data gathering Capabilities Complementing Dynamic Capabilities

The literature highlights the significance of structured sensing capabilities in dynamic capability theory, which are essential for detecting, interpreting, and adapting to disruptions (Barbosa & Carvalho, 2023a; Teece, 2007). However, some scholars argue that while dynamic capabilities (DCs) enable adaptation in stable environments, they are less applicable in high-velocity contexts (Eisenhardt & Martin, 2000). In contrast, ad-hoc capabilities (AHCs), known for their flexibility and decision-making agility (Hepworth et al., 2017; Jerbrant & Gustavsson, 2013; Ritala et al., 2016), can fill the gaps left by insufficient DCs, offering organizations a more immediate response. The findings from this study corroborate this view, demonstrating that AHCs—such as ad-hoc data collection during the pandemic (Disruption 1), tacit (Disruption 2), and explicit knowledge gathering (Disruption 4)—enabled Schiphol to manage disruptions when formal sensing capabilities were constrained. Additionally, ad-hoc data gathering was used to enable resource allocation and planning during unforeseen events at project level (Disruption 5), illustrating AHCs' role in bridging gaps and supporting decision-making in high-uncertainty environments.

Academic Contribution: DCs and ad-hoc data gathering

- This study expands the literature by providing empirical evidence that ad-hoc data gathering capabilities complement dynamic capabilities by offering flexible, immediate responses in uncertain environments. It demonstrates how ad-hoc data collection, were crucial in managing disruptions when dynamic sensing capabilities were constrained, supporting decision-making and portfolio reconfiguration.

8.3 Impact of Disruption and Capabilities Applicable

Research suggests that the severity of disruptions dictates the management approach. Severe disruptions, such as natural disasters or market shifts, require large-scale interventions, while less severe disruptions can be managed with more targeted strategies (Barbosa & Carvalho, 2023b; Haghighi & Ghasemi, 2018). This is evident in Schiphol's response to disruptions, demonstrating that high-impact disruptions, such as the COVID-19 pandemic (disruption 1), required dynamic, large-scale capabilities across the portfolio. Similarly, security personnel shortages (disruption 2) and strategic shifts (disruption 4) required portfolio reconfiguration and escalation processes to prioritize critical operations and prevent shutdowns, further emphasizing the role of DCs in addressing disruptions that span multiple projects across portfolio. Schiphol's response demonstrates the application of DCs in managing portfolio-wide disruptions. In contrast, localized disruptions are managed through application of AHCs, as seen in Schiphol's security lane shortages (disruption 3) and weather-related (disruption 4) disruptions. These disruptions did not affect the broader portfolio and were (partly for security lane shortage) managed using quick, improvised strategies, highlighting the application of AHCs for localized issues. This illustrate the hybrid use of AHCs and DCs, where localized issues are managed with AHCs, while broader disruptions necessitate the strategic capabilities provided by DCs.

Academic Contribution: impact and capability application

This study extends theory by demonstrating the hybrid use of AHCs and DCs, with application of AHCs to manage localized disruptions and leveraging DCs to address high-impact, portfolio-wide challenges, thereby offering practical insights into disruption management.

8.4 Time to Respond and Capabilities Applicable

Research by Jerbrant and Gustavsson (2013), Ritala et al. (2016), Wang and Wang (2017), and Hepworth et al. (2017) highlights the varying roles of DCs and AHCs depending on response time and environmental volatility. Jerbrant and Gustavsson (2013) argues that a hybrid approach, integrating both capabilities, enables organizations to manage different disruptions by balancing flexibility with structure. However, delayed responses often limit the use of DCs, compelling organizations to rely on rapid, ad-hoc decision-making. Ritala et al. (2016) differentiates between predictable disruptions, where DCs are useful, and highly unpredictable ones, where AHCs prevail. Similarly, Wang and Wang (2017) emphasizes that AHCs, driven by tacit knowledge and quick action, offers flexibility in high-pressure, time-constrained environments.

At Schiphol, this was observed across multiple disruptions. Delayed actions hindered workforce optimization and resource reallocation for managing security personnel shortages (disruption 2), illustrating the limitations of DCs under time pressure. When response time is too short, organizations are more likely to rely on reactive, ad-hoc capabilities. In the case of security lane adjustments (disruption 3), the complexity of the schedule constrained structured DCs, highlighting their diminished applicability when time constraints or environmental complexity limit flexibility. Unforeseen weather conditions (disruption 5) provided no opportunity for proactive DCs, necessitating reactive ad-hoc data gathering and decision-making to adjust resources and schedules. This underscores that sudden, unpredictable disruptions demand AHCs, as DCs lose their relevance. Lastly, late-stage decisions due to strategic shifts (disruption 4) complicated structured portfolio adjustments, further reinforcing the need for ad-hoc solutions in such scenarios. The expert session reinforces the study's findings on urgency influencing the balance between DCs and AHCs. Experts emphasized that urgent disruptions, like safety risks or design changes, require bypassing formal procedures in favor of ad-hoc capabilities, aligning with observations that delayed responses increase reliance on AHCs. This supports the study's conclusion that unpredictable, high-urgency disruptions limit DC applicability, demanding flexible, immediate problem-solving approaches.

Academic Contribution: time to respond and capability application

This study extends theory by illustrating the application of AHCs when time constraints or environmental uncertainty limited the applicability of DCs, offering practical insights into balancing flexibility and structure in disruption management.

9 Conclusion, Limitations and Recommendations

This section provides an overview of the conclusions drawn from the research findings. It also discusses the study's limitations, highlighting practical and theoretical constraints that may impact the generalizability or application of the findings. Finally, practical and theoretical recommendations are offered to guide organizations in adopting strategies and capabilities to better manage disruptions and enhance resilience under uncertainty.

9.1 Conclusion

This research aimed to investigate how a hybrid approach combining dynamic capabilities (DCs) and ad-hoc capabilities (AHCs) is applied in project portfolio management (PPM) to address disruptions in uncertain environments. Specifically, it examined when and how DCs are complemented by AHCs. Using Schiphol Airport as a case study, the research explored the interplay between these capabilities in managing disruptions. The primary objective was to address the main research question, as outlined in this section, which was answered through four sub-questions detailed in Section 1.

9.1.1 Sub-question 1

How do dynamic and ad-hoc capabilities support PPM in managing disruptions under varying conditions, and what role does a hybrid approach play?

Insights from the literature indicate that dynamic and ad-hoc capabilities support project portfolio management (PPM) by addressing disruptions under varying conditions.

- Dynamic capabilities, such as sensing, seizing, and reconfiguration capabilities, provide a structured and strategic approach to detect and respond to disruptions. These capabilities involve a long preparation time, structured decision-making, and routines, enabling organizations to maintain portfolio alignment with strategic objectives. Ad-hoc capabilities, on the other hand, emphasize immediate, flexible and reactive responses to disruptions. They rely on intuitive, situation-specific actions that address challenges without requiring extensive formal processes or preparation.

- While DCs and AHCs operate as distinct approaches, the literature highlights the potential of a hybrid approach, integrating components of both capabilities. This could balance structure and flexibility, allowing organizations to anticipate disruptions through proactive, dynamic capabilities while also addressing unforeseen events through ad-hoc, reactive capabilities.

- Disruptions in PPM, as suggested in the literature, arise from environmental factors, organizational complexity, and single-project challenges. Their varying conditions—characterized by response time and impact—shape the applicability of responses. Response time refers to how quickly an organization can identify and react to disruptions, while impact indicates the severity of these disruptions on organizational objectives.

9.1.2 Sub-question 2

What types of disruptions has Schiphol Airport encountered, and how have their response times and impacts varied across different sources of uncertainty?

Throughout the first round of interviews, 11 disruptions were identified, stemming from different sources of uncertainties.

- The analysis of disruptions at Schiphol Airport reveals that they vary significantly in terms of both impact and response time. Disruptions can range from low-impact, contained issues affecting individual projects to high-impact events that disrupt the entire portfolio and Airport operation. The response time varies from immediate, where impacts are observed almost instantly, to long-term, with detection occurring over a year before effects are seen.
- Environmental disruptions, such as COVID-19 and changing customer needs, had high impacts but required varied respond times, ranging from short-term actions to strategic long-term adjustments. Organizational complexity disruptions, such as portfolio dynamics and resource shortage issues (CSHI, personnel and lanes), demonstrated medium-to-high impacts and required short-term to intermediate responses. Finally, single-project uncertainties, such as variability in project estimates, unforeseen weather, and soil discoveries, mostly resulted in localized disruptions with shorter response times.
- The analysis of impact levels and response times illustrated that the severity of impact and the time available for responses varied significantly across these categories, highlighting the importance of employing context-specific approaches.

9.1.3 Sub-question 3

Which dynamic and ad-hoc capabilities does Schiphol Airport employ to address disruptions?

This analysis illustrates that Schiphol employs a mix of proactive, dynamic capabilities (DCs) and improvised, reactive- ad-hoc capabilities (AHCs) to manage disruptions. A total of 24 capabilities were identified that are employed at Schiphol to address disruptions:

- **Sensing mechanisms (DC)** include Tracking Resource Demand and Supply by Resource Coordinator, Explicit Knowledge Gathering using Forecasting Models, and Tracking Operational and Legal Compliance.
- **Seizing mechanisms (DC)** involve tools, roles and processes such as the Central Planning Tool (CPT), the Airport Development Team (ADT), the Capital Life Cycle Process (CLP), escalation processes via PPM boards, scenario analysis informed by predetermined prioritization, and lessons learned.
- **Reconfiguration mechanisms (DC)** encompass adjusting planning, reallocating resources, collaborating with contractors, implementing planning buffers and margins, optimizing workforce strategies, terminating or postponing projects, adding new projects to the portfolio, and collectively accepting risks.
- **Ad-hoc capabilities** include ad-hoc data gathering and improvised solutions.

9.1.4 Sub-question 4

How were dynamic and ad-hoc capabilities in a hybrid manner used for managing disruptions at Schiphol Airport?

The case study of Schiphol Airport reveals two distinct types of hybrid approaches in managing disruptions, combining dynamic and ad-hoc capabilities:

- **Type 1: Improvised Solutions Complement Dynamic Capabilities.** In this approach, Schiphol initially relied on dynamic capabilities, such as planning adjustment and structured project investment processes (CLP), to address disruptions. When these measures proved insufficient, ad-hoc solutions were implemented as contingency measures. *This part is intentionally left blank*
- **Type 2: Dynamic Capabilities Complement Ad-Hoc Data Gathering.** Here, ad-hoc data gathering provided reactive insights that informed dynamic capabilities, such as reconfiguration and seizing capabilities. Examples include ad-hoc data collection during COVID-19 to prioritize projects and adjust the portfolio, as well as gathering tacit knowledge from project managers to guide scenario planning for security personnel shortages and unforeseen weather conditions. In these instances, ad-hoc data gathering helped seizing and reconfiguration strategies in response to disruptions, complementing the structured, long-term decision-making provided by dynamic capabilities.

9.1.5 Main Research Question

In what context can ad-hoc and dynamic capabilities complement each other to manage disruptions in project portfolios?

The hybrid approach for managing disruptions in project portfolios at Schiphol Airport demonstrates how dynamic capabilities (DCs) and ad-hoc capabilities (AHCs) can complement each other under varying conditions.

- **Impact and capabilities.** AHCs are typically used for localized disruptions within specific programs, such as security lane shortages or weather-related disruptions, where quick adjustments are necessary without portfolio-wide coordination. However, when disruptions affect broader operations or the entire portfolio, DCs are essential for coordinated, structured responses, as seen with the pandemic or security personnel shortages.
- **Response time and capabilities**. Delayed responses to disruptions reduce the applicability of DCs, leading to an increased reliance on AHCs. For example, delays in addressing security personnel shortages or unforeseen weather conditions meant Schiphol had to rely heavily on reactive, ad-hoc measures to adjust resources and schedules. Early identification and timely action are crucial for leveraging DCs, while delayed reactions require improvised, ad-hoc solutions.
- The expert judgment session corroborated the research findings, emphasizing that while ad-hoc solutions complement structured, formalized approaches at the project level, the hybrid approach's application at the portfolio level remains underdeveloped. Experts highlighted the need to better integrate lessons learned from ad-hoc problem-solving into structured decision-making frameworks at the portfolio level. This integration could enhance the

applicability of the hybrid approach, providing a more cohesive management strategy for disruptions at both project and portfolio levels.

9.2 Limitations

9.2.1 Practical Limitations

- **Scope and Generalizability**: This study focuses exclusively on Schiphol's project portfolio management practices, potentially limiting the applicability of findings to other airports or industries. Schiphol operates within a unique regulatory, economic, and environmental context in the Netherlands, which may not fully align with conditions elsewhere. Consequently, the recommendations may not be directly transferable to airports in different regions or countries. Also, by focusing exclusively on the Airside sub-portfolio, the research may not fully capture the diversity of PPM practices across Schiphol's broader portfolio. This focus potentially impacts the results, as Airside's unique approach may not represent the practices of other sub-portfolios, limiting the generalizability of the conclusions.

- **Data Collection and Sampling**:The research included only a subset of decision-makers due to time constraints, which may have constrained the diversity of perspectives analyzed. A more comprehensive inclusion of stakeholders could have enriched the findings and enhanced validity. Additionally, while semi-structured interviews provided valuable qualitative insights, they introduced the potential for subjective bias in both participant responses and researcher interpretation. This reliance on qualitative methods may have affected the robustness of the conclusions.

- **Implementation Challenges**: Improvisational practices, a key focus of this study, are inherently difficult to formalize or standardize. This makes the practical implementation of recommendations challenging, as improvisation depends on situational judgment and cannot be easily quantified or systematically trained.

9.2.2 Theoretical Limitations

- **Framework or Model Constraints**: The study relied on a hybrid approach that extended partially beyond traditional project portfolio management (PPM) frameworks. While this provided novel insights, it introduced potential challenges in aligning findings with established theories.

- **Assumptions and Simplifications**: The research made assumptions about the nature of disruptions and management responses, often treating them as distinct categories. However, the overlap between structured and improvisational approaches blurred these boundaries, complicating the analysis.

- **Interdisciplinary Gaps**: While the hybrid approach integrates elements beyond traditional PPM, it may have overlooked nuances in the varied sub-portfolios at Schiphol. Different sub-portfolios operate under distinct uncertainty factors, potentially requiring tailored management approaches. This gap highlights the need for future studies to account for such contextual differences.

- **Bias and Subjectivity**: The study faced challenges in objectively assessing the impact of disruptions due to limited quantitative and qualitative documentation. Interpretations of

disruption severity, decision-making timelines, and outcomes were subjective, potentially introducing bias. Additionally, participants' perceptions of structured versus improvised approaches varied, leading to inconsistencies in categorization. Social desirability bias may also have influenced interview responses, with participants presenting an idealized version of their practices. Finally, as the study was conducted by a single researcher, personal judgment and decision-making in data analysis could have further impacted the objectivity and comprehensiveness of the findings.

9.3 Recommendations

9.3.1 Practical Recommendations

Use AHC as validation capability for decision-making
The use of both dynamic capabilities (DCs) and ad-hoc capabilities (AHCs) highlights the tension between early detection and the risks of over-relying on predictive tools. While both approaches are valuable for gathering data used for disruption management, they have limitations. DCs, such as sensing mechanisms, depend heavily on the reliability of input data and the clarity of interdependencies between factors. When assumptions or variable data introduce uncertainty, DCs can lead to overly cautious or inaccurate decisions. To address this, it's recommended to complement DCs with AHCs, like real-time data gathering or tacit knowledge, to validate or challenge forecasts, ensuring more effective decision-making. For example, during shortages of important assets such as security personnel and checkpoints, real-time data on staff availability, actual wait times, and passenger flow at security checkpoints could asses forecasts already generated by sensing mechanisms. By integrating AHCs with DCs, organizations can make their PPM decision-making more accurate decision-making and prevent unnecessary interventions, especially in dynamic environments where data uncertainty and real-time adjustments are critical for maintaining operational efficiency.

Create Feedback-loop at Portfolio-level
The study and expert judgment findings highlight how integrated seizing mechanisms are used to learn from previous project decisions when managing disruptions. However, at the portfolio level, there is no formalized feedback loop, creating an opportunity to enhance the portfolio management approach. Over the past years, recurring resource shortages, particularly in technical personnel and critical assets, have posed significant challenges across industries. Schiphol's case study demonstrates this recurring issue, with disruptions like security lane and personnel shortages, highlighting the need for consistent decision-making feedback to improve learning from past decisions. Implementing more structured processes in areas such as risk analysis, decision feedback, and strategic adaptability could offer additional benefits.

To address this, organizations, such as Schiphol, could explore the implementation of a Project Portfolio Management Information System (PPMIS) to document decision-making processes and create a structured feedback loop. Some researchers explored the use of PMMIS, determining that such as tool can centralize decision data, enabling post-impact analyses and continuous improvement of risk management strategies (Gemünden et al., 2020). By incorporating standardized evaluation frameworks and visualizing project interdependencies, the system can improve decision-making, support strategic adaptability, and optimize resource allocation. The recommendation to use AHCs as validation capability for decision-making enhances the PPMIS's ability to provide more accurate forecasts. By integrating real-time, ad-hoc, data and tacit knowledge

through AHCs, the system can validate and adjust DC-generated predictions, leading to better risk mitigation.

Constant Value driven
The research highlights an opportunity to improve Schiphol's PPM by systematically analyzing the strategic impacts of management decisions on value pillars, particularly during disruptions. While Schiphol has established value pillars to guide project selection, disruptions often lead to sudden shifts in the values that are most important, altering the suitability of the project portfolio. Currently, project values are assessed at the beginning of the PPM process, but there is no continuous adaptation of these values when disruptions occur. As the Schiphol case study demonstrates, changes in customer requirements, stakeholder interests, market opportunities, and regulatory factors are recurring disruptive events, affecting the value projects contribute throughout their life cycle.

Therefore, it is recommended to integrate a value-driven approach into Schiphol's PPMIS by systematically analyzing the strategic impacts of management decisions on value pillars, enabling continuous real-time adaptation of project values as disruptions arise. A PPMIS can track project performance and environmental changes, providing decision-makers with up-to-date insights on how these factors influence the strategic value of each project. The system should include scenario analysis tools to assess the potential impact of disruptions on key value pillars and allow for real-time adjustments, ensuring the portfolio remains aligned with Schiphol's strategic objectives.

Quantify the Emotional Impact of Management Decisions
The interview responses highlight an opportunity for improving Schiphol's PPM decision-making by systematically accounting for the emotional and operational impacts of management decisions, especially during disruptions. Last-minute changes can disrupt workflows, affect morale, and strain relationships with stakeholders (e.g. main contractors). To address this, Schiphol could implement a scoring system and post-disruption surveys to quantify these impacts, such as stress from overtime or additional workload caused by resource allocation. This would allow decision-makers to balance current prioritization criteria (e.g. financial outcomes) with criteria such as employee well-being and stakeholder relationships.

9.3.2 Theoretical Recommendations

Explore the use of ad-hoc capabilities as seizing mechanisms:
While this research identified where AHCs has similar roles as sensing and reconfiguration mechanisms, their potential to perform the role of seizing mechanisms remains unexplored. Investigating this area could reveal how improvised and ad-hoc data gathering actions might address the evaluation and decision-making functions of seizing mechanisms. Such research could bridge the gap between structured portfolio adjustments and flexible, real-time seizing opportunities under uncertainty.

Integrating the emotional impact of decision-making on decision-makers in PPM:
Decisions, especially during disruptions, can cause significant emotional strain on decision-makers. This "empathetic damage," coming from the personal and organizational decisions, remains largely unquantified. Future research could explore frameworks to account for emotional impacts of

decision-making processes, offering insights into how these factors impact portfolio reconfiguration.

Providing empirical evidence across countries and sectors:
Extending this research to different countries and sectors could help validate the findings in wider context. By examining the application of a combination of DCs and AHCs in diverse environments, such as Airports with other environmental context, researchers could assess the generalizability of these approaches and identify sector-specific insights.

Measuring decision-making effectiveness:
Future research could develop methods to quantify the effectiveness of decision-making processes in managing disruptions. This could involve assessing the outcomes of DCs and AHCs under different conditions, such as the impact, scope, and timing of disruptions. This way researchers could better evaluate the strengths and limitations of these capabilities, offering evidence-based guidance for gaining knowledge of their use in PPM.

References

Ahern, T., Leavy, B., & Byrne, P. (2014). Knowledge formation and learning in the management of projects: A problem solving perspective. *International Journal of Project Management*, *32*, 1423–1431. https://doi.org/10.1016/j.ijproman.2014.02.004

Amit, R., & Schoemaker, P. J. H. (1993). Strategic assets and organizational rent. *Strategic Management Journal*, *14*(1), 33–46. https://doi.org/10.1002/smj.4250140105

Barbosa, A., & Carvalho, M. (2023a). Toward a multilevel framework of dynamic capabilities through the lens of project management. *International Journal of Managing Projects in Business*, *16*, 600–624. https://doi.org/10.1108/IJMPB-02-2020-0058

Barbosa, A., & Carvalho, M. (2023b). Toward a multilevel framework of dynamic capabilities through the lens of project management. *International Journal of Managing Projects in Business*, *16*, 600–624. https://doi.org/10.1108/IJMPB-02-2020-0058

Bible, M., & Bivins, S. (2011). *Mastering project portfolio management*. J.Ross publishing.

Biedenbach, T., & Müller, R. (2012). Absorptive, innovative and adaptive capabilities and their impact on project and project portfolio performance. *International Journal of Project Management*, *30*(6), 621–635. https://doi.org/10.1016/j.ijproman.2012.01.016

Clegg, S., Killen, C. P., Biesenthal, C., & Sankaran, S. (2018). Practices, projects and portfolios: Current research trends andnew directions. *International Journal of Project Management*, *36*, 762–772. https://doi.org/https://doi.org/10.1016/j.ijproman.2018.03.008

Cooper, R. G. (1990). Stage-gate systems: A new tool for managing new products. *Business Horizons*, *33*, 44–54. https://doi.org/https://doi.org/10.1016/0007-6813(90)90040-I

Cooper, R. G., Edgett, S. J., & Kleinschmidt, E. J. (1997). Lessons from the leaders–i. *Research Technology Management*, *40*, 16–28. https://doi.org/http://dx.doi.org/10.1080/08956308.1997.11671170

Cooper, R. (1981). An empirically derived new product project selection model. *IEEE Transactions on Engineering Management*, *3*, 54–60.

Daniel, P., & Daniel, C. (2018). Complexity, uncertainty and mental models: From a paradigm of regulation to a paradigm of emergence in project management. *International Journal of Project Management*, *36*(1), 184–197. https://doi.org/http://dx.doi.org/10.1016/j.ijproman.2017.07.004

Eden, C., Williams, T., Ackermann, F., & Howick, S. (2000). The role of feedback dynamics in disruption and delay on the nature of disruption and delay (dd) in major projects. *Journal of the Operational Research Society*, *51*(3), 291–300. https://doi.org/10.2307/254087

Eisenhardt, K. M., & Martin, J. A. (2000). Dynamic capabilities: What are they? *Strategic Management Journal*, *21*(10-11), 1105–1121. https://doi.org/10.1002/1097-0266(200010/11)21:10/11<1105::AID-SMJ133>3.0.CO;2-E

EUROCONTROL. (2021, July). Covid-19 impact on eurocontrol airports: Amsterdam schiphol airport briefing [Accessed: 16 July 2021]. https://www.eurocontrol.int

Gemünden, H., Kock, A., Killen, C., & Dunkel, A. (2023). Project portfolio management: A dynamic capability to improve innovation success. *International Journal of Project Management*, *41*, 600–616. https://doi.org/10.1016/j.ijproman.2023.04.002

Gemünden, H., Kock, A., Kopmann, J., & Schulz, B. (2020). Project portfolio management information systems' positive influence on performance – the importance of process maturity. *International Journal of Project Management*, *38*, 229–241. https://doi.org/https://doi.org/10.1016/j.ijproman.2020.05.001

Group, R. S. (2020). Jaarcijfers 2020: Sterke daling luchtverkeer en van financiële resultaten als gevolg van covid-19-pandemie [Accessed: October 8, 2024]. https://www.schiphol.nl

Group, R. S. (2022). Royal schiphol group in 2022 [Accessed: October 8, 2024]. https://www.schiphol.nl/en/schiphol-group/page/annual-reports/

Haghighi, A., & Ghasemi, R. (2018). Developing dynamic project scheduling techniques under uncertainty: Case studies. *International Journal of Project Management*, *36*(8), 1234–1246. https://doi.org/10.1016/j.ijproman.2018.07.003

Hanssen, L., & Svejvig, P. (2022). Seven decades of project portfolio management research (1950–2019) and perspectives for the future. *Project Management Journal*, *53*, 277–294. https://doi.org/10.1177/87569728221089537

Hanssen, L., & Svejvig, P. (2023). Principles in project portfolio management: Building upon what we know to prepare for the future. *International journal of Project Management*, *54*, 607–628. https://doi.org/10.1177/87569728231178427

Hardingham, R. (1970). A simple model approah to multiple-project monitoring. *RD Management*, *1*, 43–47. https://doi.org/https://doi.org/10.1111/j.1467-9310.1970.tb01197.x

Hepworth, A., Misopoulos, F., Manthou, V., & Michaelides, R. (2017). *Exploring ad-hoc portfolio management: Does it work, and is it the flexibility that supports project portfolio management?* https://doi.org/10.1016/j.procs.2017.11.047

Howick, S., & Eden, C. (2008). Dynamic feedback and project success: Lessons from major projects. *Project Management Journal*, *39*(4), 47–60. https://doi.org/10.1002/pmj.20304

Jerbrant, A., & Gustavsson, T. (2013). Managing project portfolios: Balancing flexibility and structure by improvising. *International Journal of Managing Projects in Business*, *6*, 152–172. https://doi.org/10.1108/17538371311291071

Killen, C. P., Hunt, R. A., & Kleinschmidt, E. J. (2008). Learning investments and organizational capabilities: Case studies on the development of project portfolio management capabilities. *International Journal of Managing Projects in Business*, *1*(3), 334–351. https://doi.org/10.1108/17538370810883800

Killen, C. P., Jugdev, K., Drouin, N., & Petit, Y. (2012). Advancing project and portfolio management research: Applying strategic management theories. *International Journal of Project Management*, *30*(5), 525–538. https://doi.org/10.1016/j.ijproman.2011.12.004

Killen, C., & Hunt, R. (2009). Project portfolio management for dynamic environments [University of Technology Sydney, Sydney, NSW, Australia]. *Modernisation in Project Management*, 1–9.

Kock, A., & Killen, C. (2023). The interplay between dynamic capabilities' dimensions and their relationship to project portfolio agility and success. *International Journal of Project Management*, *41*, 102469. https://doi.org/10.1016/j.ijproman.2023.102469

Korhonen, T., Laine, T., & Martinusio, M. (2014). Management control of project portfolio uncertainty: A managerial role perspective. *Project Management Journal*, *45*, 21–37. https://doi.org/10.1002/pmj.21390

Mahmoudi, R., & Alidoosti, M. (2022). Project portfolio management under uncertainty: A robust optimization approach. *Computers Industrial Engineering*, *167*, 107943. https://doi.org/10.1016/j.cie.2022.107943

Markowitz, H. (1952). Portfolio selection. *Journal of Finance*, *7*, 77–91. https://doi.org/10.1002/9780470404324.hof002001

Martinsuo, M. (2013). Project portfolio management in practice and in context. *International Journal of Project Management*, *31*, 794–803. https://doi.org/10.1016/j.ijproman.2012.10.013

Martinsuo, M., & Geraldi, J. (2020). Management of project portfolios: Relationships of project portfolios with their contexts. *International Journal of Project Management*, *37*, 441–453. https://doi.org/https://doi.org/10.1016/j.ijproman.2020.02.002

Martinsuo, M., Korhonen, M., & Laine, T. (2014). Identifying, framing and managing uncertainties in project portfolios. *International Journal of Project Management*, *32*, 732–746. https://doi.org/http://dx.doi.org/10.1016/j.ijproman.2014.01.014

Messina, M. (2023). New product development (npd) project portfolio management: What is the role of learning? *Corporate ownership control*, *20*, 85–99. https://doi.org/https://doi.org/10.22495/cocv20i3art6

Oosterlee, A., Zandt, I., & Keuken, R. H. (2018). Nieuw onderzoek geluidhinder schiphol [Research on noise nuisance around Schiphol Airport, including effects on sleep disturbance and health concerns in the region of Kennemerland.]. *Geluid*, (3), 10–13. https://www.ggdkennemerland.nl/geluidshinder_schiphol_2018

Pasquini, L., & De Smedt, C. (2023). The way forward for europe's aviation sector. *Skyway*, *77*. https://doi.org/https://www.eurocontrol.int/archive_download/all/node/14020

Petit, Y. (2012). Project portfolios in dynamic environments: Organizing for uncertainty. *International Journal of Project Management*, *30*, 539–553. https://doi.org/https://doi.org/10.1016/j.ijproman.2011.11.007

Petit, Y., & Hobbs, B. (2010). Project portfolios in dynamic environments: Sources of uncertainty and sensing mechanisms. *Project Management Journal*, *41*(4), 46–58. https://doi.org/10.1002/pmj.20201

PMI, P. M. I. (2017). *The standard for portfolio management*. Project Management Institute (PMI).

Ritala, P., Heiman, B., & Hurmelinna-Laukkanen, P. (2016). The need for speed—unfamiliar problems, capability rigidity, and ad hoc processes in organizations. *Industrial and Corporate Change*, *25*(5), 757–778. https://doi.org/10.1093/icc/dtw028

Royal Schiphol Group. (2023). Turnaround for schiphol in the first half year of 2023 [2023 Interim Results of Royal Schiphol Group]. https://www.schiphol.nl/en/schiphol-group/page/financial-information/

Sawik, T. (2017). Selection of project portfolios under risk and resource constraints. *European Journal of Operational Research*, *259*(3), 1097–1109. https://doi.org/10.1016/j.ejor.2016.11.030

SchipholGroup. (n.d.). *Improving quality by catching up on maintenance* [https://news.schiphol.com/schiphol-improving-quality-by-catching-up-on-maintenance/].

SchipholGroup. (2023a). *Annual report 2023* (tech. rep.). Schiphol Group.

SchipholGroup. (2023b). *Traffic review 2023*. https://doi.org/https://www.schiphol.nl/en/download/b2b/1710834396/2UYfC67GM37jfzpLvOJHga.pdf

Sheffi, Y. (2015). Preparing for disruptions through early detection. *MIT Sloan Management Review*, *57*(1), 31–41. https://www.researchgate.net/publication/281865735_Preparing_for_Disruptions_Through_Early_Detection

Shenoy, G., & Mahanty, B. (2024). Optimizing project portfolios in uncertain environments: A stochastic approach. *Journal of Risk and Uncertainty*, *45*, 210–225. https://doi.org/10.1007/s11166-023-09345-4

Strategy&, P. (2023, June). Evaluatie herstart schiphol, mei 2023. https://www.pwc.nl

Suddab, R., Coraiola, D., Harvey, C., & W., F. (2020). History and the micro-foundations of dynamic capabilities. *Strategic Management Journal*, *41*, 341–623. https://doi.org/https://doi.org/10.1002/smj.3058

Te Wu, Y. H. J., Huy Will Nguyen, & Ren, I. Y. (2024). Not the usual project management: A better way to prepare for major disruptions. *Journal of Business Strategy*, *45*(5), 338–347. https://doi.org/10.1108/JBS-05-2023-0108

Teece, D. J. (2007). Explicating dynamic capabilities: The nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal*, *28*(13), 1319–1350. https://doi.org/10.1002/smj.640

Teece, D., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, *18*(7), 509–533. https://doi.org/10.1002/(SICI)1097-0266(199708)18:7<509::AID-SMJ882>3.0.CO;2-Z

Teller, T., Unger, B., Kock, A., & Gemunden, H. (2012). Formalization of project portfolio management: The moderating role of project portfolio complexity. *International Journal of Project Management*, *30*, 596–607. https://doi.org/http://dx.doi.org/10.1016/j.ijproman.2012.01.020

Usher, J. (2024). Dynamic capabilities and their role in project portfolio management. *Strategic Management Journal*, *45*(1), 55–70. https://doi.org/10.1002/smj.3245

van Infrastructuur en Waterstaat, M. (2024). *Actieplan omgevingslawaai schiphol 2024-2029* (Plan for managing and reducing environmental noise around Schiphol Airport for the period 2024-2029.). Ministerie van Infrastructuur en Waterstaat. The Hague, Netherlands. https://www.rijksoverheid.nl/onderwerpen/geluid/actieplan-schiphol

Voss, M., & Kock, A. (2013). Impact of relationship value on project portfolio success: Investigating the moderating effects of portfolio characteristics and external turbulence. *International Journal of Project Management*, *31*, 847–861. https://doi.org/10.1016/j.ijproman.2012.11.005

Wang, Y., & Wang, Y., K. (2017). How do firms tackle strategic change? a theoretical model of the choice between dynamic capability-based and ad hoc problem-solving approaches. *Journal of Organizational Change Management*, *30*, 725–743. https://doi.org/10.1108/JOCM-03-2016-0045

Wang, Y., Zhang, H., & Li, X. (2019). A multi-objective decision-making model for project portfolio management. *Journal of Systems Engineering*, *49*(2), 312–325. https://doi.org/10.1007/s00450-019-0945-3

Ward, S., & Chapman, C. (2003). Transforming project risk management into project uncertainty management. *International Journal of Project Management*, *21*(2), 97–105. https://doi.org/10.1016/S0263-7863(01)00080-1

Winter, S. (2003). Understanding dynamic capabilities. *Strategic Management Journal*, *24*(10), 991–995. https://doi.org/10.1002/smj.318

Zarghami, S. A., & Zwikael, O. (2022). Measuring project resilience: Learning from the past to enhance decision making in the face of disruption. *Decision Support Systems*, *160*, 113831. https://doi.org/10.1016/j.dss.2022.113831

A Disruptions at Schiphol Airport

This section elaborates on the phrases of the interviews, documents and other information sources regarding the disruptions identified at Schiphol Airport.

Table 31: Disruption: Variability in Project Estimates

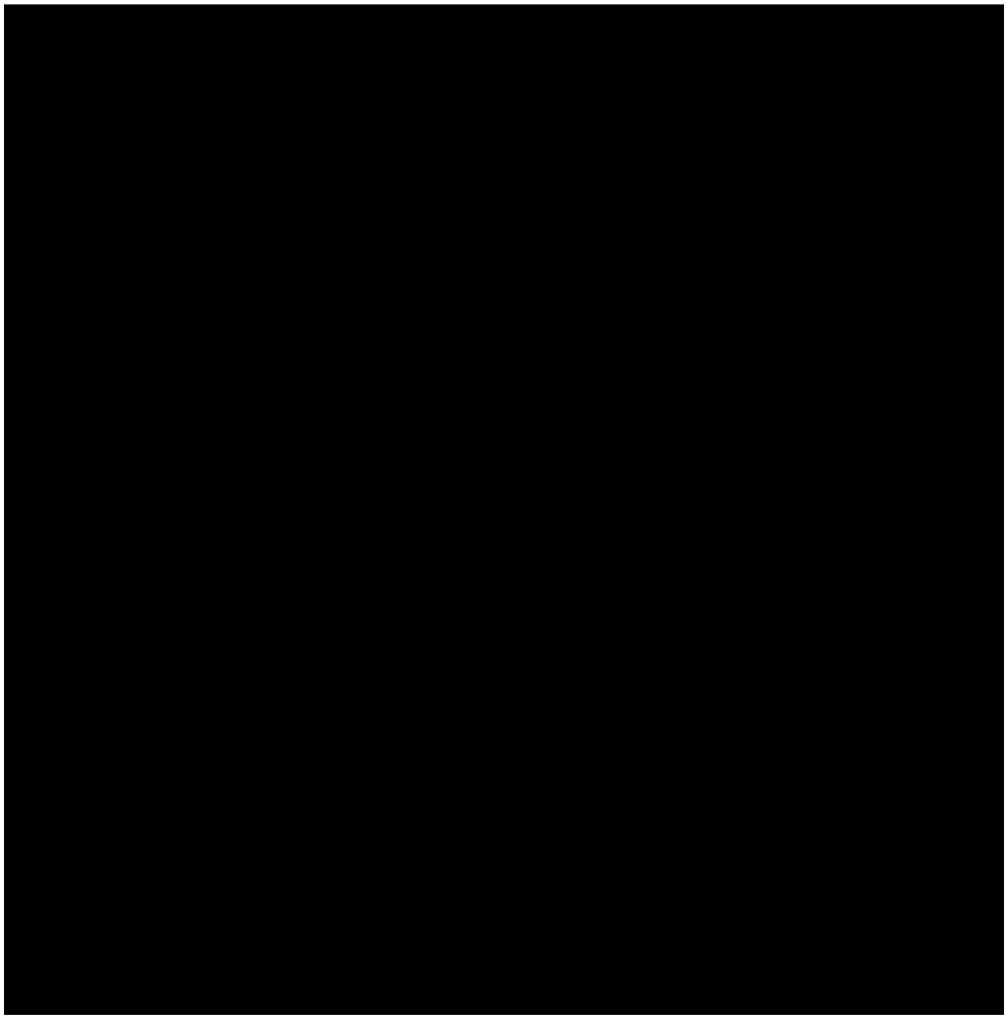


Table 32: Disruption: Unforeseen Events - Bad Weather Conditions

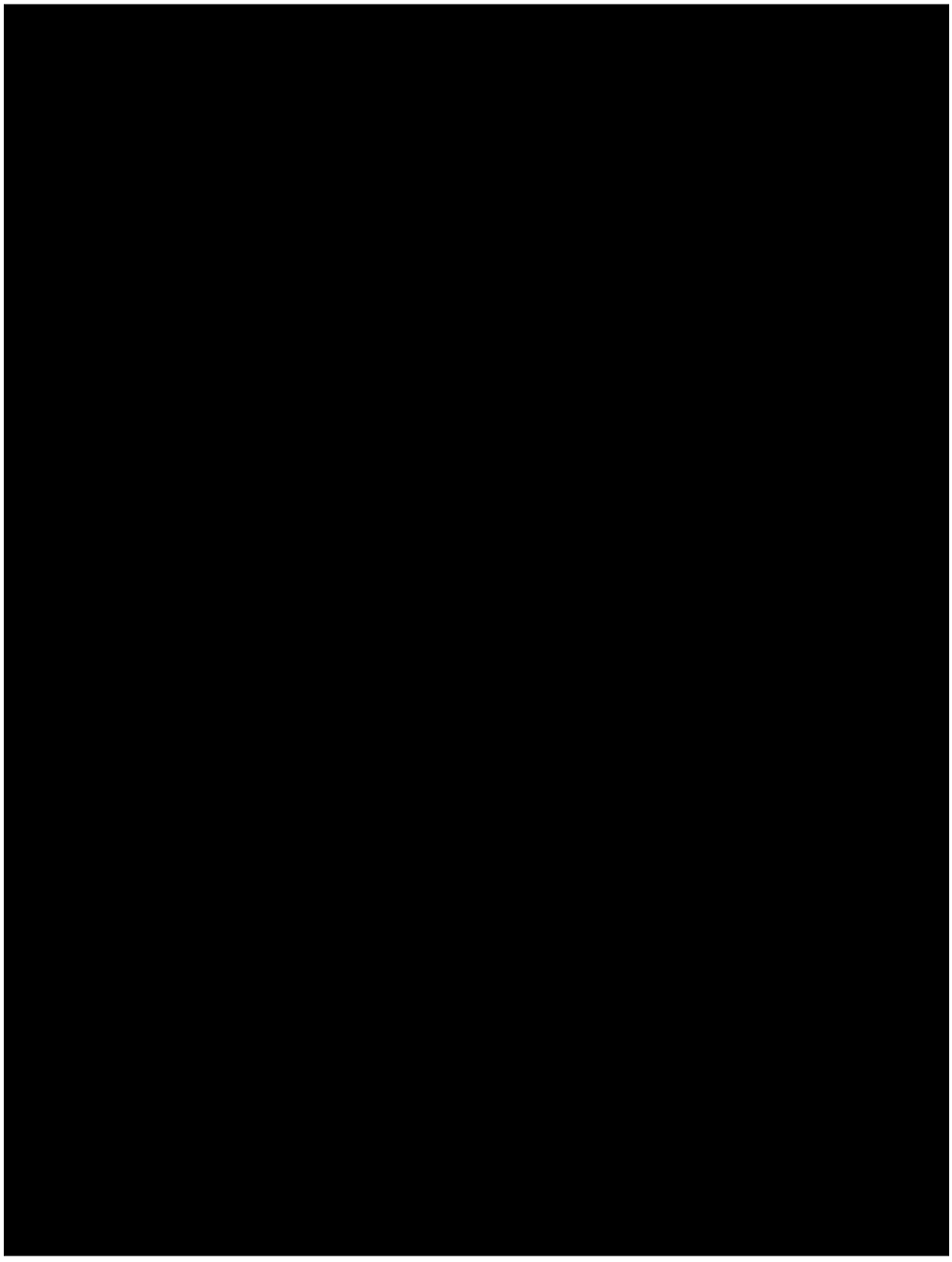


Table 33: Case 5: Disruption Unforeseen Weather Conditions

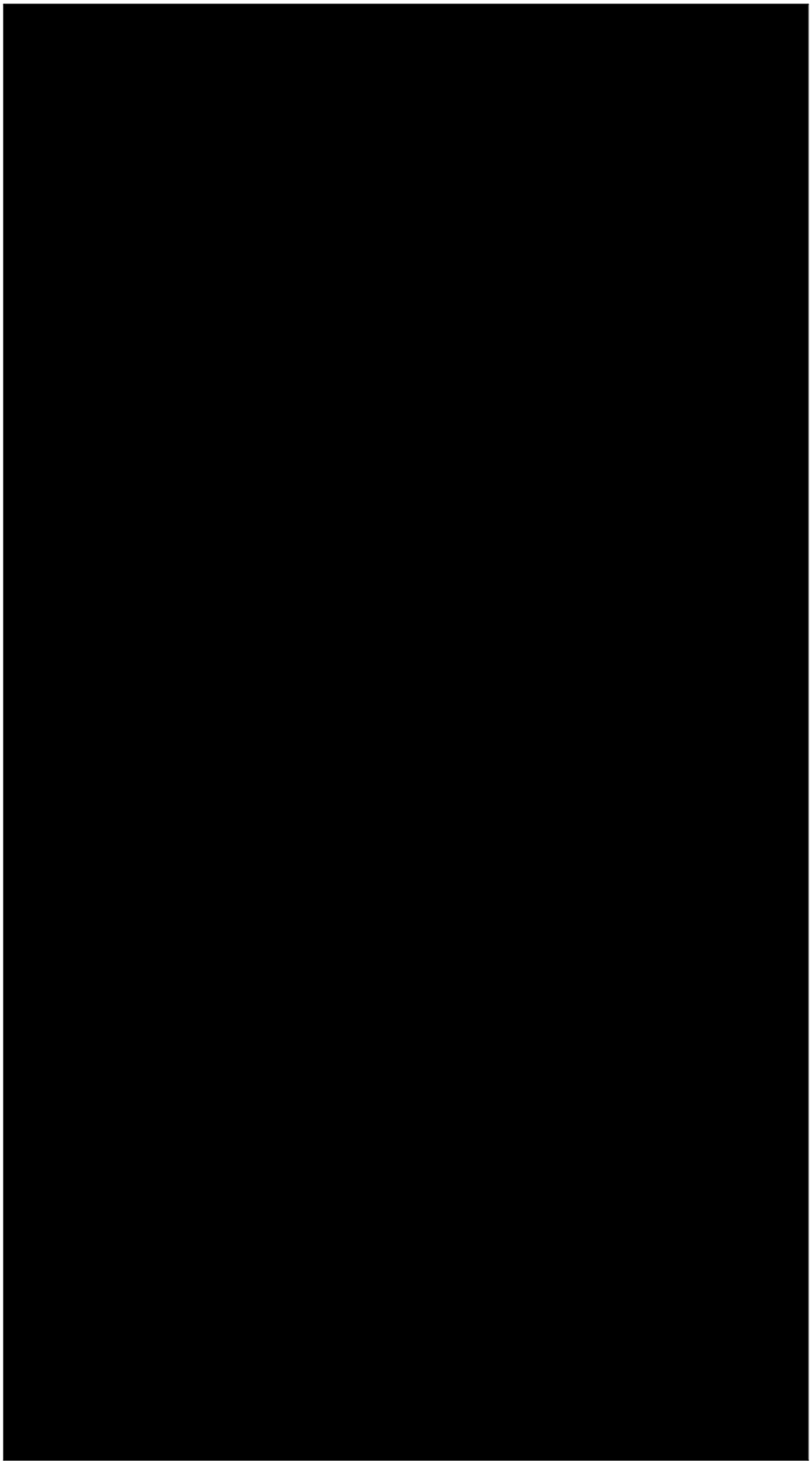


Table 34: Case 5: Uncertainty Unforeseen Weather Conditions

Table 35: Disruption: Unforeseen Event - Soil Discoveries

Table 36: Disruption: Strategic Shifts

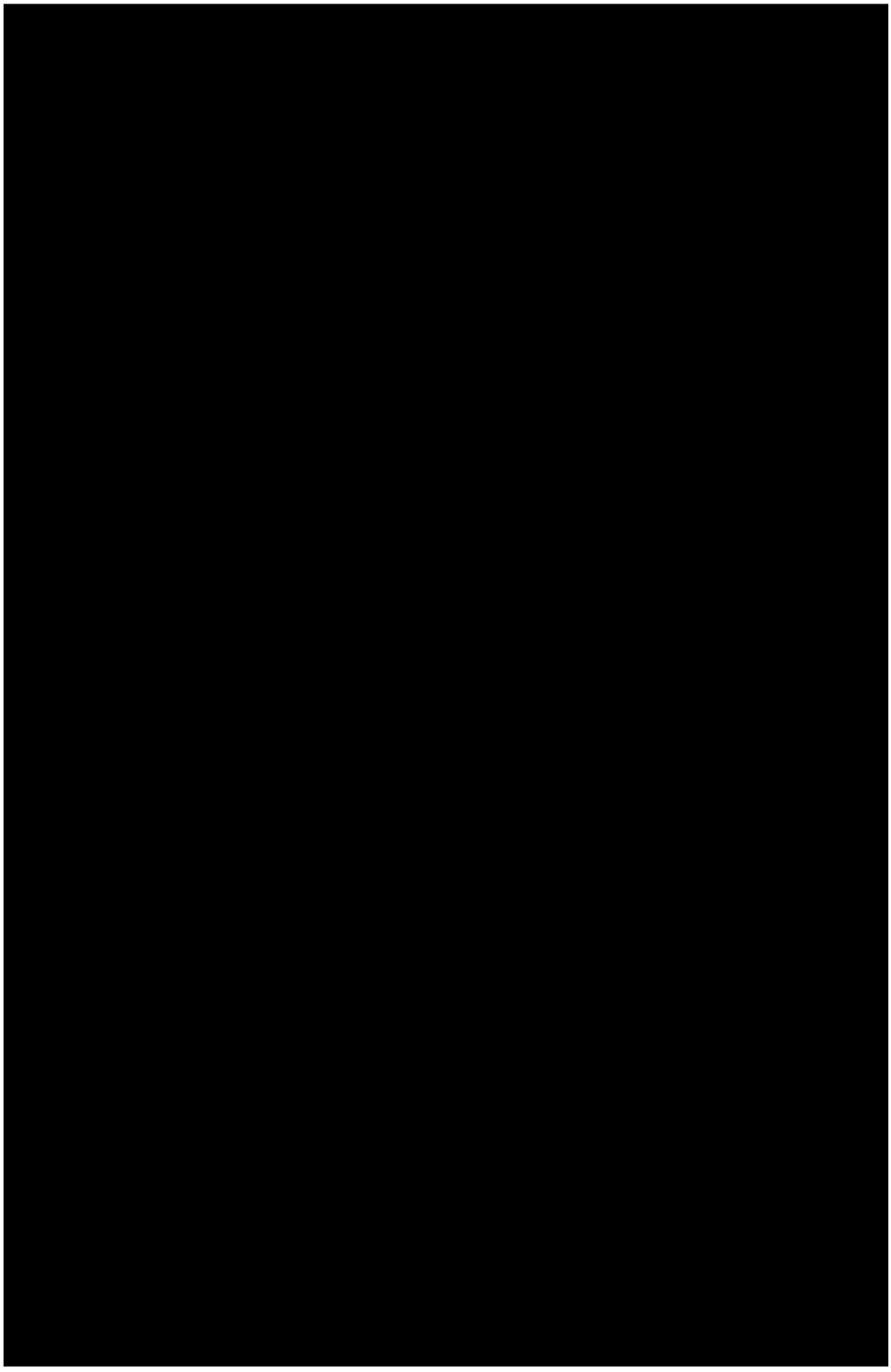


Table 37: Case 4: Disruption ILT inspections

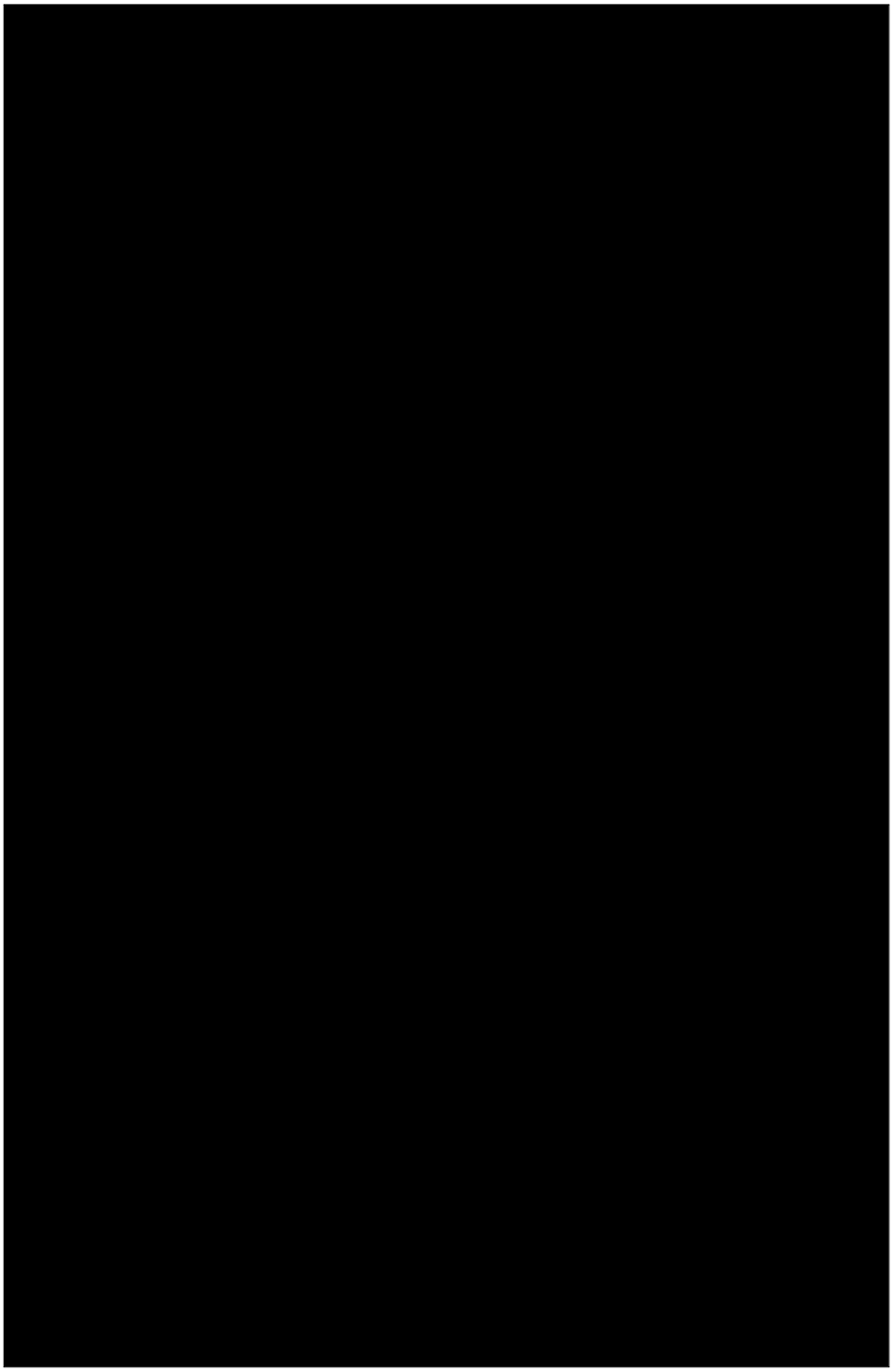


Table 38: Case 4: Uncertainty ILT inspections

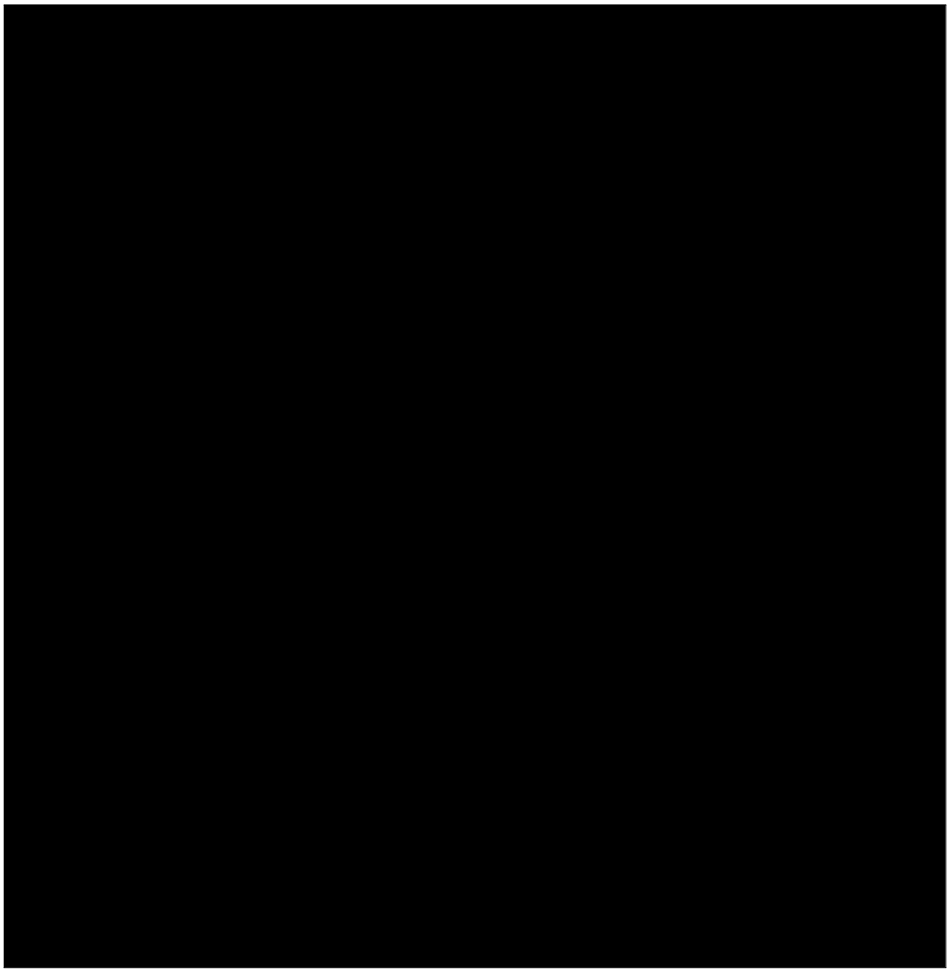


Table 39: Disruption: Portfolio Dynamics

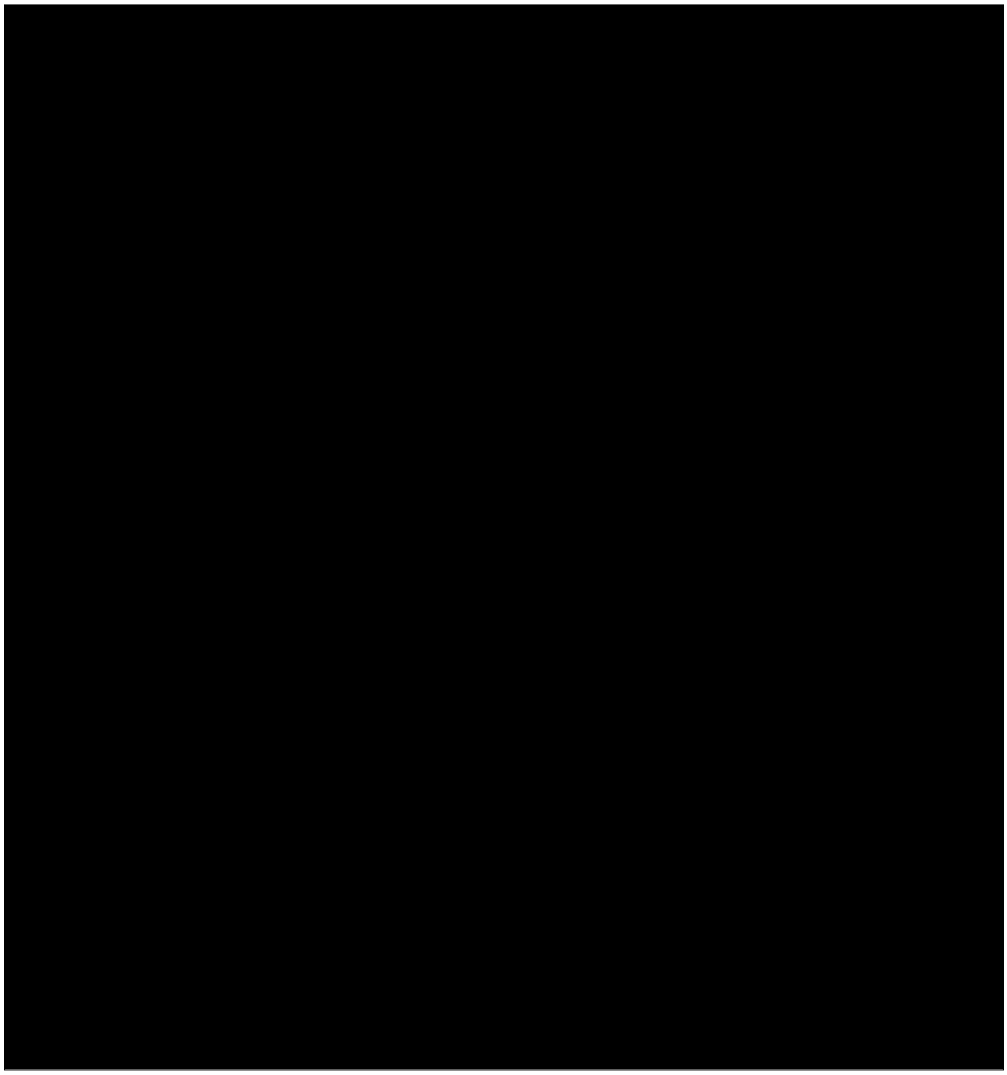


Table 40: Disruption: Resource Shortage - CSHI Capacity

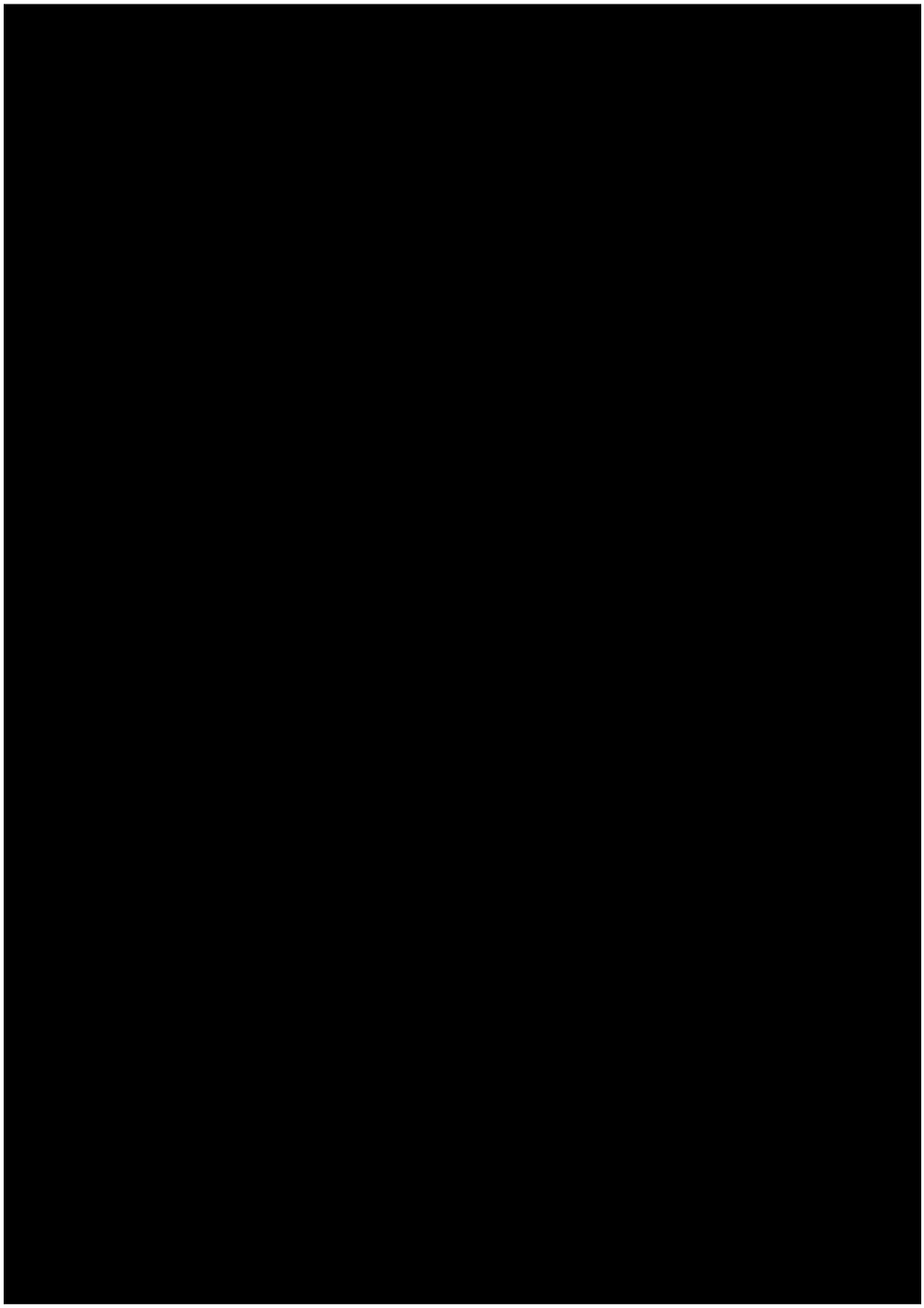


Table 41: Disruption: Resource Shortage - Security Personnel

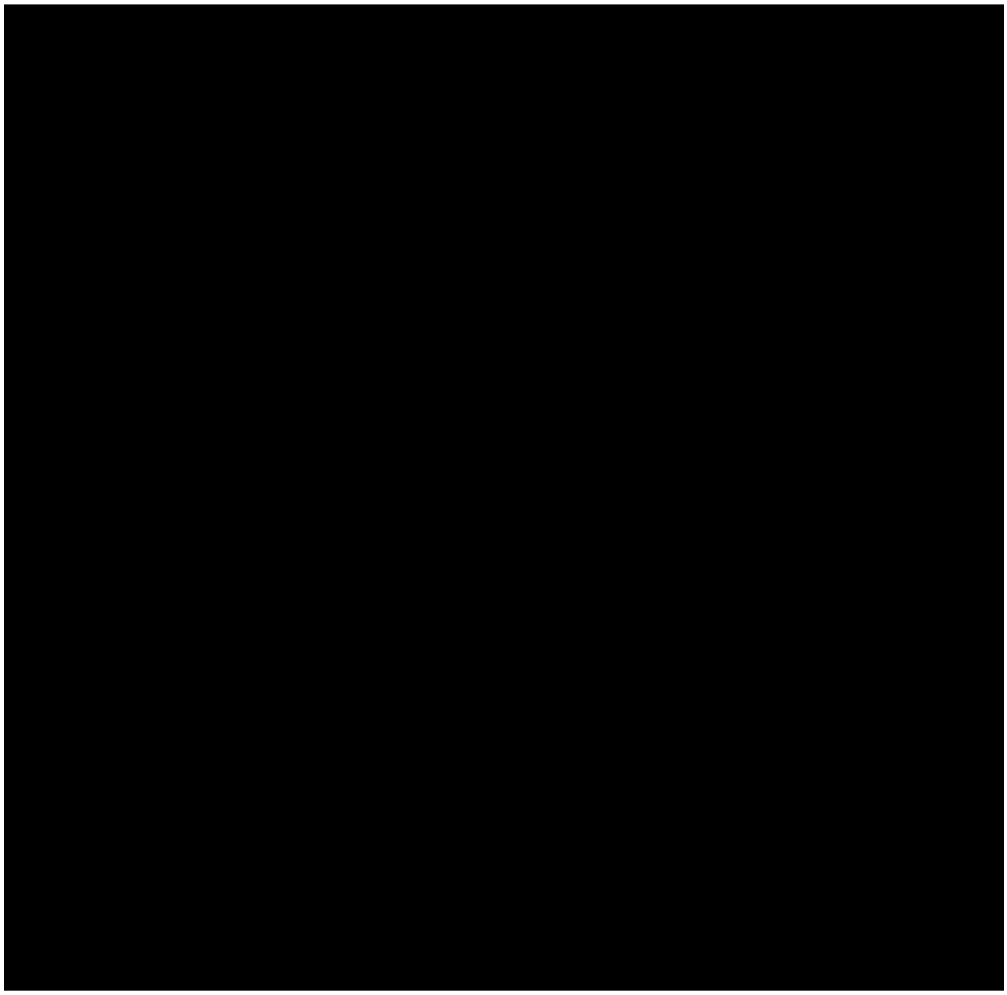


Figure 13 shows the monthly number of passengers (in millions) at Schiphol Airport for the years 2021 and 2022. It indicates a significant increase in passenger traffic throughout 2022 compared to 2021, with passenger numbers more than doubling during peak months like July, August, and September.

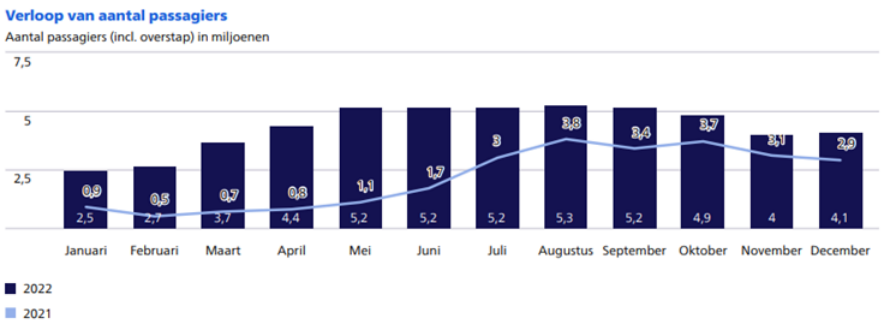


Figure 13: Monthly movement passengers Schiphol 2021 and 2022, source (Group, 2022)

Figure 14 shows the Net Promoter Score (NPS) per month at Schiphol Airport, highlighting a significant drop in customer satisfaction during 2022, followed by a gradual recovery into 2023.

Figure 14: Net Promoter Score per month, Schiphol 2019 to 2023, source (Royal Schiphol Group, 2023)

Figure 15 displays the media attention for the operational situation at Schiphol Airport between April 21 and September 30, 2022, showing the number of articles published each day. Peaks in the graph indicate specific events during April, May, June, July, and September that drew significant media coverage regarding Schiphol's operational issues.

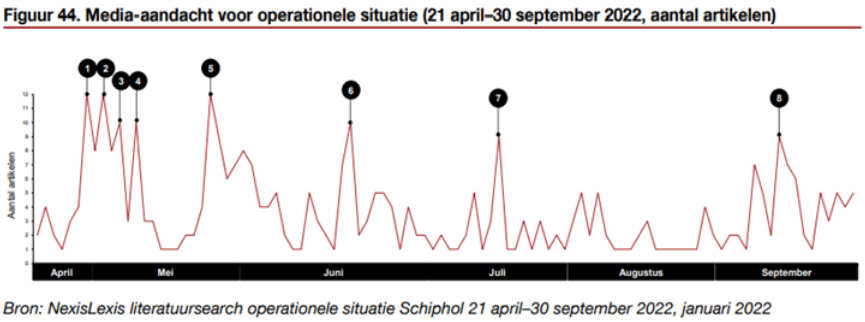


Figure 15: Media Attention, operational disturbance Schiphol 2022, source (Strategy&, 2023)

Figure 16 shows an overview of the Projects that required security personnel during the shortage in 2022. This information is provided by Schiphol group, demanding no explicit number publication.

Projecten die een claim leggen op security capaciteit P5 (security begeleiders)

Projecten	Prio	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
G-Pier																		
Retro bridge																		
Y-apron																		
A-Pier																		
GMI Upgrade/ inhuur																		
IT LCM																		
Applicatie SIMS																		
MJOP GOH 18C																		
Fase 6																		
Onderhoud deuren																		
MJOP TER Lift 1,2,11																		
STB kortlopend																		
Teamleider																		
Vraag																		
Aanbod																		
Verschil																		

Figure 16: Projects requiring security personnel during shortage in 2022, source Schiphol documentation

Table 42: Case 2: Uncertainty Security Personnel Shortage

Table 43: Disruption: Resource Shortage - Security Lanes

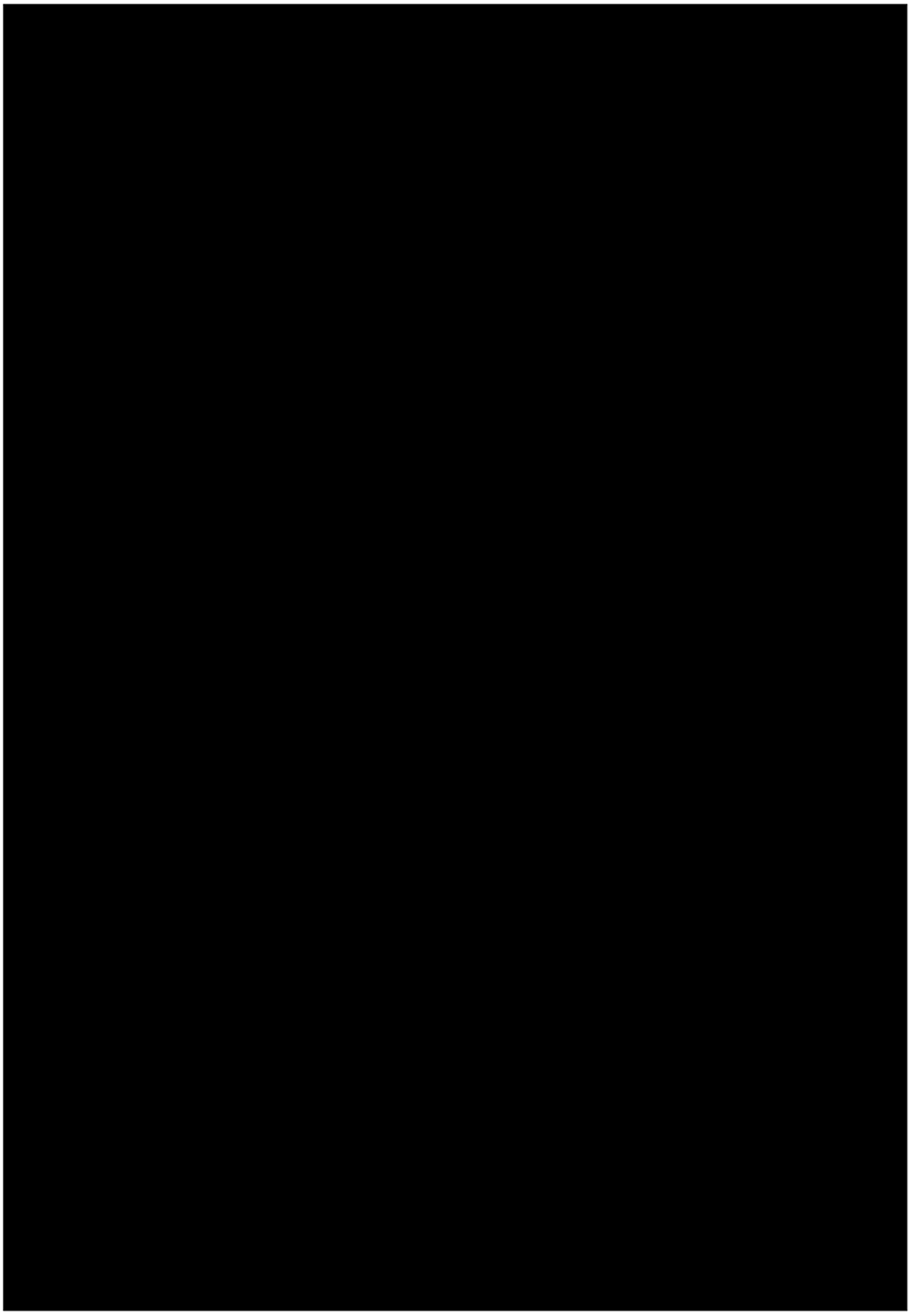


Table 44: Case 3: Disruption Security Lane Shortage

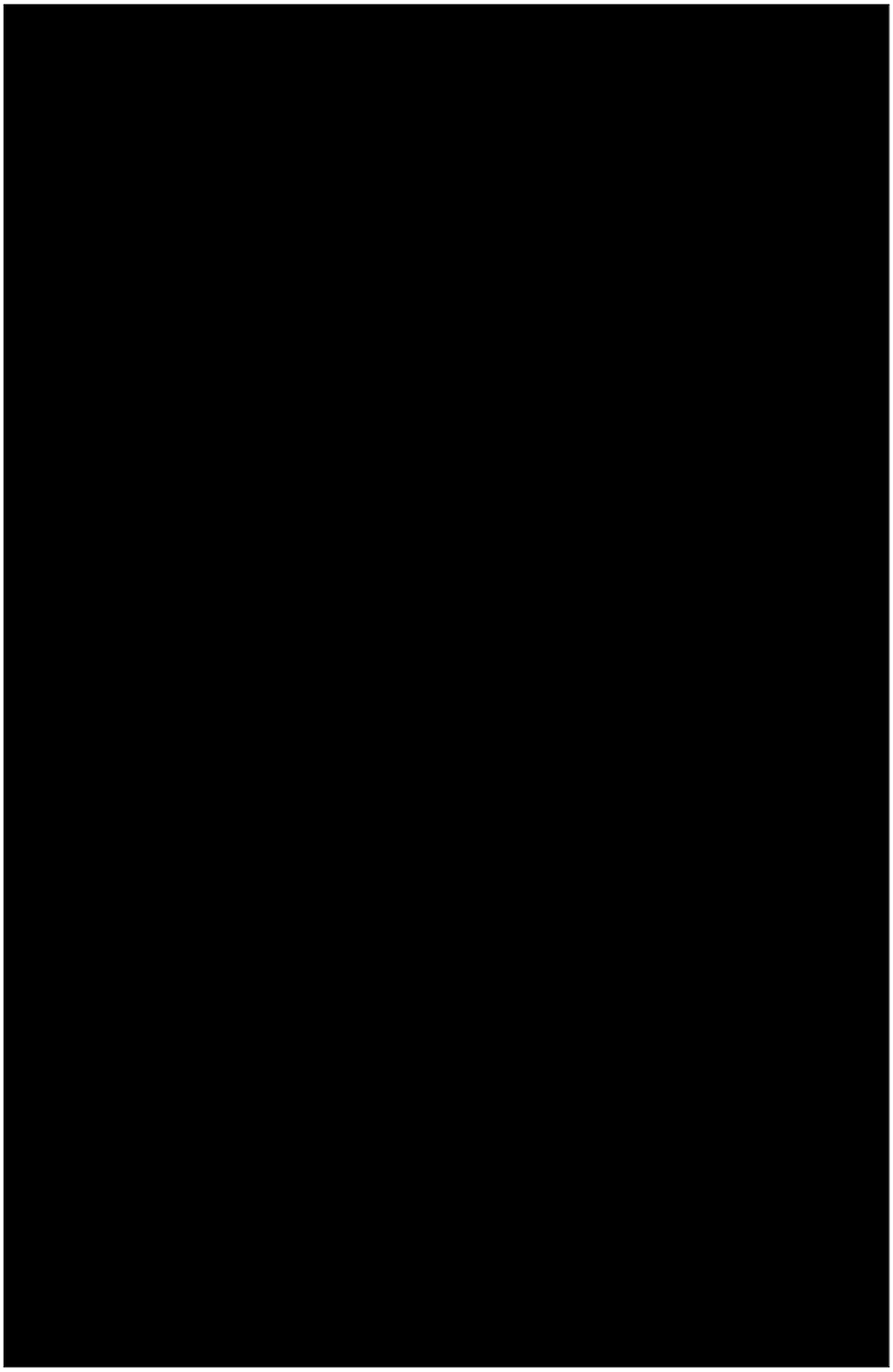


Figure 17 provides an overview of the security Lanes available and required per week in 2024 while Figure 18 provides an overview per day. These figures indicate the dis balance between supply and demand of the security Lanes on Airside.

Figure 17: Security Lanes required and available per week 2024, source Schiphol documentation

Figure 18: Security Lanes required and available per day 2024, source Schiphol documentation

Table 45: Case 3: Uncertainty Security Lane Shortage

Table 46: Disruption: COVID-19 Pandemic

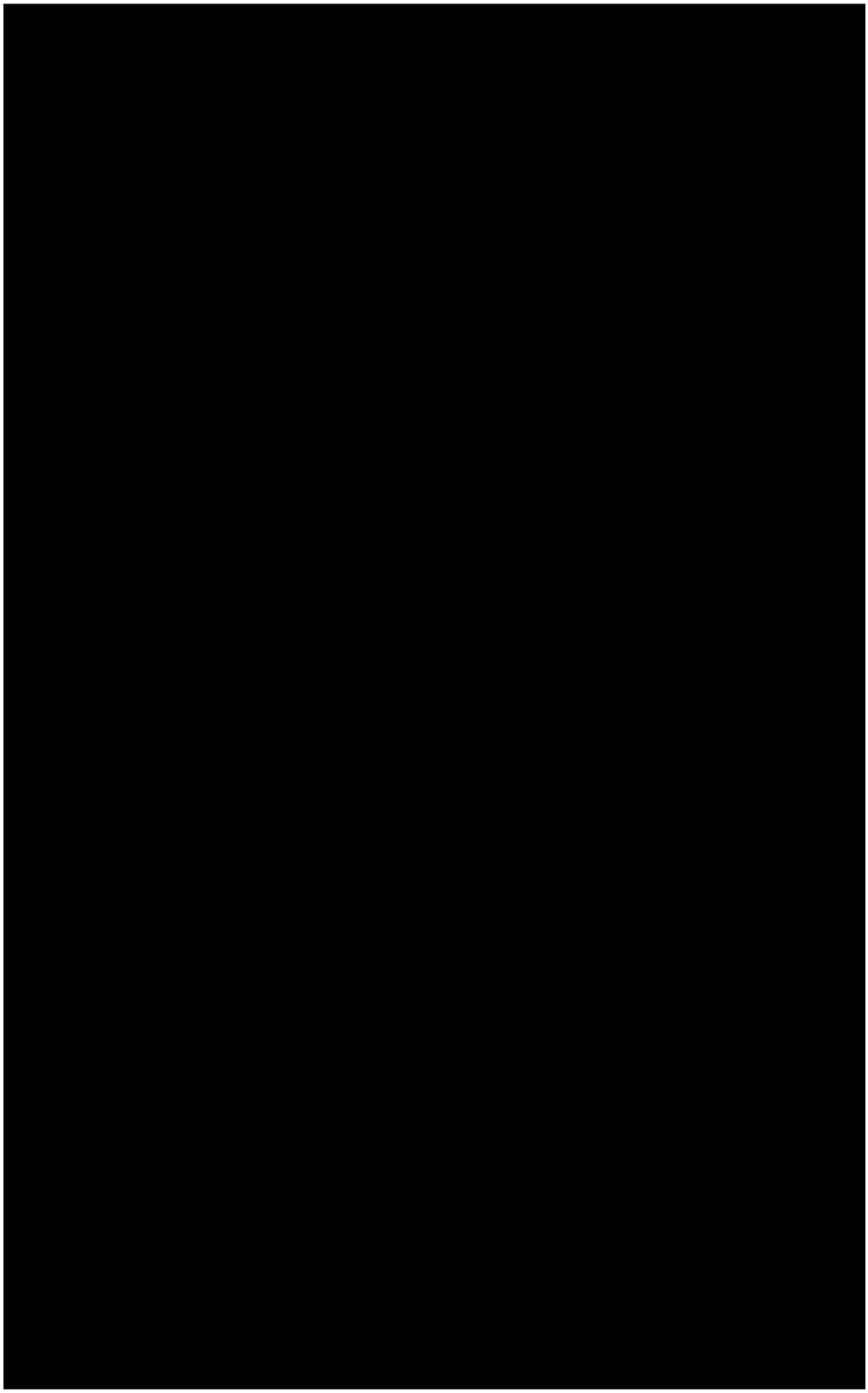


Figure 19 shows the variation in the 7-day average number of flights at Amsterdam Schiphol Airport from 2019 to 2021, highlighting a significant drop in flight activity during 2020 due to the COVID-19 pandemic, followed by a gradual recovery in 2021.

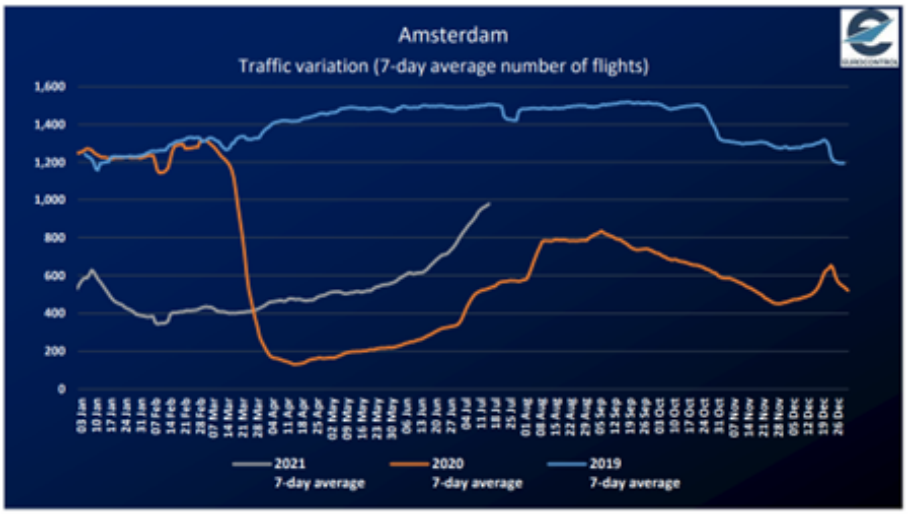


Figure 19: Traffic Variation Schiphol 2019-2021, source (EUROCONTROL, 2021)

Figure 20 shows that Schiphol's financial performance in 2020 was severely affected compared to 2019, with net revenue decreasing by 57.4% and the net result dropping from a profit of €355 million to a loss of €563 million.

Kerncijfers

EUR miljoen tenzij anders vermeld	2020	2019	%
Netto-omzet	**688**	1.615	-57,4
Overige resultaten uit vastgoed	**-64**	113	-157,1
Bedrijfslasten (excl. afschrijvingen en bijzondere waardeveranderingen)	**830**	1.039	-20,1
EBITDA[1]	**-206**	**689**	**-129,9**
Afschrijvingen, amortisatie en bijzondere waardeveranderingen	**324**	294	10,4
Exploitatieresultaat	**-530**	**395**	**-234,2**
Financiële baten en lasten	**-92**	-84	-9,2
Resultaat geassocieerde deelnemingen	**-107**	127	-184,3
Resultaat voor belastingen	**-730**	**438**	**-266,6**
Winstbelasting	**162**	-76	313,4
Resultaat	**-568**	**362**	**-256,8**
Minderheidsaandeelhouders	**-5**	7	-173,6
Resultaat toekomend aan aandeelhouders	**-563**	**355**	**-258,4**

Figure 20: Financial Performance Schiphol 2020, source (Group, 2020)

Table 47: Case 1: disruption COVID-19

Table 48: Case 1: uncertainty COVID-19

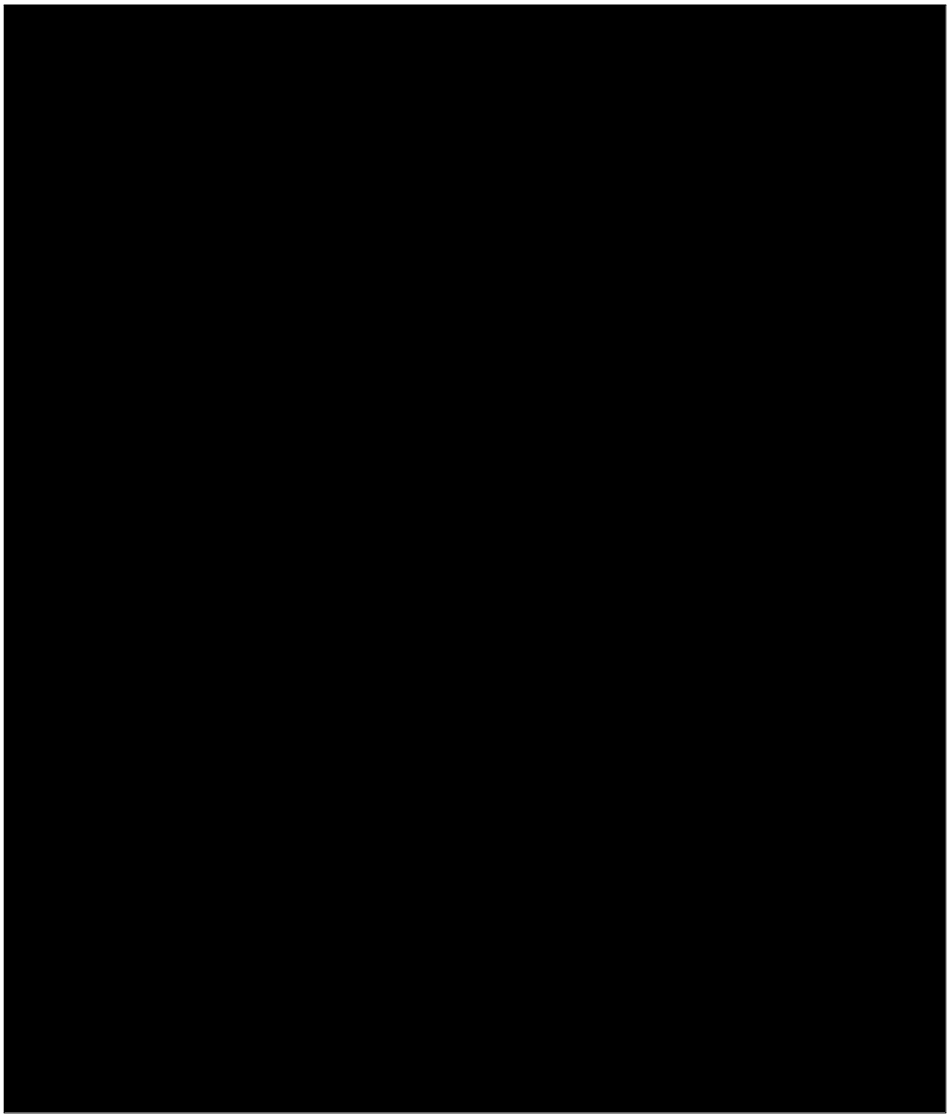


Table 49: Disruption: Ukraine War

Table 50: Disruption: Changing Customer Needs

A.1 Synthesis

This section elaborates on the phrases of the interviews regarding the impact and time response levels of the disruptions identified at Schiphol Airport

Table 51: Impact and Response Time Phrases for Variability in Project Estimates

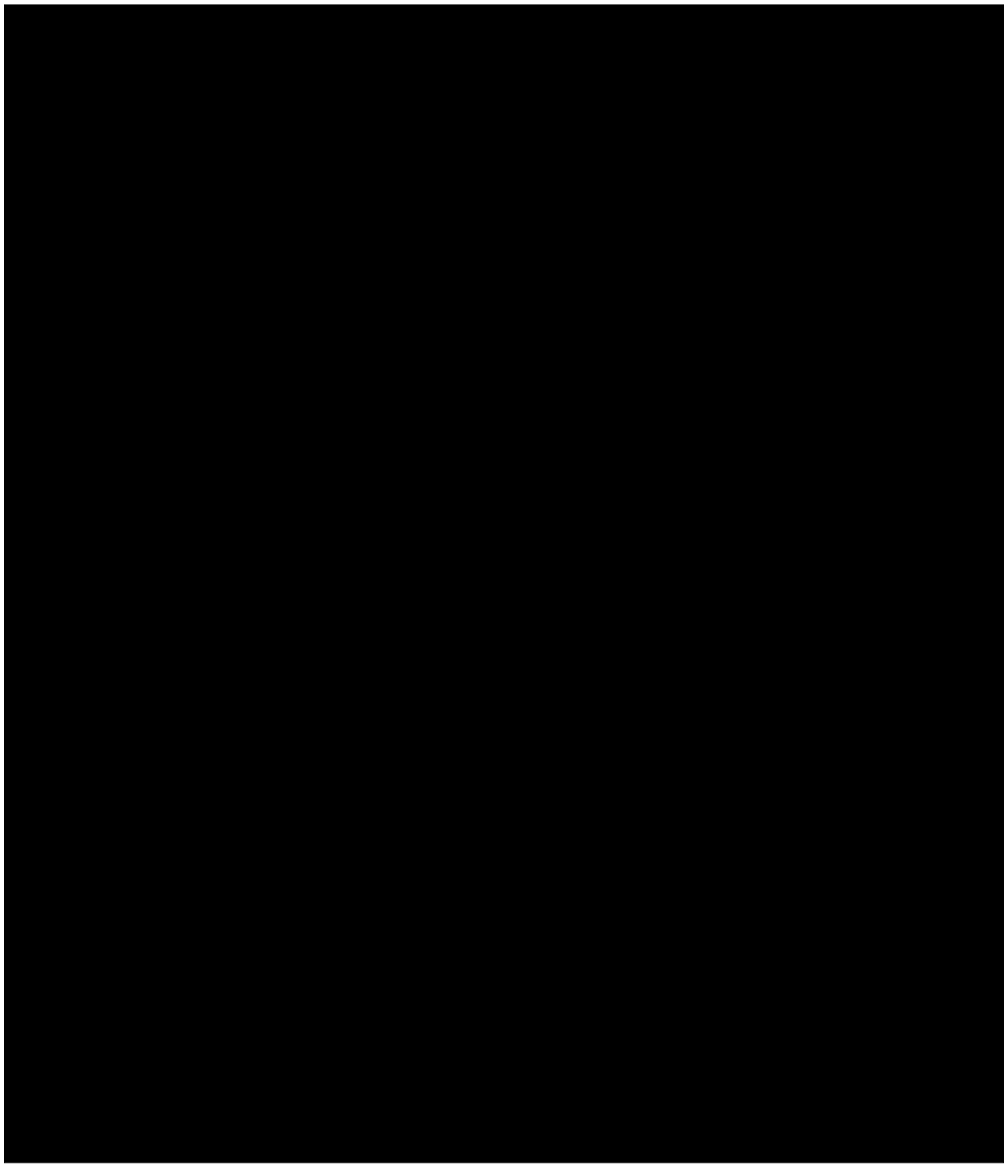


Table 52: Impact and Response Time Phrases for Unforeseen Events - Bad Weather Conditions

Table 53: Impact and Response Time Phrases for Unforeseen Event - Soil Discoveries

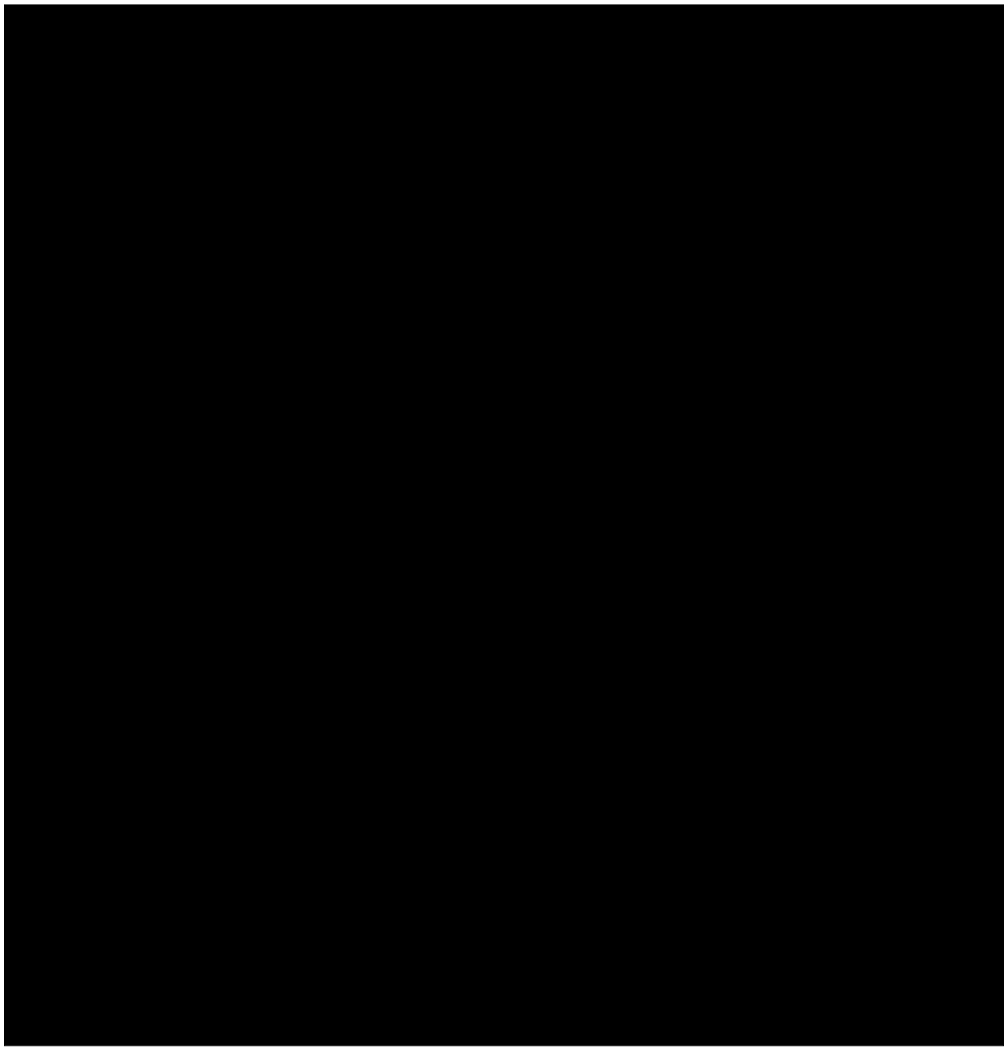


Table 54: Impact and Response Time Phrases for Resource Shortage - CSHI Capacity

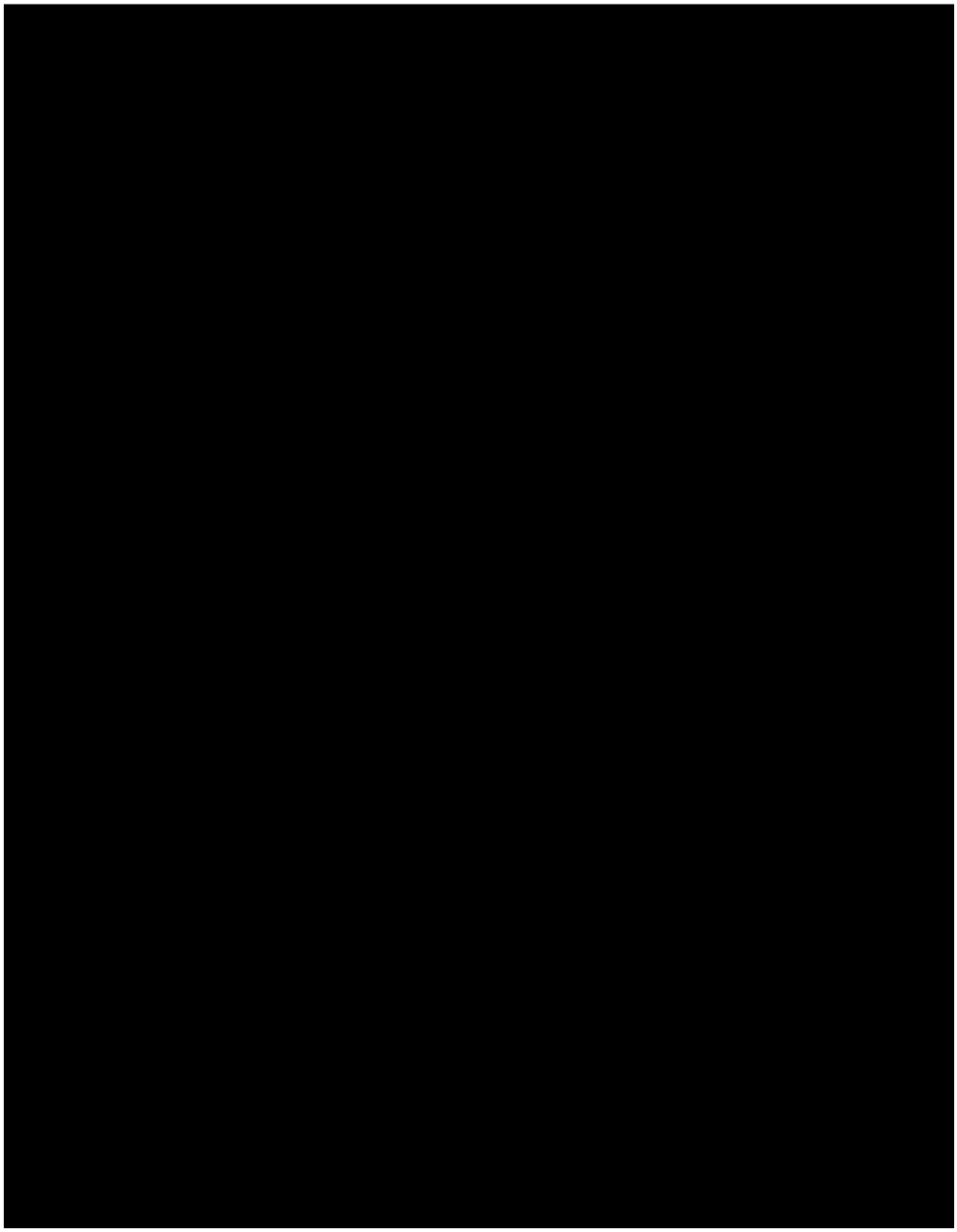


Table 55: Impact and Response Time Phrases for Resource Shortage - Security Lanes

Table 56: Impact and Response Time Phrases for Portfolio Dynamics

Table 57: Impact and Response Time Phrases for Strategic Shifts

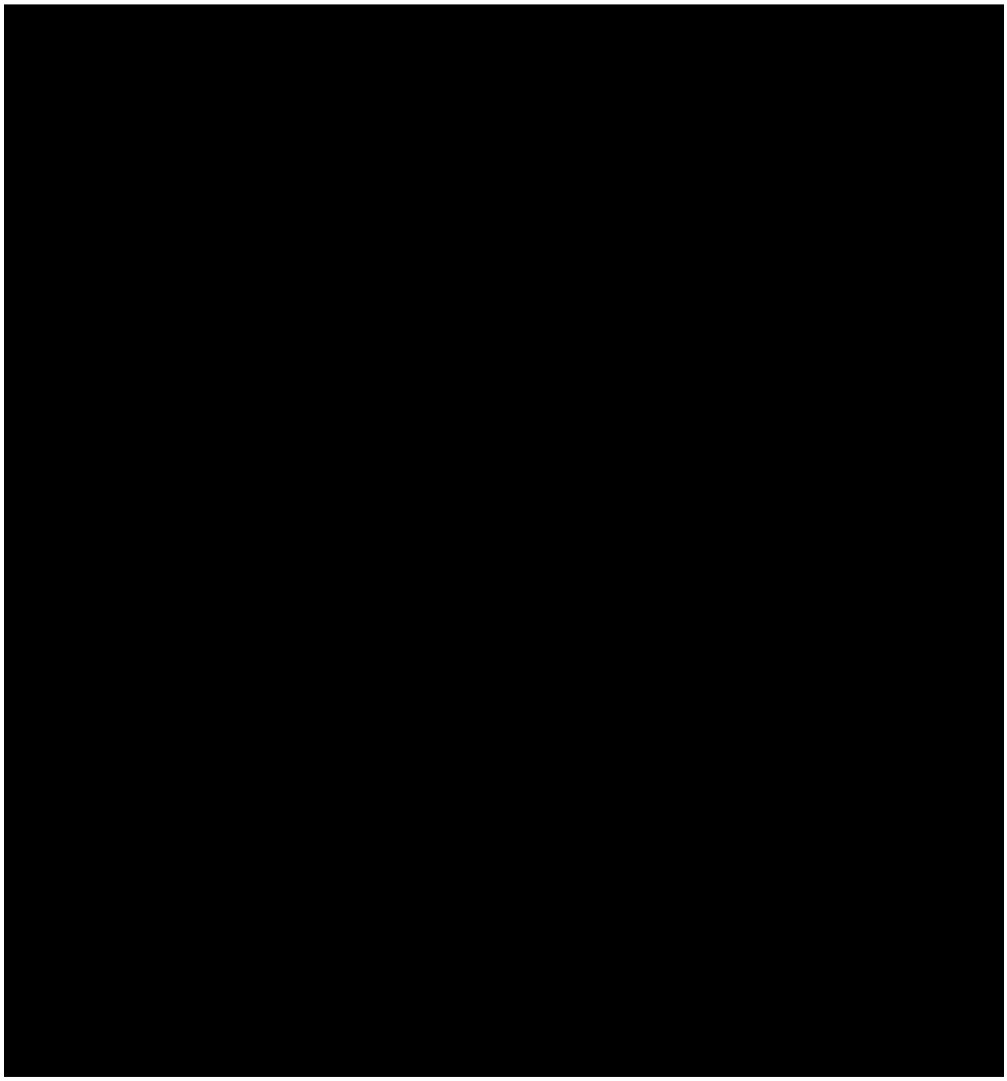


Table 58: Impact and Response Time Phrases for COVID-19 Pandemic

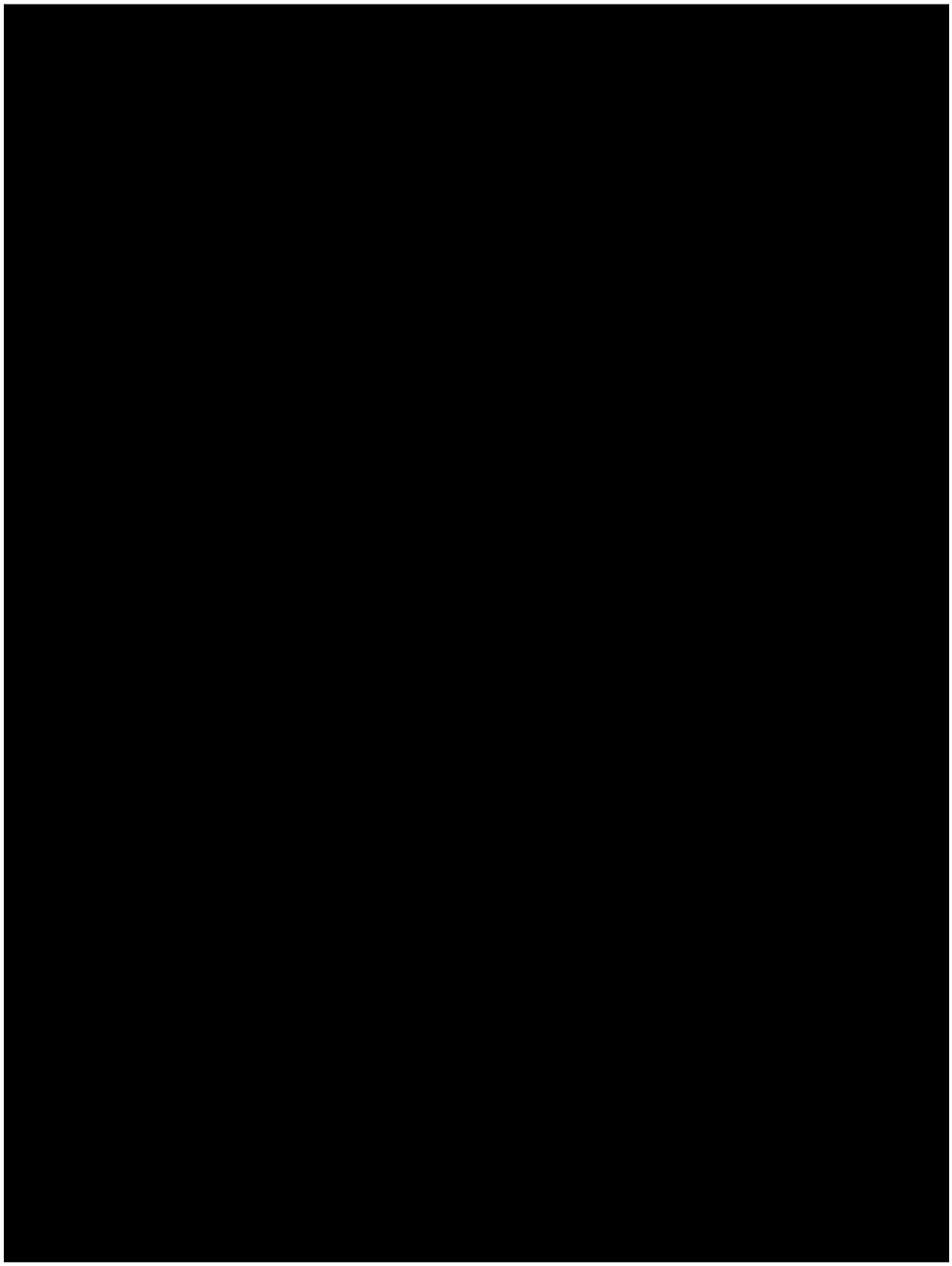


Table 59: Impact and Response Time Phrases for Changing Customer Needs

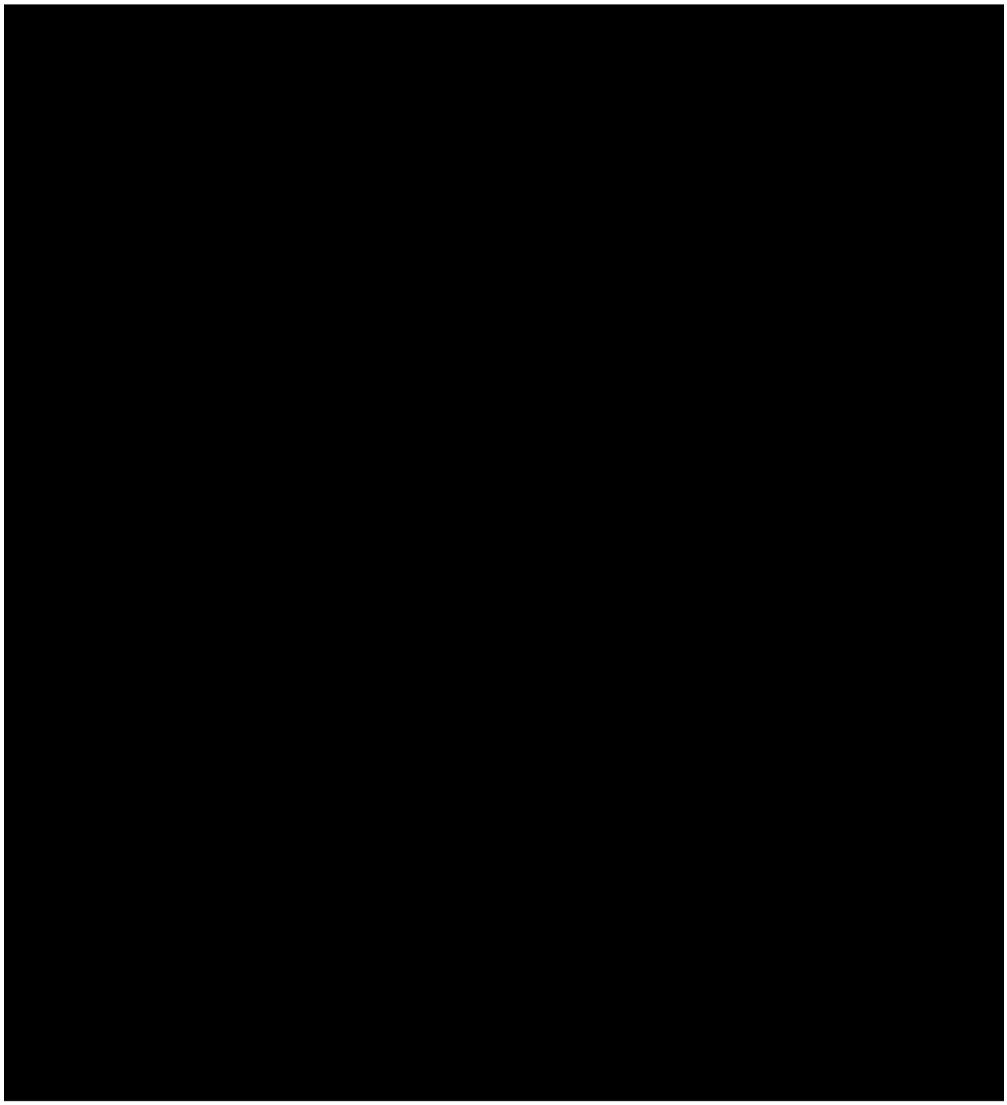


Table 60: Overview of Disruptions, Impact Levels, and Response Times

Disruption	Level	Explanation
E1a	Impact Level: High	Extensive portfolio reductions, inability to operate, workforce downsizing, and canceled projects demonstrate a significant portfolio-wide impact.
	Response Time: Short-Term	Actions were implemented urgently within two months to manage the disruption.
E1b	Impact Level: Medium-High	Supply chain disruptions and cost adjustments created uncertainty, influencing costs and timelines but not operationality.
	Response Time: Mid-Term	Extended period required for renegotiating contracts and stabilizing sourcing indicates a mid-term response.
E2	Impact Level: High	Incompatibility with customer requirements could render parts of the airport non-operational, requiring significant infrastructure adjustments.
	Response Time: Long-Term	Infrastructure changes range from 15 to 50 years, aligning with a long-term strategic response.
O1	Impact Level: High	Resource reallocation and project delays threatened operational shutdown, indicating a critical impact on the portfolio.
	Response Time: Mid-Term	The process to implement changes and adapt to the shifts took approximately six months.
O2	Impact Level: Medium-High	Addition of unplanned projects and reprioritization caused moderate disruptions across the portfolio without broader operational impacts.
	Response Time: Mid-Term	Occurring regularly over a span of months (e.g., January to September) reflects a mid-term response.
O3a	Impact Level: Medium-High	Delay in high-priority projects (e.g. runway maintenance) could (worst-case), impact part of operations.
	Response Time: Long-Term	Issues were often detected years in advance, suggesting a need for long-term planning and mitigation.
O3b	Impact Level: High	Insufficient capacity caused project halts, canceled flights, and widespread delays, severely impacting operations.
	Response Time: Short-Term	Persistent issues over the summer required urgent and immediate management.
O3c	Impact Level: Medium	Capacity constraints affected multiple projects within the Airside cluster but remained contained within the area.
	Response Time: Intermediate-Term	Insights into capacity constraints were visible a year before the impact, indicating a long-term response.
SP1	Impact Level: Low-Medium	Inaccurate initial planning required adjustments, impacting portfolio resources but not critically.
	Response Time: Intermediate-Term	Planning and adjustments for projects occurring year to 6 months in advance.
SP2a	Impact Level: Medium-High	Cascading delays across multiple projects due to weather disruptions were significant but contained within the Airside cluster.
	Response Time: Immediate	Unpredictable weather necessitated immediate responses during execution.
SP2b	Impact Level: Medium-Low	Contaminations and unexpected findings affected single projects without broader portfolio-wide implications.
	Response Time: Short-Term	Discoveries often occurred at the start of execution, allowing time to adjust.

B Appendix: Capabilities

This section elaborates on the phrases of the interviews regarding the capabilities identified at Schiphol Airport.

B.1 Dynamic Sensing capabilities

This section elaborates on the phrases of the interviews regarding the dynamic sensing capabilities identified at Schiphol Airport

Table 61: Sensing Mechanism: Established role: Resource Coordinator

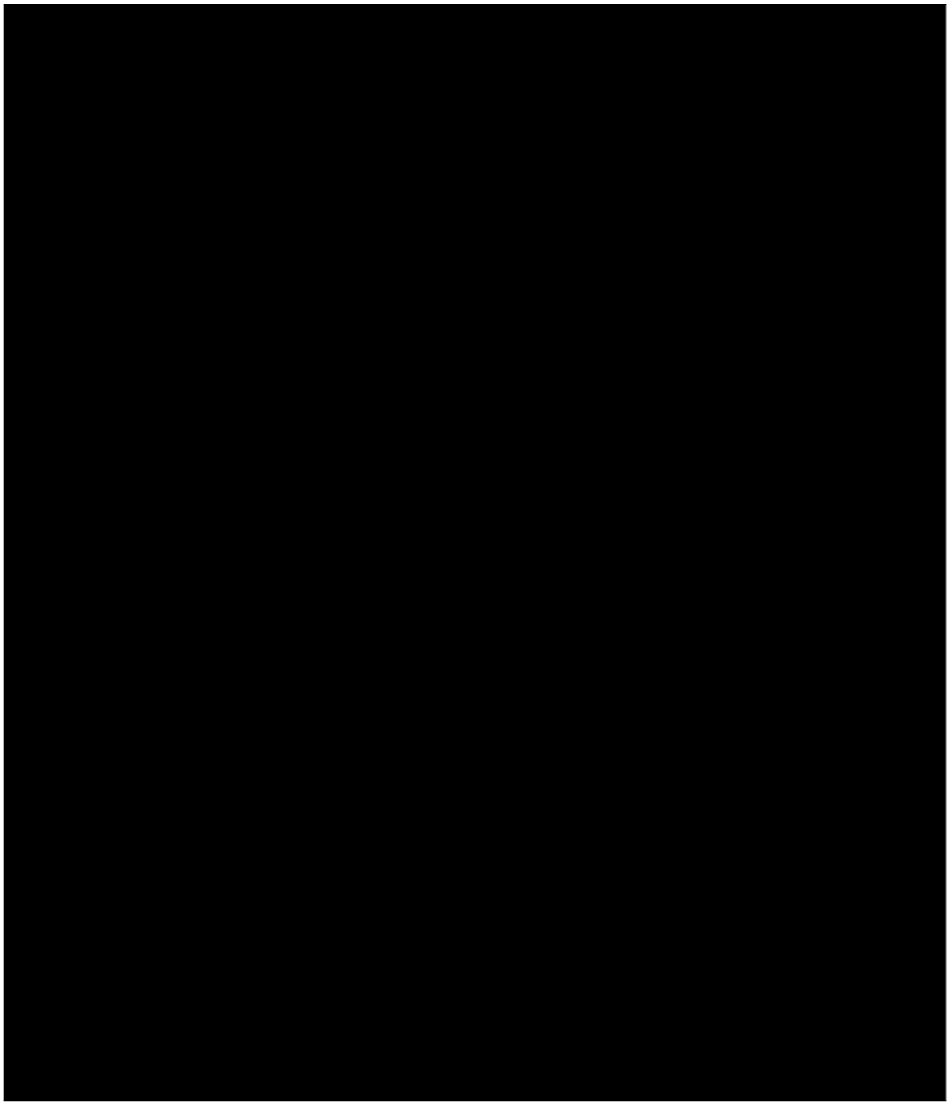


Table 62: Sensing Mechanism:Explicit Knowledge gathering

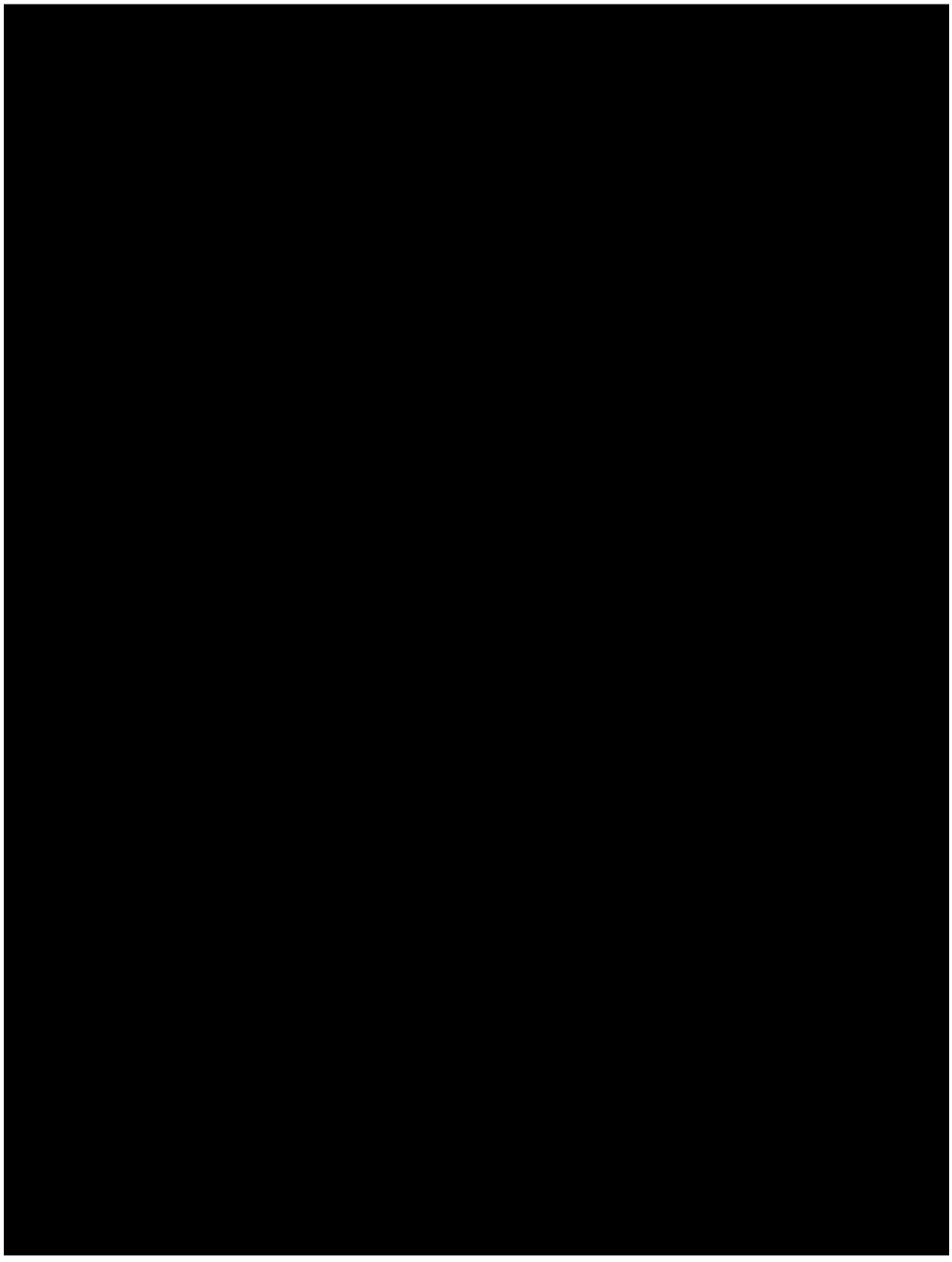


Table 63: Sensing Mechanism: Regulation and Operational Compliance

B.2 Dynamic Seizing Mechanisms

This section elaborates on the phrases of the interviews regarding the dynamic seizing capabilities identified at Schiphol Airport

Table 64: Seizing Mechanism: Integrated Planning Workspace (IPW)

Figure 21: Seizing Mechanism: Team Airport Development, source: Schiphol Documentation

Table 65: Seizing Mechanism: Capital Lifecylce Process (CLP)

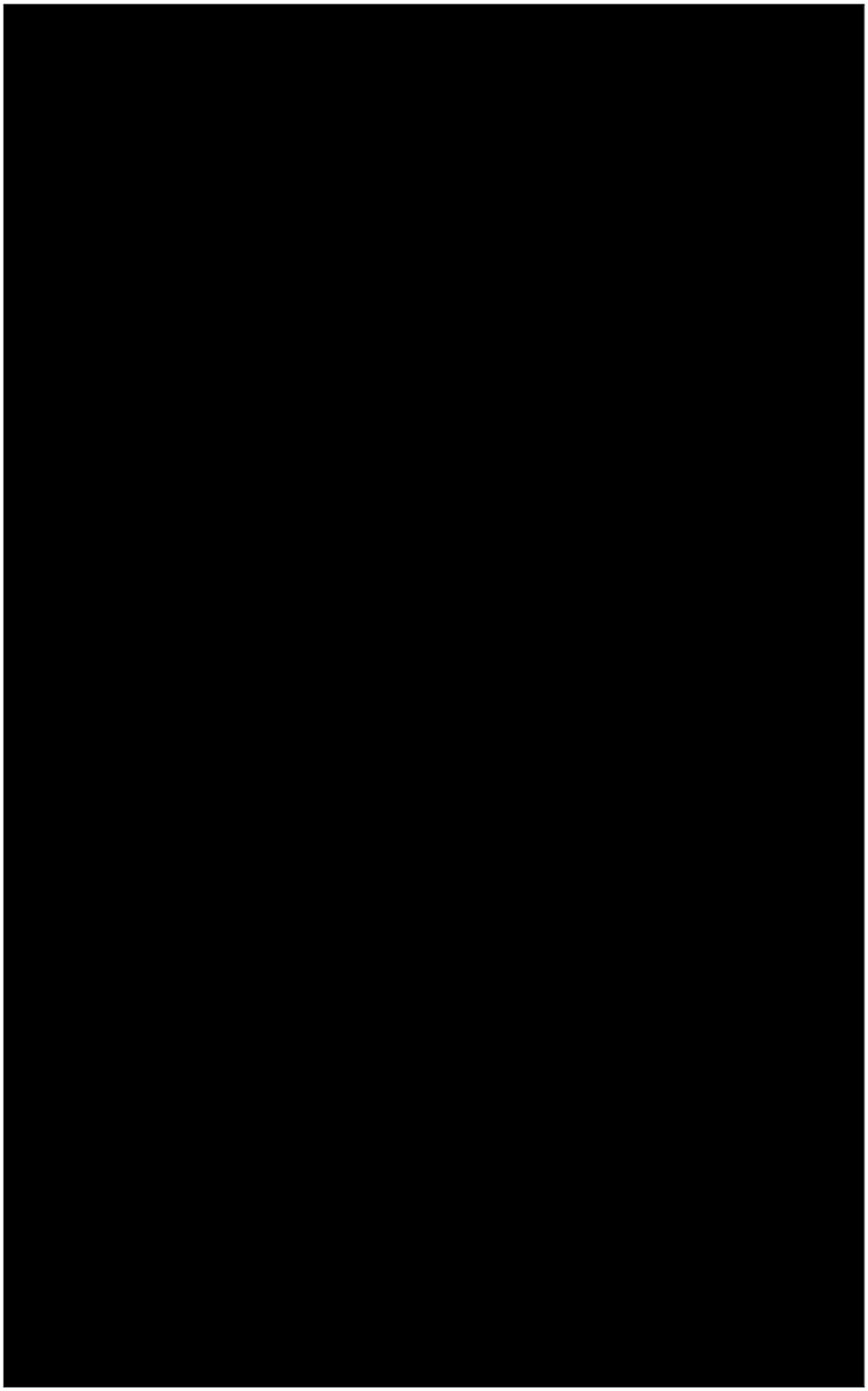


Table 66: Seizing Mechanism: Structured Escalation Process

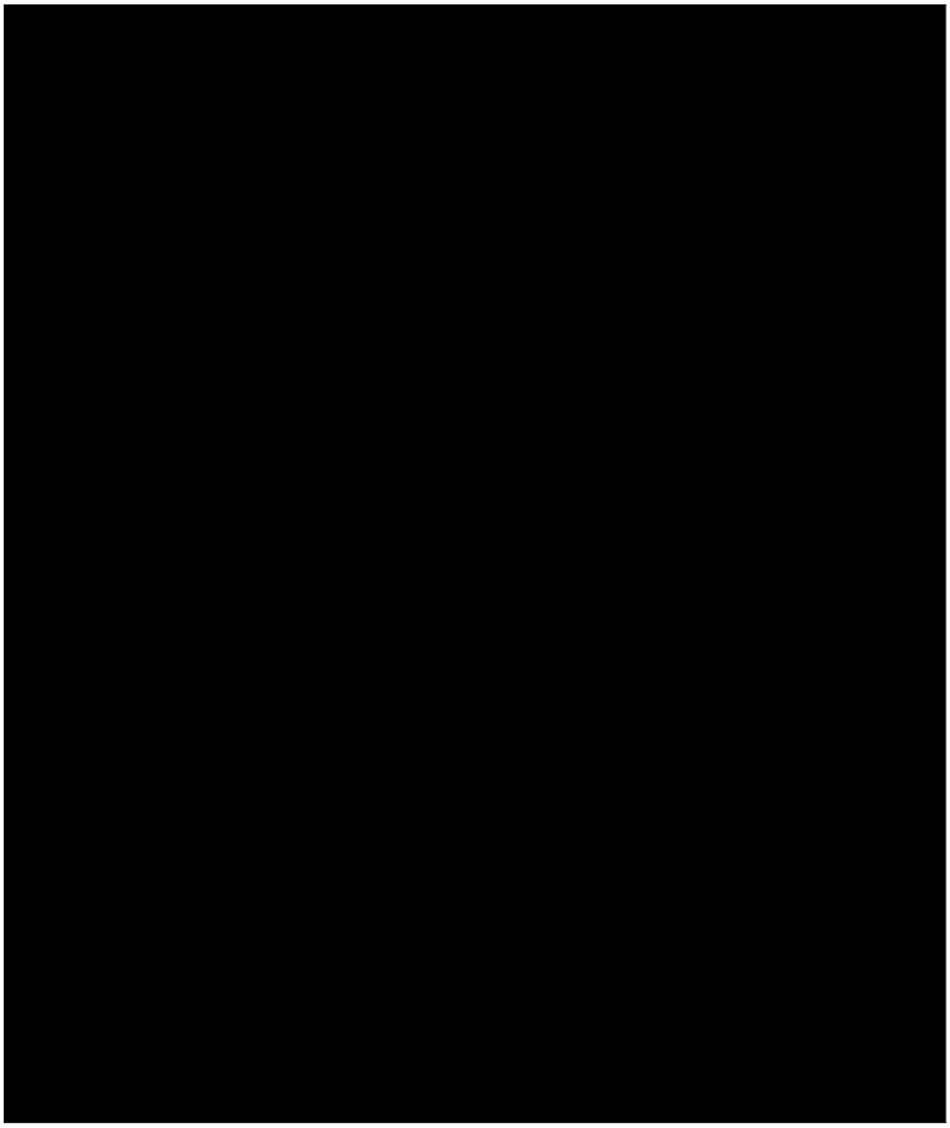


Table 67: Seizing Mechanism: Scenario Analysis Based on Predetermined Prioritization Criteria

Table 68: Seizing Mechanism: Lessons Learned

B.3 Reconfiguration Mechanisms

This section elaborates on the phrases of the interviews regarding the dynamic reconfiguration capabilities identified at Schiphol Airport

Table 69: Reconfiguration Mechanism: Adjust Planning

Table 70: Reconfiguration Mechanism: Reallocate Resources

Table 71: Reconfiguration Mechanism: Collaboration with Contractors

Table 72: Reconfiguration Mechanism: Buffer Planning and Margins

Table 73: Reconfiguration Mechanism: Workforce Optimization

Table 74: Reconfiguration Mechanism: Terminate, Postpone, or Prioritize Projects

Table 75: Disruption: Portfolio Adjustments - Adding or Removing Projects

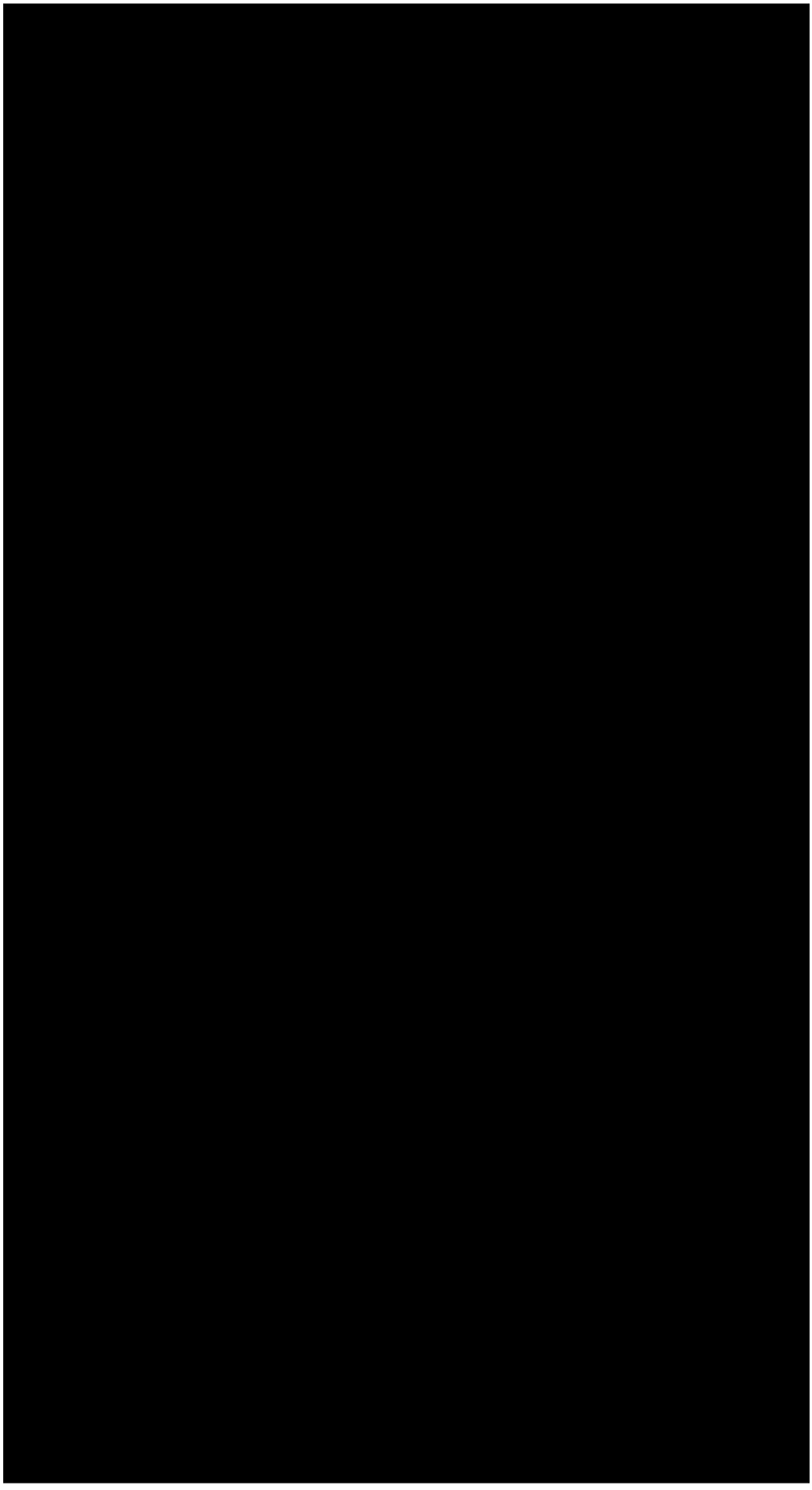


Table 76: Reconfiguration Mechanism: Risk Acceptance

Table 77: Ad-Hoc Capability: Ad-Hoc Data Gathering

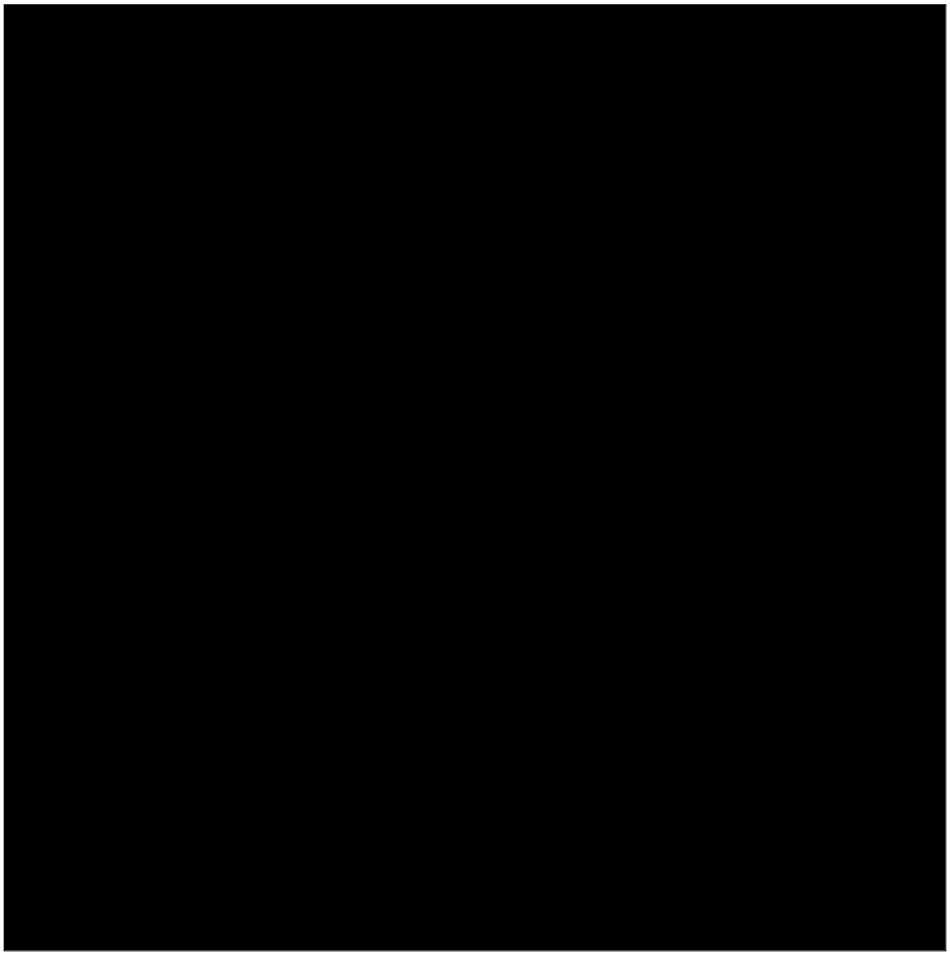


Table 78: Ad-Hoc Capability: Improvised Solutions

C Appendix: Case Studies

C.1 Interview Protocol

At the beginning of the interview, introduce yourself and briefly explain the purpose of the interview. Inform the participant about the objective of the discussion and emphasize the following points:

Obtain consent for recording the interview.

Explain the confidentiality and anonymity of their responses to ensure transparency and build trust.

Begin the interview by describing the approach to be discussed, for instance:
"Within the finalization phase of the PPM process, the selection of projects to be included in Schiphol's portfolio is determined. A schedule is then created for the execution of these projects, followed by gathering information on each project's resource availability, costs, timelines, and demand. This information helps identify imbalances, such as resource shortages, which are resolved to establish a feasible portfolio with a clear execution plan. However, between the determination of an executable portfolio and its actual execution, the portfolio may face disruptions. An example is a sudden reduction in available human resources, such as in the case of Spanningsinstallatie/Laagspanningsinstallatie (CSHI). Disruptions can arise due to internal or external factors, leading to imbalances within the portfolio. In response to such disruptions, Schiphol is compelled to take specific actions to restore the portfolio's feasibility."
Background Information:

- Describe your role and responsibilities at Schiphol.

Nature of Disruption:

- How did the disruption affect the project portfolio?
- Within what timeline was the disruption detected?

- Can you describe the scale and scope of the disruption (e.g., number of projects affected, duration, immediate impacts)?

Decision-Making Process:

- Have you ever combined ad hoc decision-making and dynamic capabilities to address the disruption?
  - If yes: Can you describe what parts were performed by dynamic capability and what parts by ad hoc problem-solving?
  - What specific strategies or actions did you take to address the disruption?
- If no: Have you separately used the approaches to address the disruption?
- What factors influenced your choice of approach (e.g., urgency, complexity, resource availability)?

Implementation Details:

- Can you provide specific examples of how dynamic capabilities were utilized during the disruption?
- Can you provide specific examples of how ad hoc problem-solving was implemented during the disruption?
- Were there any challenges or obstacles you faced while implementing these approaches?

Effectiveness:

- How did you determine the effectiveness of the approach used?
- Can you provide examples that indicate the success or failure of the approach?
- If the participant mentions criteria for determining effectiveness, ask for outcomes based on this list.
- If some criteria are not mentioned, ask for outcomes based on these criteria (e.g., speed of response, resource availability, stakeholder satisfaction, etc.).
- What were the benefits and drawbacks of using a combined approach?

Reflection and Improvement:

- How can the combined approach be better utilized in managing disrupted project portfolios?
- What recommendations would you make for improving the integration of a combined approach?

C.2 Roles and responsibilities

The Cluster Lead Airside role combines two key responsibilities. First, as a client representative, the lead oversees civil projects on the Airside, ensuring alignment with budgets, timelines, and stakeholder requirements while guiding project teams. Second, the role involves functional leadership, managing client representatives and ensuring the feasibility of the annual portfolio, including scope, budget, and scheduling, as exemplified by the 2025 portfolio planning process.

The Cluster Manager role involves responsibility for portfolio management, advisory functions, and accountability, with a focus on Airside monitoring and performance. Key tasks include supporting the tactical phase, such as defining the annual portfolio, ensuring the continuity of feasibility assessments, and providing strategic insights. Additional responsibilities may arise as projects progress, but these represent the primary focus areas.

The Program Lead role within the Airside of the Program Development department focuses on the strategic planning and programming of long-term initiatives (10-15 years) aligned with organizational goals. The role centers on the define phase of Project Portfolio Management (PPM), involving strategic feasibility analyses and evaluations of organizational capacity to ensure the development of realistic and executable plans. Additionally, the role facilitates decision-making by analyzing financial, technical, and operational factors, contributing to updates such as the 2025-2030 portfolio review.

Airport Development Programme Owner is responsible for overseeing large-scale development programs at the airport, ensuring alignment with strategic goals, regulatory compliance, and operational needs. This role involves managing program scope, budgets, timelines, and stakeholder coordination to deliver infrastructure projects that support long-term airport growth and efficiency.

The Team Leader at Schiphol Projects (Airside) oversees a team of 15 project managers (senior, medior, and junior) responsible for delivering all projects within the Airside area of Schiphol. These projects range from small maintenance tasks to major renovation efforts, including expansion, adjustments, upgrades, and electrification—covering diverse activities such as asphalt and concrete work.

The Senior Manager role for Schiphol Projects (Airside and Landside) involves overarching responsibility for the successful delivery of projects, focusing on budget, quality, and overall outcomes. The role includes the authority to intervene at any level within the scope of responsibility while delegating project-specific decisions to project managers to ensure effective execution.

The Project Manager role within Airside involves overseeing the delivery of various infrastructure projects, ensuring they are completed on time, within budget, and according to specifications. Key responsibilities include managing maintenance and construction initiatives, coordinating with stakeholders, and aligning projects with strategic objectives. The role also involves addressing escalations and managing changes through formal processes to maintain project alignment and accountability.

The project client role represents the business case for projects under recent organizational changes. Responsibilities include overseeing projects into the DG two-phase model after a concept selec-

tion, ensuring budget approval from management, and monitoring the project's alignment with Schiphol's goals. The role ensures the business case remains valid throughout the entire execution process.

The Resource Coordinator forecasts and balances critical resource demand and supply for Airside projects over a two-year horizon, focusing on CSHI, ASE supervisors, security personnel, and Security checkpoint capacity. Using planning data and input from stakeholders, the role identifies weekly resource gaps and explores adjustments or escalates issues to management for prioritization. While forecasts assume even demand distribution, practical variations are managed with margins to minimize delays and ensure project continuity.

The Works Advisor in Operations translates the annual portfolio into operational impact by coordinating with Resource Coordinator. Key responsibilities include preparing project plans, managing permits, safety assessments, and informing the operations department. Additionally, the role focuses on long-term 5-year portfolio planning, identifying risks, trends, and opportunities, while assessing future resource needs with the Resource Coordinator.

The Security Works Advisor provides strategic advice on Airside and terminal projects, ensuring alignment with security regulations and infrastructure capacity. This role acts as a liaison between projects and security, assessing plans, resource needs, and potential risks to support the successful delivery of projects.

Project Manager Main Contractor (Heijmans) role is overseeing maintenance and infrastructure projects for Schiphol. Responsibilities include managing MJOP (maintenance) initiatives, advising on asset maintenance, and aligning projects with Schiphol's strategic goals and planning. The role serves as the main contact for Schiphol, ensuring coordination of maintenance needs, safety standards (e.g., EASA), and project scope definition.

The Manager Realization is part of the Asset Management department, which oversees the lifecycle of critical assets, focusing on maintenance, upgrades, and new construction to ensure performance, safety, and alignment with strategic goals. The Manager Realization leads the execution of construction and major maintenance projects, ensuring they meet business objectives, budgets, and timelines while coordinating stakeholders and maintaining compliance.

Reliability Engineer is Responsible for asset performance on Airside and translating this into strategic maintenance plans. This includes runway and taxiway maintenance, VOP activities, and investments in strategic vehicles.

C.3 Disruption: COVID-19

This section elaborates on the phrases of the interviews regarding the hybrid approach identified at Schiphol Airport. This is categorized for each disruption selected.

Table 79: Case 1: Reconfiguration mechanisms COVID-19

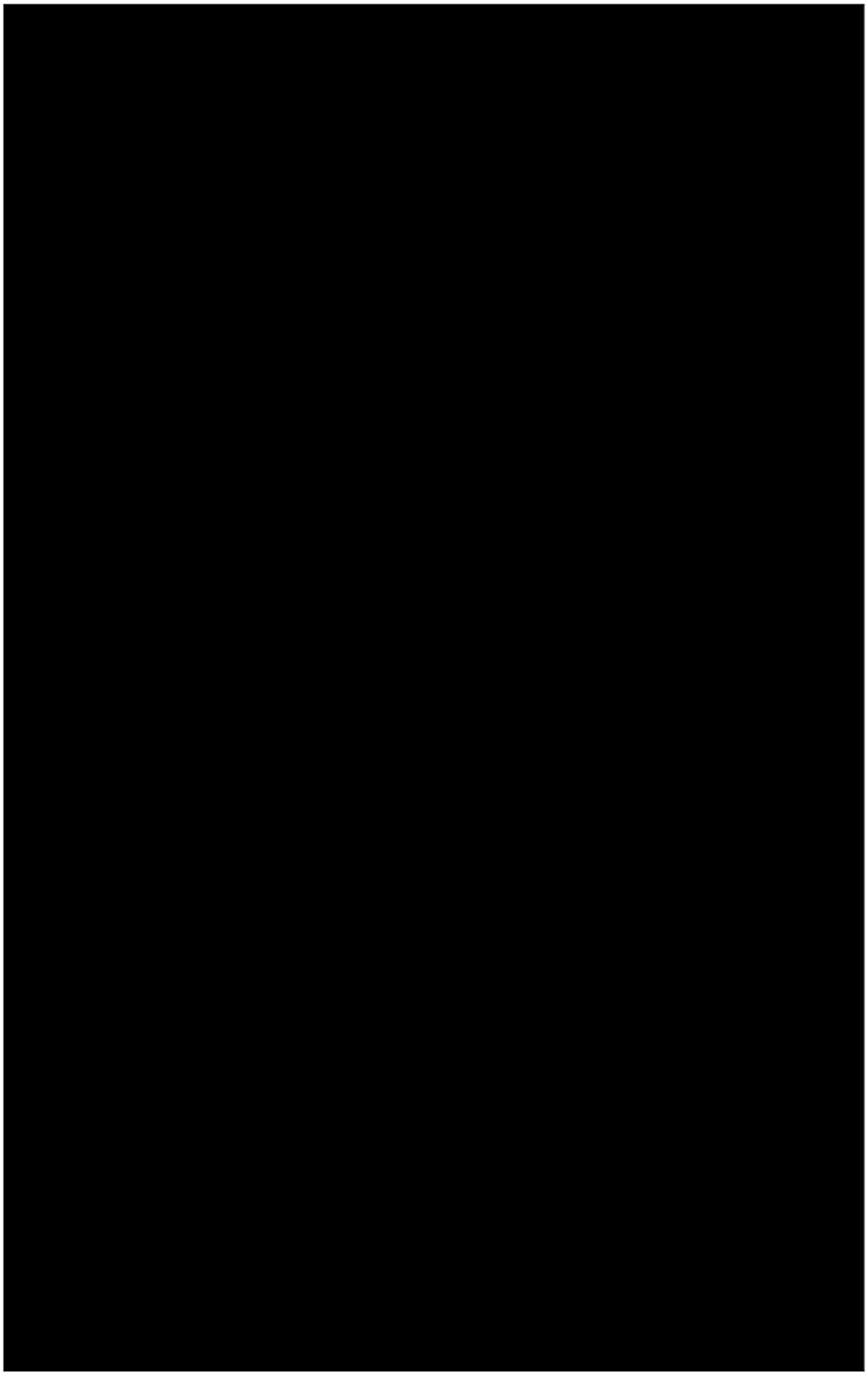


Table 80: Case 1: Sensing Seizing mechanisms COVID-19

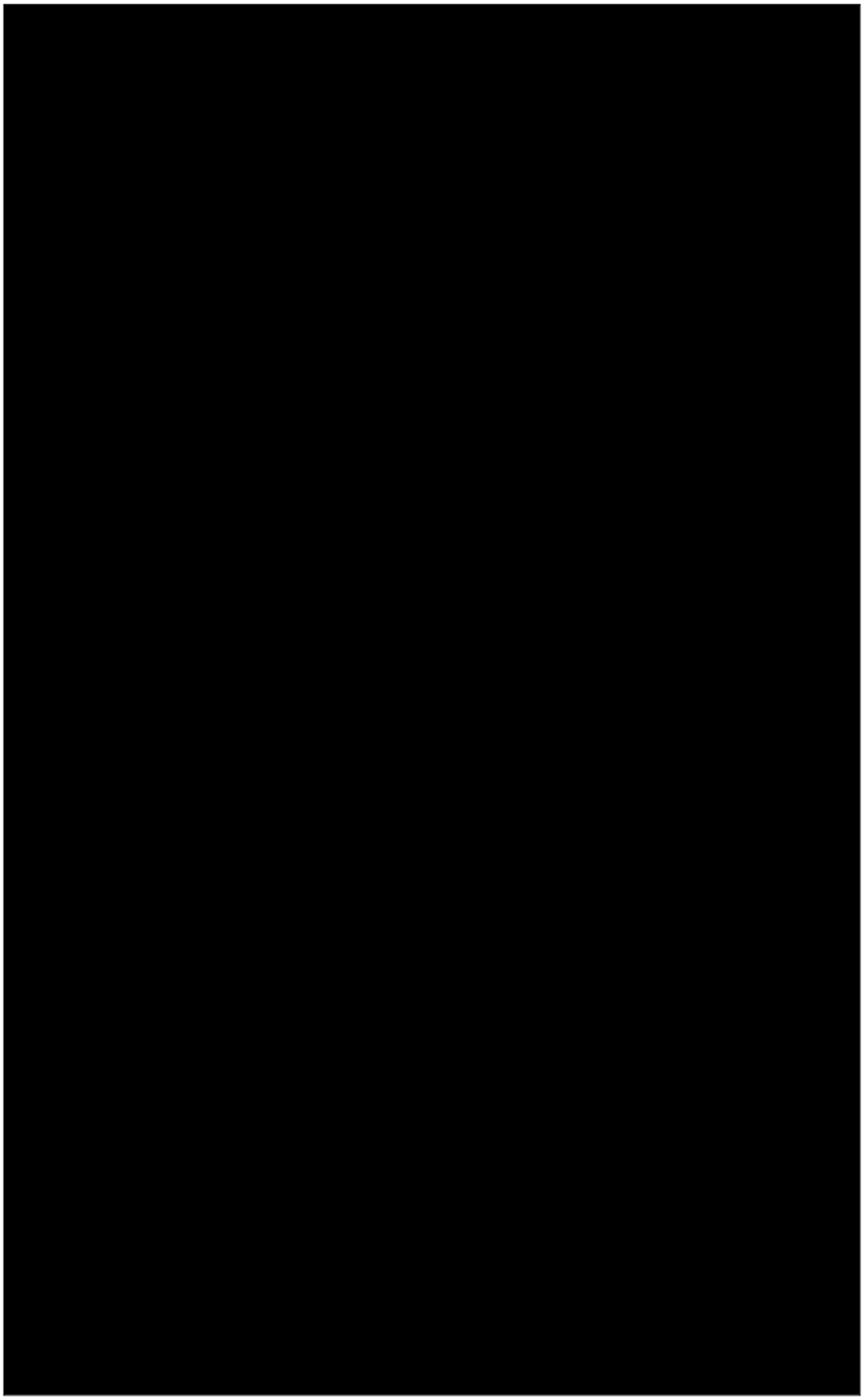
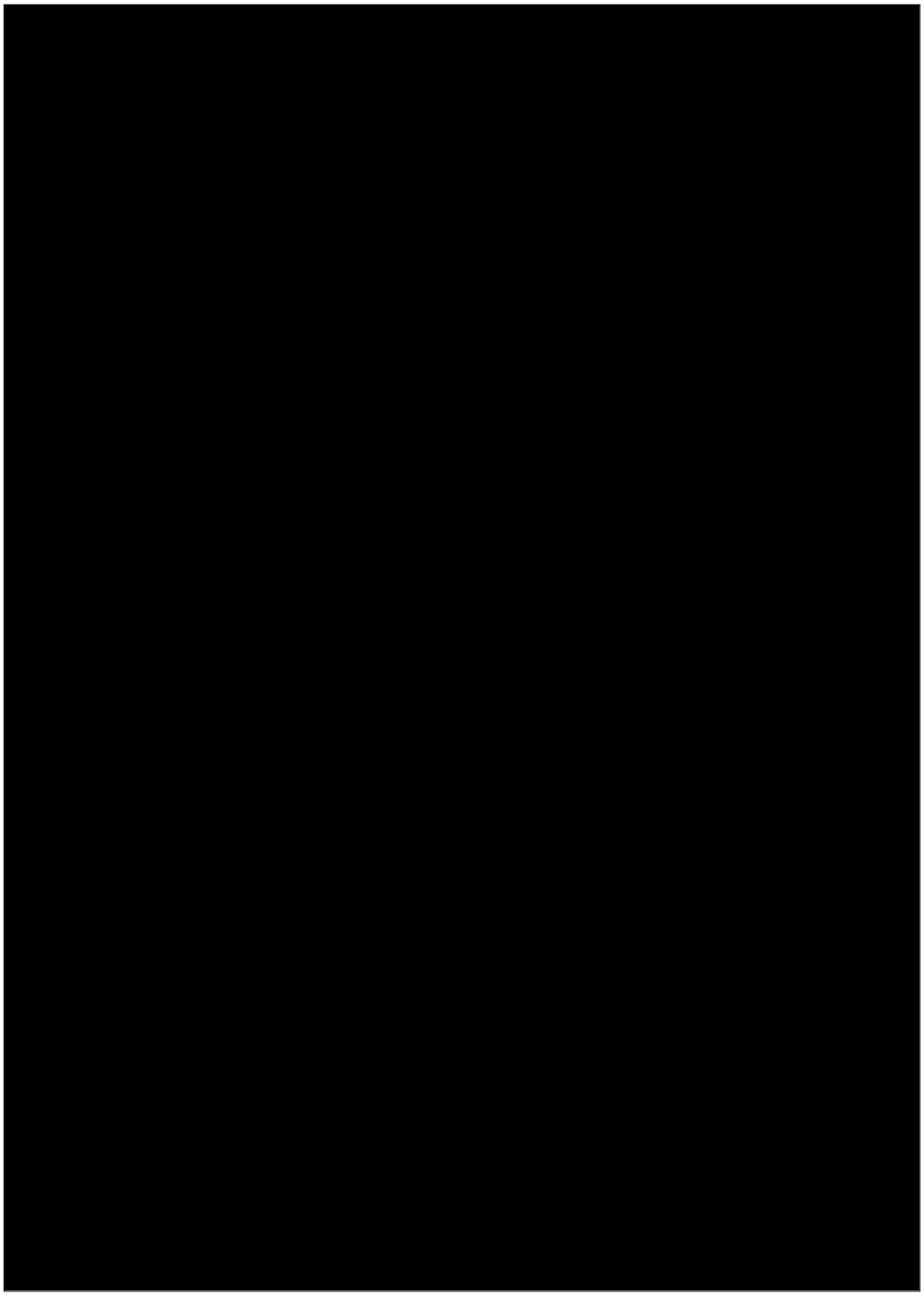


Table 81: Case 1: Decision-making COVID-19



C.4 Disruption: Security Personnel Shortage

Table 82: Case 2: Reconfiguration mechanisms Security Personnel Shortage

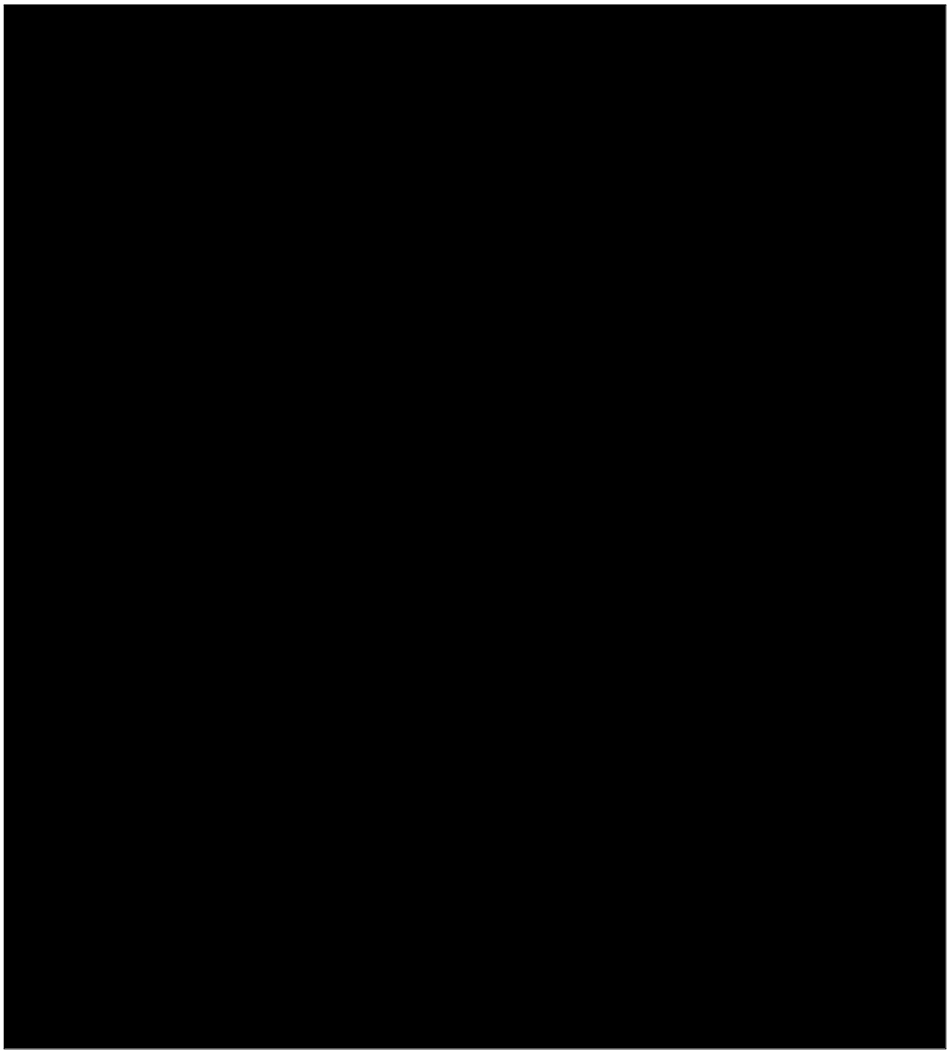


Table 83: Case 2: Sensing Seizing mechanisms Security Personnel Shortage

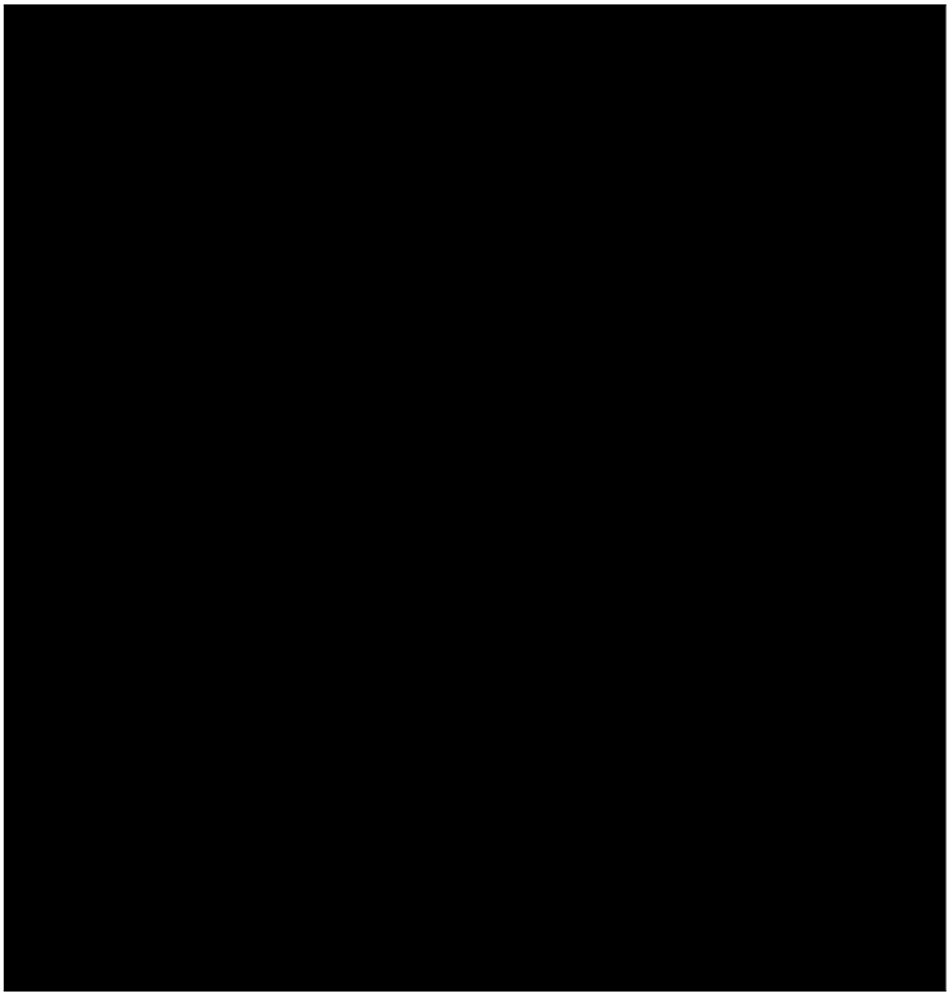
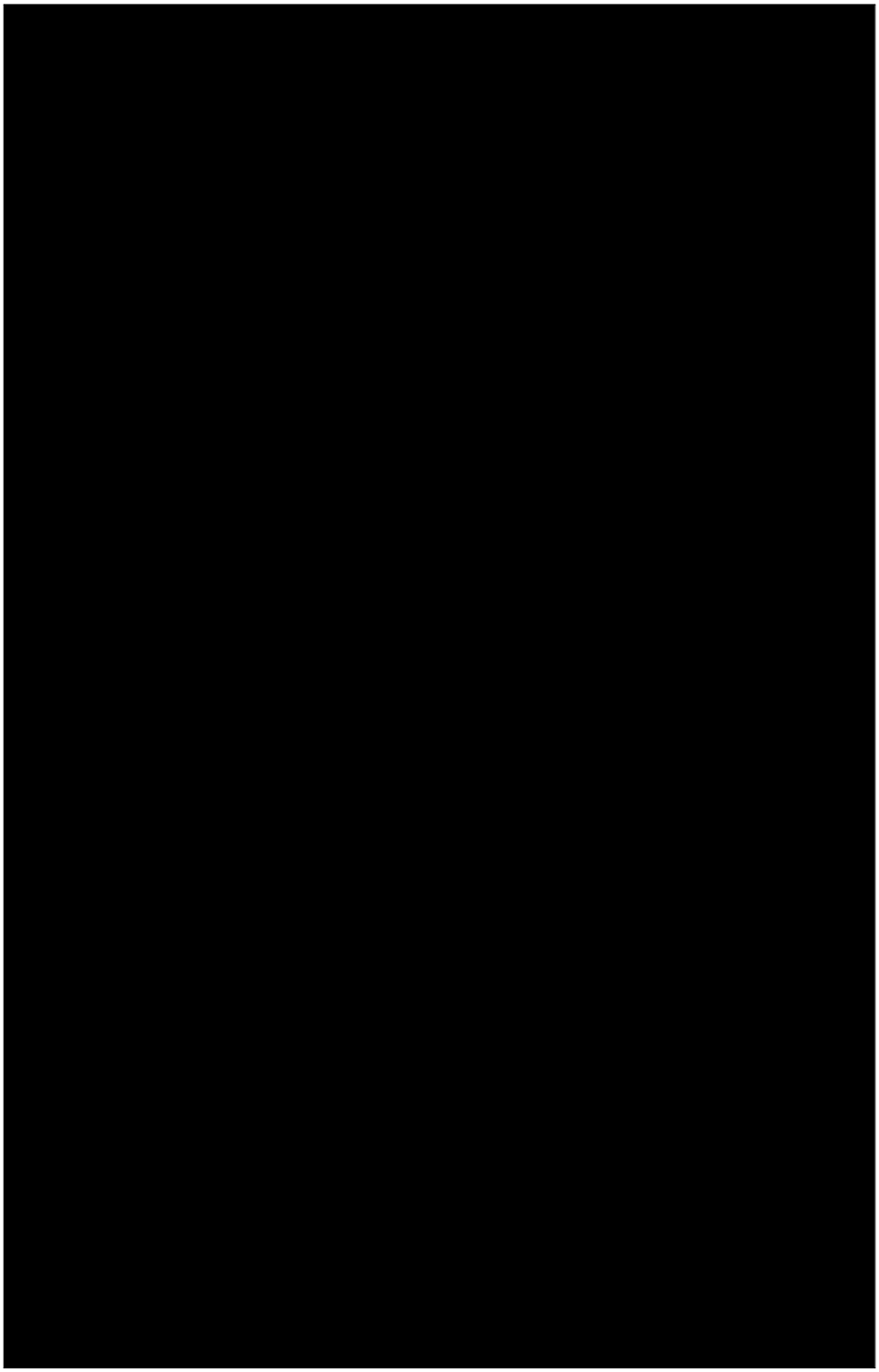


Table 84: Case 2: Decision-making Security Personnel Shortage



C.5 Disruption: Security Lane Shortage

Table 85: Case 3: Reconfiguration mechanisms Security Lane Shortage

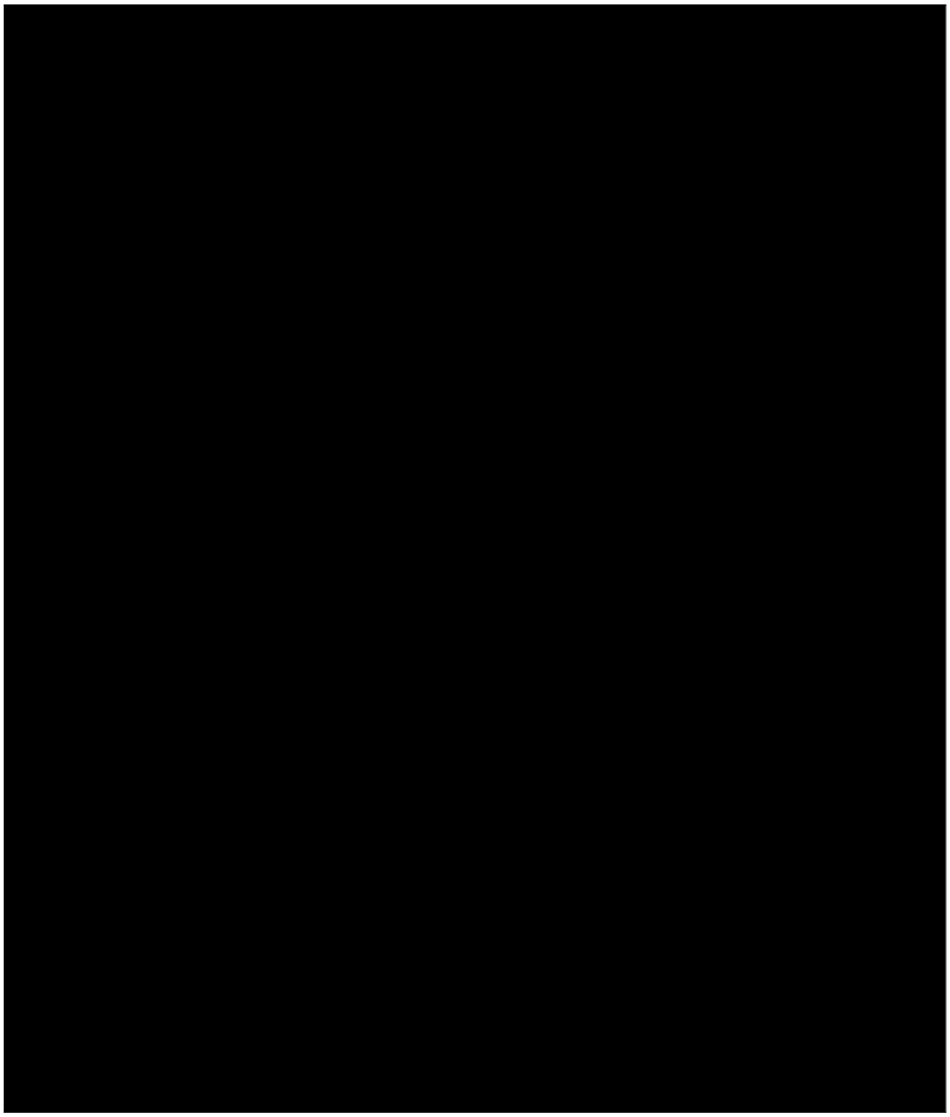


Table 86: Case 3: Sensing Seizing mechanisms Security Lane Shortage

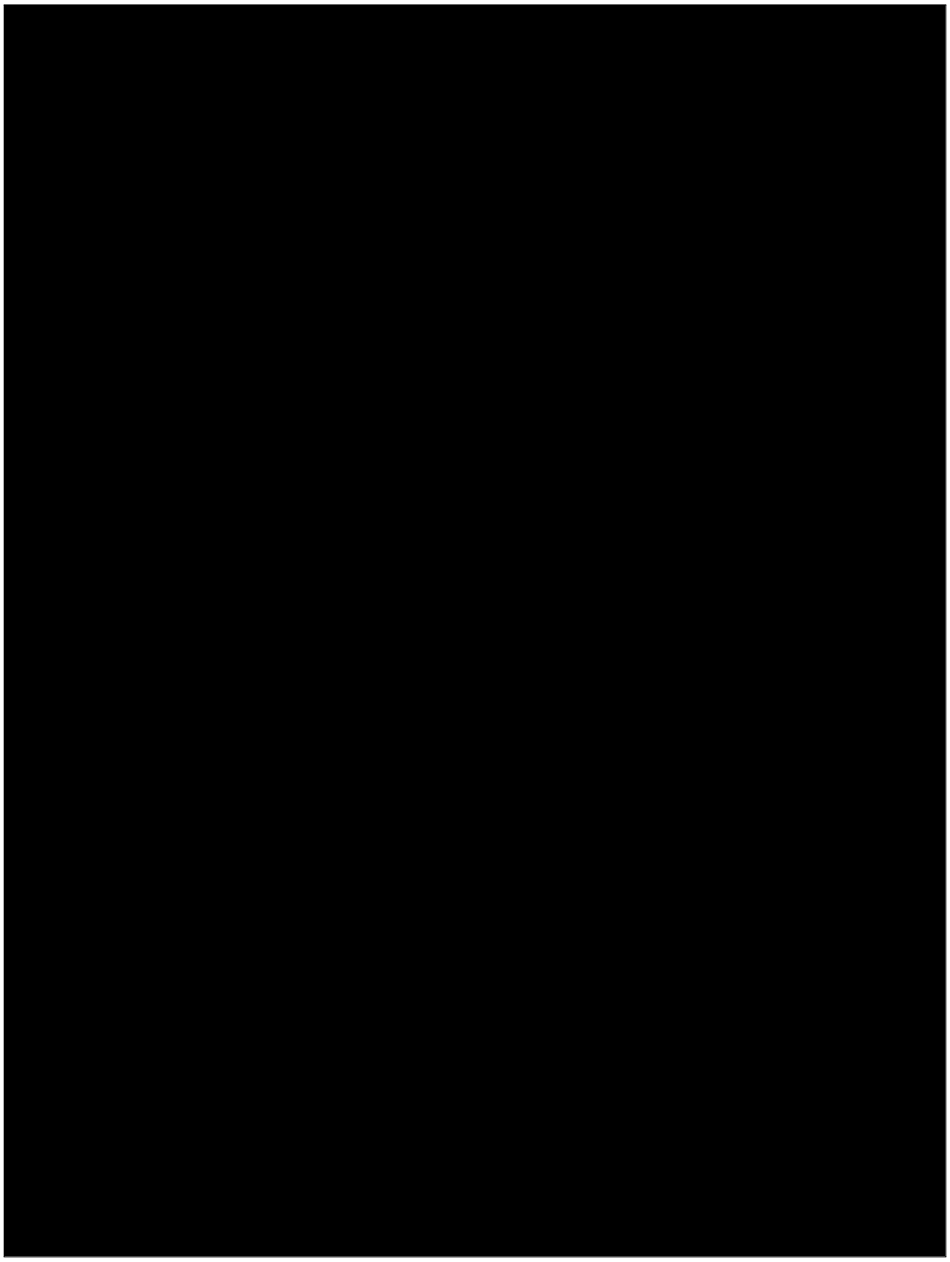
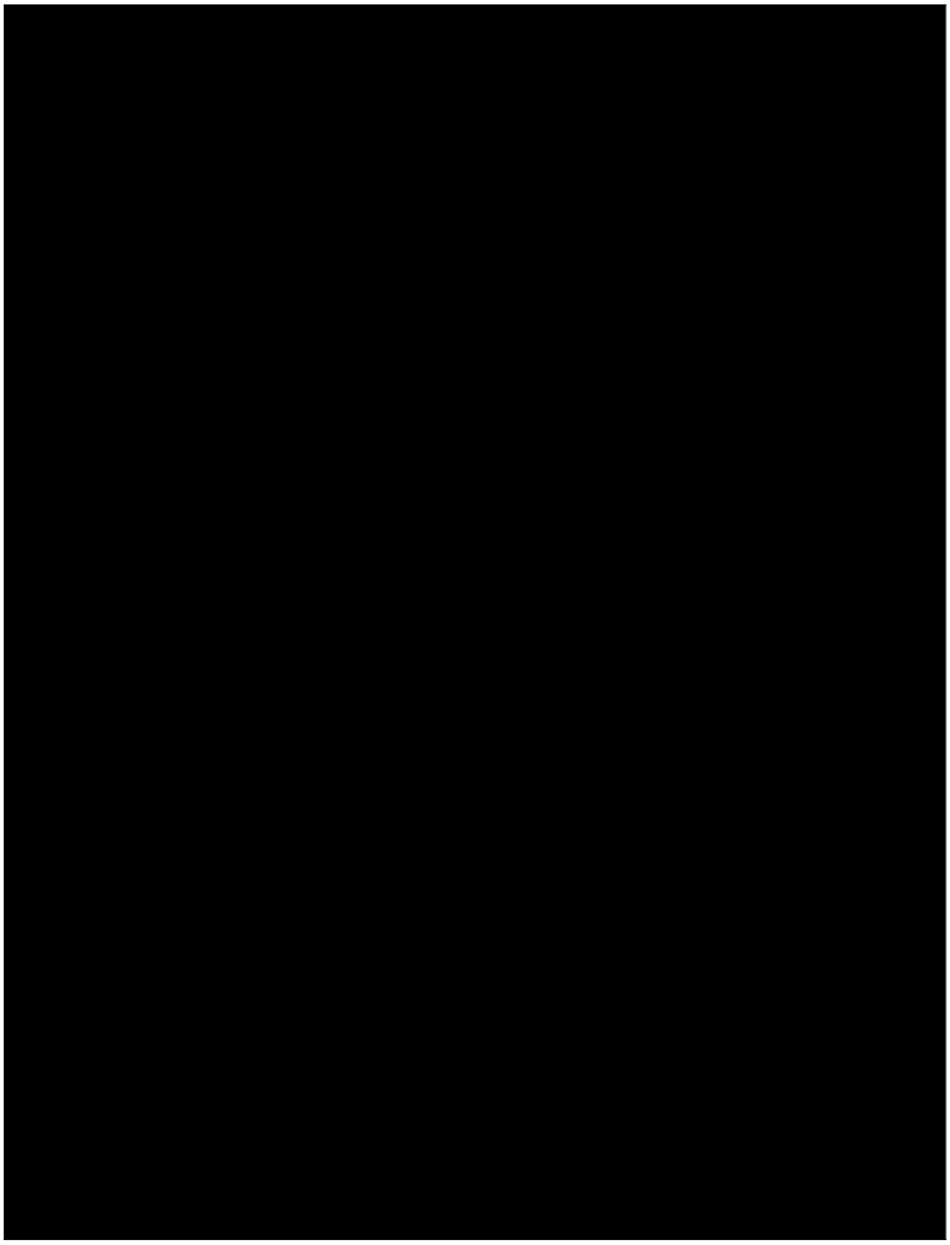


Table 87: Case 3: Decision-making Security Lane Shortage



C.6 Disruption: Strategic Shift

Table 88: Case 4: Reconfiguration mechanisms ILT inspections

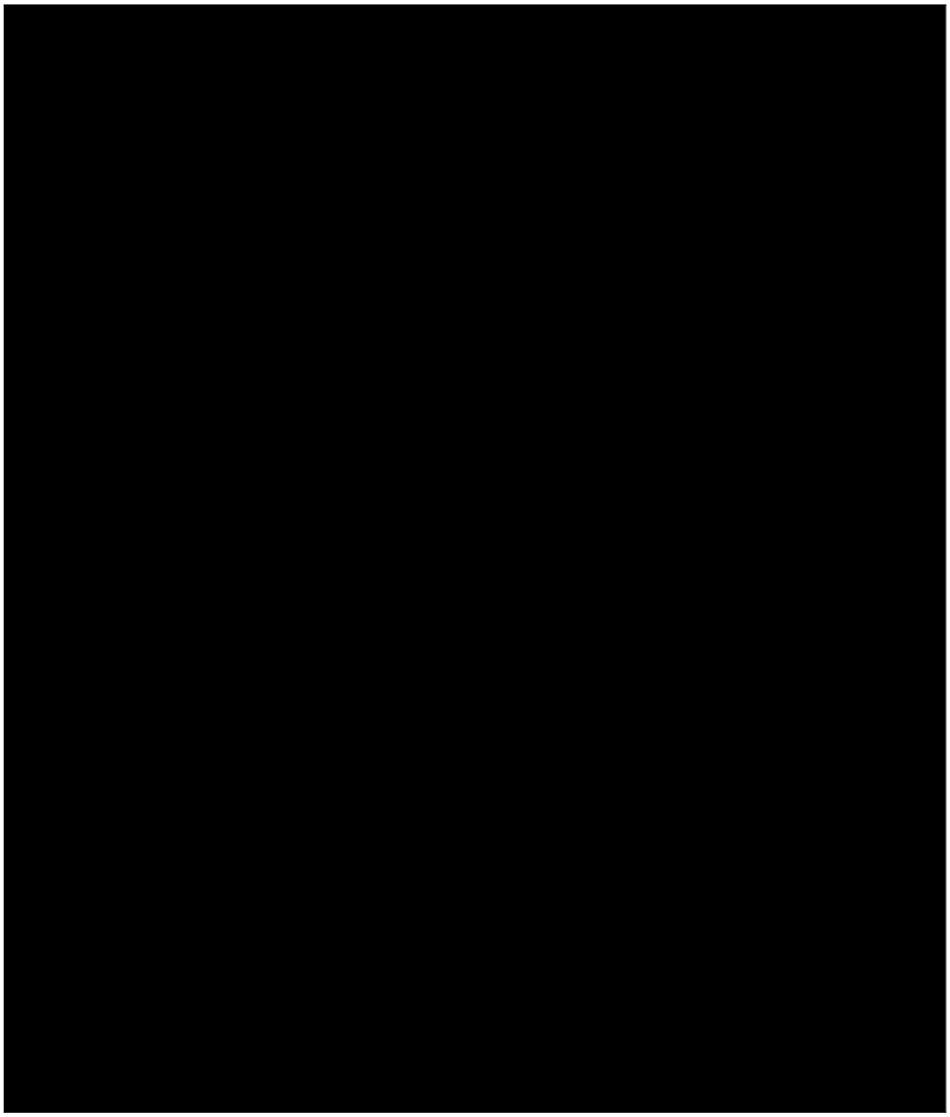


Table 89: Case 4: Sensing Seizing mechanisms ILT inspections

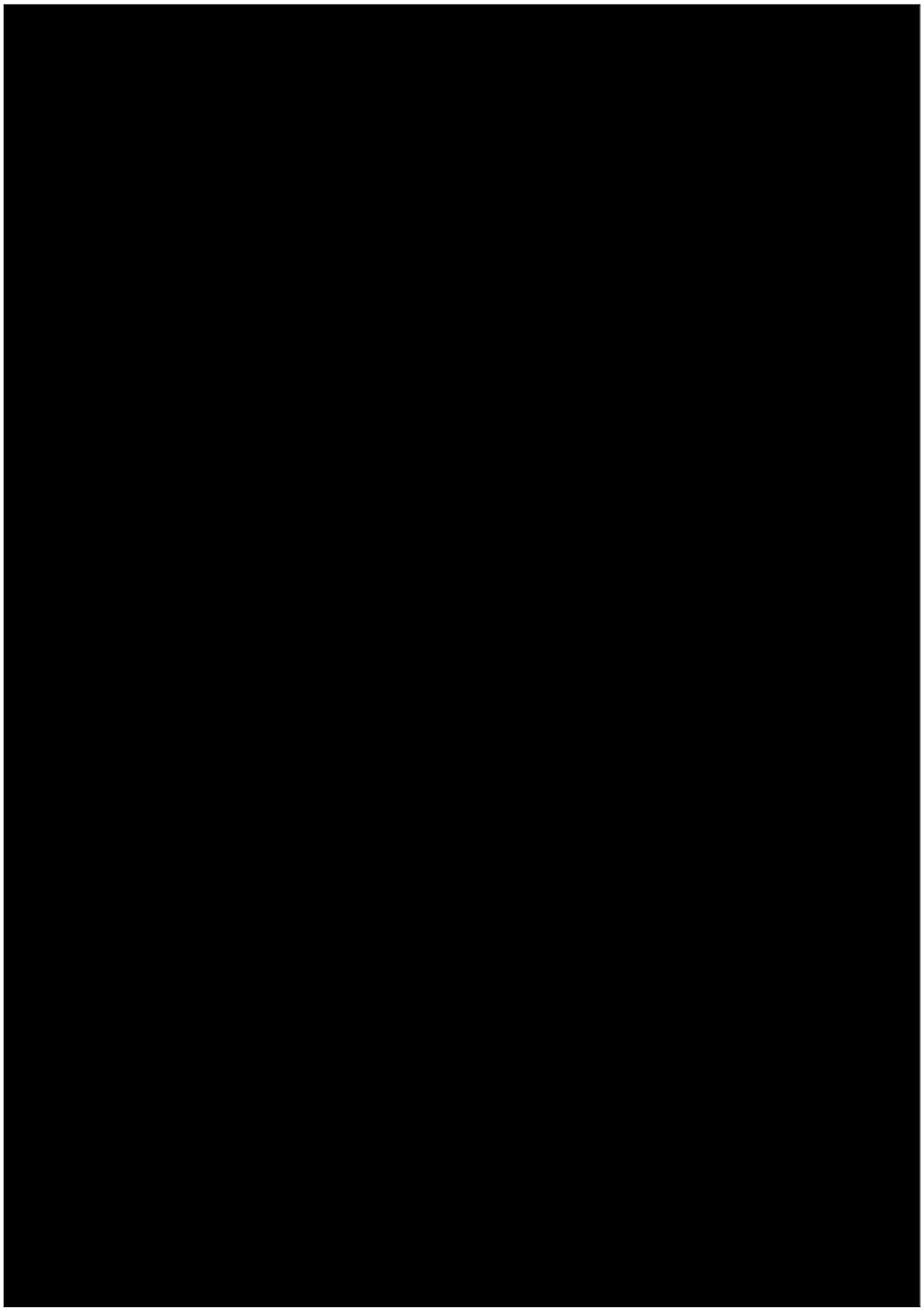
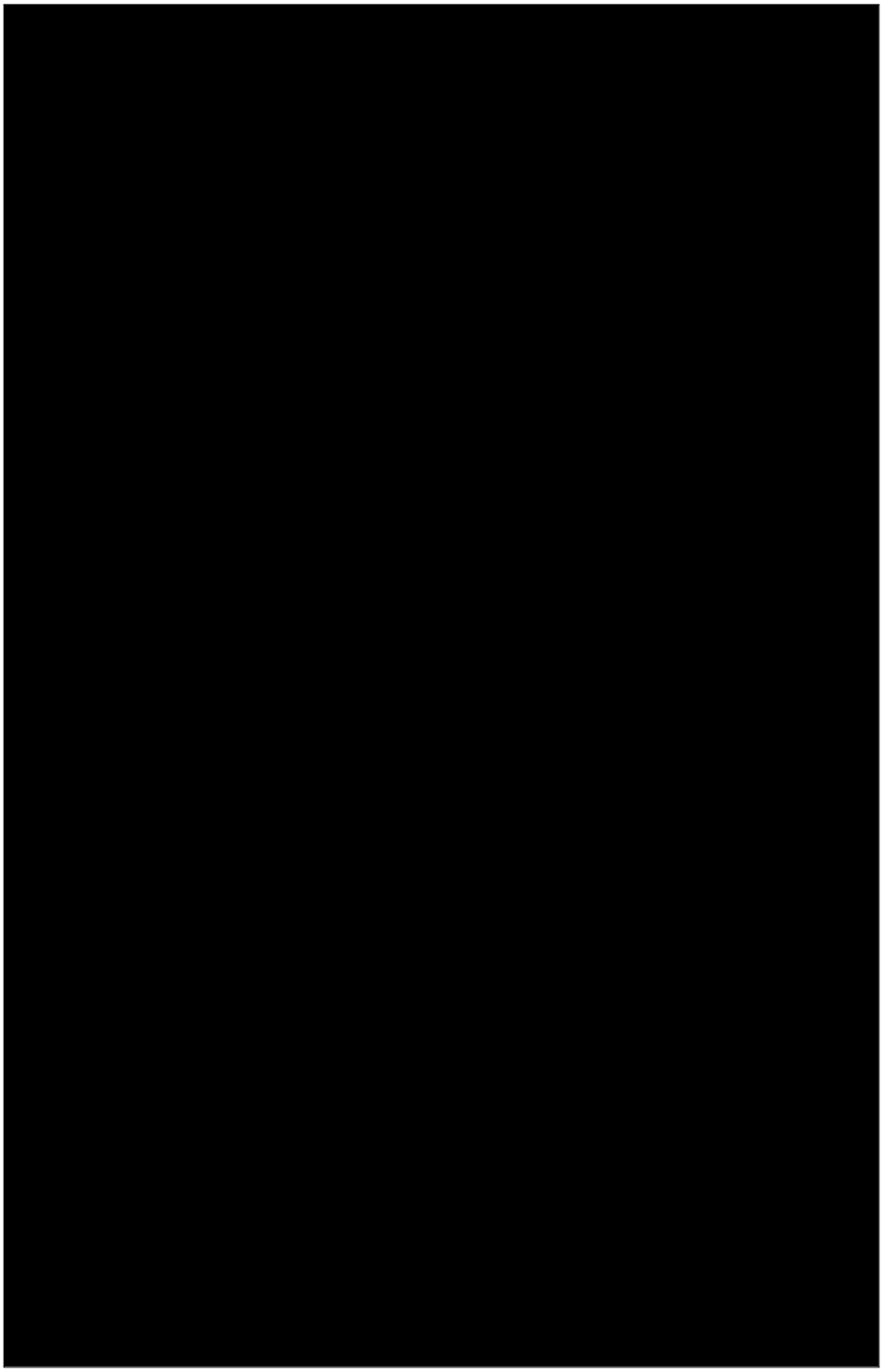


Table 90: Case 4: Decision-making ILT inspections



C.7 Disruption: Unforeseen Weather Conditions

Table 91: Case 5: Reconfiguration mechanisms Unforeseen Weather Conditions

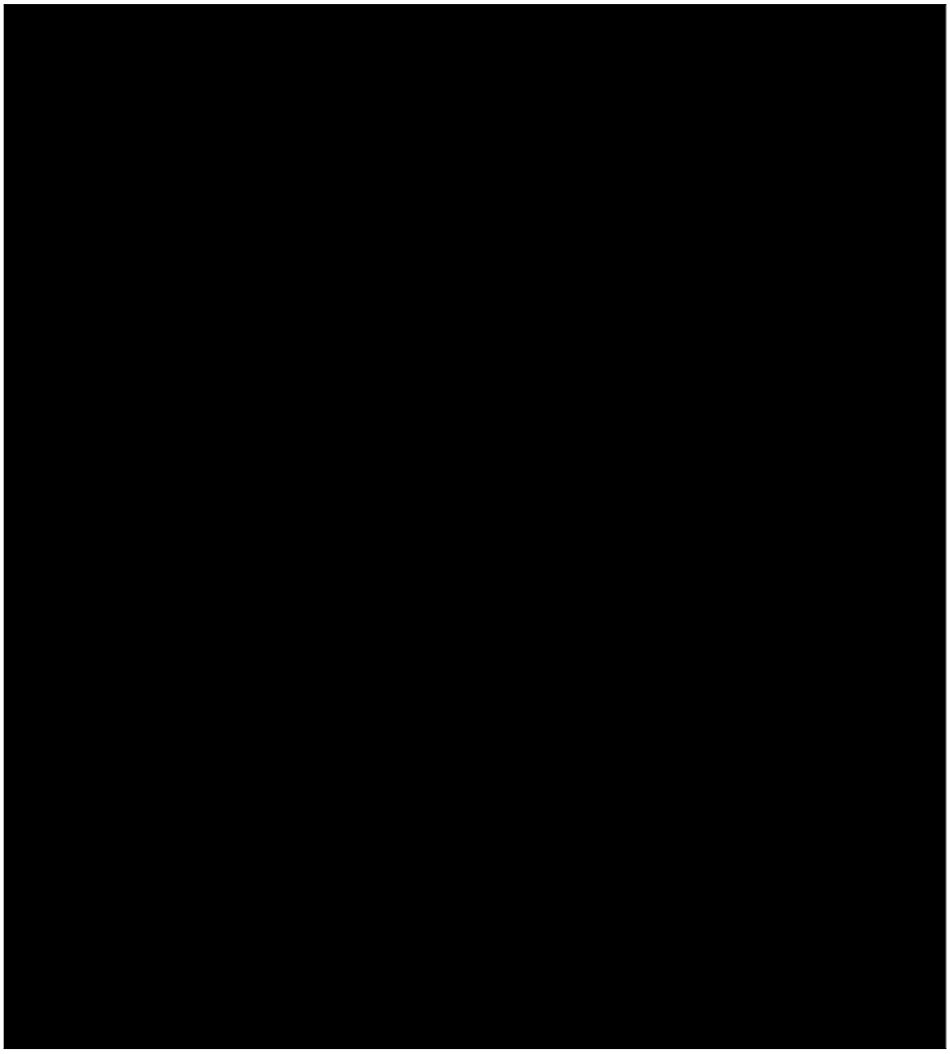


Table 92: Case 5: Sensing Seizing mechanisms Unforeseen Weather Conditions

Table 93: Case 5: Decision-making Unforeseen Weather Conditions

D Expert Judgment

Table 1: Examples of disruptions where both predefined strategies and ad-hoc problem solving were applied

Table 94: Your table caption here

Table 2: Which ad-hoc and structured/formalized methods are applied in such situations?

Table 95: Your table caption here

Table 3: Can you provide an example of information that is proactively monitored or collected and then used to support ad-hoc problem solving?

Table 96: Your table caption here

Table 4: Can you provide an example where the shortcomings of a structured method were addressed with ad-hoc problem solving?

Table 97: Your table caption here

Table 5: Can you provide an example of 'lessons learned' from ad-hoc problem solving that were integrated into a structured method?

Table 98: Your table caption here

Tabel 6: Can you provide examples where the urgency was that high that formalized procedures cannot be used and your team relied on ad-hoc problem solving?

Table 99: Your table caption here