Improving Aircraft Towing Coordination to Make Towing a More Efficient and Predictable Element of the Turnaround Process

Thesis

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Table 1: Supervisors

Preface

As a part-time brake operator in KLM's Aircraft Towing Department, alongside my studies in Aviation Operations, I feel incredibly fortunate to have the best side job an aspiring pilot and aviation enthusiast could ever ask for. However, my experience in this role, combined with the academic knowledge gained from my studies, has also made me aware of the inefficiencies that often arise in the workplace, and the impact they have not only on operations but also on my much appreciated colleagues.

This awareness has inspired me to address this challenge in my graduation thesis, where my objective has not solely been to enhance operational efficiency, but more importantly, to support my colleagues in streamlining their daily tasks. By addressing disruptions and reducing uncertainty, I aim to transform towing into a more efficient and predictable part of the turnaround process.

First, I would like to express my deepest gratitude to Mark van Heijningen for introducing me to KLM's Aircraft Towing Department, which ultimately led me to the role of brake operator.

Next, I am thankful to Catya Zuniga Alcaraz for introducing me to the Knowledge Development Centre, where I was able to propose my thesis idea, and for graciously volunteering to be my official internship supervisor through the Amsterdam University of Applied Sciences.

A special thanks goes to Koos Noordeloos for facilitating the initiation of my thesis proposal within the Knowledge Development Centre and for involving LVNL, Schiphol, and KLM in this collaborative effort, as well as for serving as my company supervisor.

I would also like to thank Richard Reijn and Romy Vreeken for the trust you placed in me, and for providing the people and resources I needed throughout the execution of the project. Without your support, this thesis would not have been possible.

Last but certainly not least, I am deeply grateful to the shift leaders and my colleagues in KLM's Aircraft Towing Department, as well as my colleagues and fellow students at the Knowledge Development Centre, LVNL's P&D-Strategy, and KLM's HCC, whose unwavering support has been essential throughout my entire internship.

Thank you all for your dedication and commitment, which have inspired me to keep striving for improvement in every aspect of my work. I hope you enjoy reading it.

Vincent van Dijk

Vogelenzang

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Management Summary

Aircraft towing plays a crucial role in the turnaround process, which encompasses all ground handling activities between an aircraft's arrival (IBT) and departure (OBT). The efficiency of aircraft towing is intrinsically linked to the overall turnaround process, as it is a critical path activity during which no other tasks can take place.

At Schiphol Airport, aircraft towing is commonly used to relocate aircraft for operational efficiency, maintenance, or space optimization. However, towing operations have been identified as a source of inefficiency and unpredictability due to disruptions and uncertainty caused by a lack of coordination between various systems and stakeholders. Despite the critical role towing plays in turnarounds, misalignments and poor coordination between various stakeholders, systems, lead to inefficiencies and delays. The lack of integration between planning systems and airport-wide systems, such as ACDM, hampers transparency and creates confusion regarding towing schedules. These issues contribute to unpredictable towing times, operational disruptions, and a negative impact on turnaround efficiency, affecting not only KLM's Aircraft Towing Department, but also other departments within KLM, as well as AAS' gate planning and apron control, and LVNL's ground and runway control.

This thesis aimed to find out how aircraft towing can become a more efficient and predictable element of the turnaround process, by addressing risks that may cause disruptions and uncertainty in the towing process, through improving its coordination.

To realise this, several recommendations are proposed:

Integration of Planning Systems: The tow planning system CHIP should be linked to other crucial planning systems such as those from the gate planning (GMS) and KCS (CaRe). Linking and enabling feedback between these systems, should make the start time of tow movements more accurate.

Treating Towing Times as ACDM Timestamps: Similar to the OBT of departing flights, the start time of tow movements should be treated as an ACDM timestamps (Tow-OBT), ensuring that all relevant stakeholders are informed and can plan accordingly.

Clear Guidelines for Operators: Operators should be given explicit guidelines on how far in advance of the Tow-OBT tasks should be completed, ensuring proper timing of pre-towing procedures.

Establishing a Tow-Window: Similar to a TSAT-window, a Tow-Window based on the Tow-OBT, in combination with real-time data from the Deep Turnaround system, should be implemented, enabling controllers to anticipate the tow in advance.

Predicting Tow Arrival Times: Tow movement formulas should be added to the Tow-OBT to predict a Tow-IBT, which should also be treated as an ACDM timestamp.

Stricter APU Restrictions: Similar to APU restrictions based on the OBT and IBT of actual flights, APU restrictions should also be implemented based on the Tow-OBT and IBT in order to reduce emissions.

Tow List for Handymen: A Tow-OBT and IBT list should be provided to the handyman to optimize assistance during towing operations.

In the short term, raising awareness among operators about the timing of their activities compared to the start of the tow will help improve operational efficiency until the long-term steps are fully implemented. Raising awareness for existing tools like Wilbur for tow movement tracking can also provide immediate efficiency improvements.

Abbreviations

AAC	Aircraft Allocation Coordinator
AAS	Amsterdam Airport Schiphol
ACDM	Airport Collaborative Decision Making
ADA	Airside Demarcated Area
AHSU	Aircraft Handling and Support Unit
API	Application Programming Interface
APU	Auxiliary Power Unit
ARD	Aircraft Refuelling Department
ATD	Aircraft Towing Department
BZO	Low-Visibility Operations
CaRe	Catering Ready
CHIP	Communicatie en Hub-Indelings Programma
CISS	Central Information System Schiphol
DFM	Duty Flow Manager
E&M	Engineering and maintenance
FIRDA	Flight Information Royal Dutch Airlines
GMS	Gate Management System
GPU	Ground Power Unit
HCC	Hub Control Centre
HCT	Hub Control Team
IATA	International Air Transport Association
IBT	In-Block Time
IenW	Infrastructure and Water Management
KCS	KLM Catering Services
KDC	Knowledge & Development Centre Mainport Schiphol
KLM	Royal Dutch Airlines
KLC	KLM Cityhopper
LVNL	Air Traffic Control the Netherlands
OBT	Off-Block Time
OCC	Operations Control Centre

OCT	Operations Control Team
PCA	Pre-Conditioned Air
P&D	Performance and Development
RASAS	Regulation Aircraft Stand Allocation Schiphol
RSG	Royal Schiphol Group
SRA	Security Restricted Area
SRA-CP	Security Restricted Area-Critical Part
TRIZ	Theory Of Inventive Problem Solving
TSAT	Target Start-up Approval Time
UDP	Uniform Daylight Period

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1. Introduction

In the complex and dynamic environment of airport operations, numerous processes must come together to achieve minute-level punctuality. When operational planning relies on outdated or unshared information, it can lead to inefficiencies, delays, and underutilization of limited airport capacity (EUROCONTROL, n.d.-a). Eurocontrol's Airport Collaborative Decision Making (ACDM) system helps address these challenges by enhancing efficiency and resilience through optimized resource use and real-time data sharing, with a particular focus on the aircraft turnaround (EUROCONTROL, n.d.-b).

Building upon ACDM, new technologies like Deep Turnaround further enhance operations by leveraging historical data in combination with real-time AI image-based processing. This technology predicts the progression of processes along the critical path of turnarounds (Schiphol, n.d.). As a result, airport operations are becoming more predictable and transparent, enabling stakeholders to make informed decisions and reducing delays and inefficiencies caused by miscommunication or lack of clarity.

1.1. Problem Statement

The problem that this study addresses, is that despite significant advancements in airport operations, particularly through systems like ACDM and technologies such as Deep Turnaround, the coordination of aircraft towing has not seen similar improvements. This discrepancy often leads to disruptions and increased uncertainty, which significantly hampers the efficiency and predictability of aircraft towing and, consequently, the entire turnaround process. For instance, in 36% of towing operations, delays occurred, with an average waiting time of 13,75 minutes (KLM, 2024-w).

While ACDM and Deep Turnaround systems optimize many aspects of airport operations, they often fall short once an aircraft leaves its stand. When the towing process begins and the aircraft moves toward various airport locations via the taxiway, it cannot benefit from the same coordination advantages provided by these systems. Furthermore, towing is highly influenced by external factors such as taxiway and runway capacity, air traffic control coordination, gate planning, and other ground service activities, which must be carefully aligned to avoid overlap with the critical path of the turnaround process.

As a result, towing becomes one of the most complex and unpredictable components of the turnaround, affecting all stakeholders involved. This often hampers the overall efficiency of towing, leading to reduced throughput for KLM's Aircraft Towing Department (ATD), decreased taxiway capacity as controllers struggle to manage unpredictable towing movements, increased emissions due to longer APU runtimes, and reduced efficiency for other operators, who are unable to plan their activities effectively around an unpredictable tow.

1.2. Department Information

To address such complex problems that require involvement of multiple stakeholders and research institutes, the Knowledge & Development Centre (KDC), a foundation with the objective to support the development of Schiphol Mainport was founded by the Dutch aviation partners: KLM, Royal Schiphol Group (RSG) and Air Traffic Control The Netherlands (LVNL) in 2006. The KDC provides a platform for applied research and development with the aim to innovate aviation in The Netherlands. The goal is to find valuable and innovative solutions for the sustainable development of Mainport Schiphol. This task is executed by defining and realizing target oriented projects with close consultation of both the air transport sector and the department of Infrastructure and Water Management (IenW). For this particular project, LVNL's P&D-Strategy, KLM's Flow Control and ATD, and RSG's Ground Control and Gate Planning are collaborating to enhance predictability in the aircraft towing process.

1.3. Research Objectives

This thesis aims to find out how aircraft towing can become a more efficient and predictable element of the turnaround process, by addressing risks that may cause disruptions and uncertainty in the towing process, through improving its coordination.

To achieve this objective, the research addresses the following sub-objectives:

1. Develop a comprehensive understanding of the turnaround process.
2. Examine aircraft towing and its role within the turnaround process, distinguishing it from pushback operations.
3. Assess the importance of effective towing coordination in turnaround efficiency.
4. Investigate Schiphol Airport's operational landscape, specifically:
    - Key locations relevant to towing operations.
    - Innovative coordination systems used.
5. Evaluate the impact of Schiphol's operational landscape on KLM's turnaround activities.
6. Analyse KLM's towing operations at Schiphol, identifying the different steps, information flows, and key stakeholders involved across:
    - The strategic phase of towing.
    - The tactical phase of towing.
    - The operational phase of towing.
7. Analyse the coordination risks across:
    - The strategic phase of towing.
    - The tactical phase of towing.
    - The operational phase of towing.

1.4. Research Scope and Limitations

Aircraft towing is one of the most complex activities in airport operations, as it involves moving an aircraft between various airport locations. This process requires the involvement of several stakeholders, including those responsible for aircraft servicing, which encompasses both maintenance and ground handling activities. Additionally, airport gate planning and air traffic control are also key stakeholders, as the tow utilizes the taxiways.

Due to the complexity of coordinating with all individuals involved in towing operations, the focus of this research will be limited to aircraft servicing activities most likely to overlap with towing. A detailed examination of all individuals involved in the towing process is beyond the scope of this study.

Furthermore, analysing every aspect of KLM's Engineering & Maintenance (E&M) operations, including the different hangars and all maintenance activities at these locations, would be too extensive for the given timeframe. As a result, the scope is generalized to a broader analysis of E&M operations as a whole.

1.5. Methodology

For this research, the Theory of Inventive Problem Solving (TRIZ) methodology is employed. This methodology posits that understanding the problem is essential for finding its solution. The method involves thoroughly analysing the problem to generalize it into a simpler, more solvable form. Once generalized, an analytical approach is used to identify a standard solution based on known inventive principles. The final step is to adapt this standard solution to the specific problem through analogy, effectively translating it into a tailored solution (Oxford Creativity, 2022). TRIZ is particularly valuable in this study as it allows for a structured and systematic analysis of aircraft towing operations, risks in its coordination and the application of standardized, inventive solutions that are already used within airport operations, adapted to the unique context of towing operations at Schiphol.

A global overview of the TRIZ methodology, adjusted to its application in this thesis, is illustrated in Figure 1.

Global Methodology: TRIZ			
Phase 1: Understanding the Operation in General	**Phase 2: Understanding the Operation in the Specific Case of this Research**	**Phase 3: Identifying the Risks**	**Phase 4: Improve**
Objectives 1, 2 and 3	Objectives 4, 5 and 6	Objective 7	Main objective
Chapter 2	Chapters 3, 4, and the first parts of chapters 5, 6 and 7	The last parts of chapters 5, 6 and 7	Chapters 8 and 9
Methods: • Qualitative desk research on external literature	Methods: • In-depth interviews • Qualitative desk research on both internal and external literature • Observations	Methods: • In-depth interviews • Qualitative desk research on internal literature • Observations	Methods: • TRIZ

Figure 1: Methodology Overview

1.5.1. Phase 1: Understanding the Operation in General

The first phase of this research aims to gain a comprehensive understanding of aircraft towing operations as a part of the turnaround process, specifically finding out why its coordination is important, and what its relation is to turnaround efficiency. This is accomplished by addressing the first three sub-objectives:

1. Develop a comprehensive understanding of the turnaround process.
2. Examine aircraft towing and its role within the turnaround process, distinguishing it from pushback operations.
3. Assess the importance of effective towing coordination in turnaround efficiency.

This is achieved through a literature review (Chapter 2) based on qualitative desk research on external literature, providing a general understanding to form the foundation for the specific case analysis of Schiphol.

1.5.2. Phase 2: Understanding the Operation in the Specific Case of this Research

The second phase of this research aims to gain a comprehensive understanding of aircraft towing operations as a part of KLM’s turnaround at Schiphol. To achieve this, at first, a dedicated chapter called *Schiphol’s Operational Landscape* (Chapter 3), is written primarily based on qualitative desk research on both internal and external literature. This chapter addresses the fourth sub-objective:

4. Investigate Schiphol Airport’s operational landscape, specifically:
    - Key locations relevant to towing operations.
    - Innovative coordination systems used.

Then chapter, a dedicated chapter called *The Influence of Schiphol's Operational Landscape on KLM's Turnaround Activities* (Chapter 4), is written based on a mix of qualitative desk research on internal literature, complemented by in-depth interviews with KLM's various service providers. This chapter addresses the fifth sub-objective:

5. Evaluate the impact of Schiphol's operational landscape on KLM's turnaround activities.

Following this, the first parts of chapters 5, 6 and 7 are written. The first parts of these chapters, called, *The Initiation* (Chapter 5)*, Planning* (Chapter 6)*, and Execution* (Chapter 7) *of Towing Movements Between Airport Locations During KLM's Turnaround at Schiphol*, are written primarily based on in-depth interviews with stakeholders, complemented by qualitative desk research on internal literature, and observations where interviews could not be conducted. The first parts of these chapter addresses the sixth sub-objective:

6. Analyse KLM's towing operations at Schiphol, identifying the different steps, information flows, and key stakeholders involved across:
    - The strategic phase of towing.
    - The tactical phase of towing.
    - The operational phase of towing.

1.5.3. Phase 3: Identifying the Risks

Following the understanding of the operation in the specific case of this research, the third phase of this research aims to gain a comprehensive understanding of the coordination risks involved in aircraft towing operations as a part of KLM's turnaround at Schiphol. To achieve this, the last parts of chapters 5, 6 and 7 are written. The last parts of these chapters, called, *The Initiation* (Chapter 5)*, Planning* (Chapter 6)*, and Execution* (Chapter 7) *of Towing Movements Between Airport Locations During KLM's Turnaround at Schiphol*, are written primarily based on in-depth interviews with stakeholders, complemented by qualitative desk research on internal literature, and observations where interviews could not be conducted. The last parts of these chapter addresses the seventh sub-objective:

7. Analyse the coordination risks across:
    - The strategic phase of towing.
    - The tactical phase of towing.
    - The operational phase of towing.

1.5.4. Phase 4: Improve

This final stage applies the last step of the TRIZ methodology to develop targeted solutions for improving aircraft towing coordination. Building on insights from the previous phases, where the problem was thoroughly analysed and broken down into simpler, more solvable risks associated with coordination, this phase focuses on translating those insights into practical solutions.

Given the similarities between towing movements and actual flight movements, an analogy is drawn between the two. This analogy serves as the basis for adapting proven coordination strategies from flight operations to towing, effectively applying innovative solutions from one domain to the other.

To achieve this, the conclusion is written (Chapter 8), followed by actionable recommendations aimed at enhancing the coordination of aircraft towing to prevent disruptions and reduce uncertainty, thus making towing a more efficient and predictable element of the turnaround process (Chapter 9). Ultimately, finding out how aircraft towing can become a more efficient and predictable element of the turnaround process, by addressing risks that may cause disruptions and uncertainty in the towing process, through improving its coordination.

2. Theoretical Framework and Literature review

This chapter will contain two main sections, starting with the case study of this research, followed by the methods used to conduct this research effectively. The first section will provide a detailed examination of the case study, including its background, context, and significance to the research topic. The second section will outline the methods employed in this research, detailing the data collection techniques, and tools used to gather and process information.

2.1. Case Study

The case study in this research aims to gain a comprehensive understanding of aircraft towing operations within the context of the turnaround process. Specifically, it seeks to explore the importance of towing coordination and its relationship to overall turnaround efficiency. The study will first examine the aircraft turnaround process as a whole, followed by a focused analysis of towing as a critical element within that process.

2.1.1. The Aircraft Turnaround

According to the International Air Transport Association (IATA, 2023), the aircraft turnaround encompasses all activities required to handle an aircraft and its passengers during the time between arrival and departure. Specifically, the arrival and departure times at the aircraft stand that frame the turnaround are referred to as the In-Block Time (IBT) and the Off-Block Time (OBT) (Schmidt, 2017). The time between these events, known as the turnaround time (Fricke & Schultz, 2008), is one of the most critical key performance indicators for airlines and airports, as it impacts operational efficiency, competitiveness, and profitability (Scardaoni, Magnacca, Massai, & Cipolla, 2021; More & Sharma, 2014).

The IBT marks the moment the aircraft's blocks are placed upon arrival, following engine shutdown and the deactivation of the anti-collision lights, signalling the start of ground handling activities (EUROCONTROL, n.d.-d). While not every ground handling activity is required for each turnaround, the essential activities are common to all turnarounds (Asadi & Fricke, 2022). Some of these activities can occur simultaneously, while others must follow a strict sequence due to spatial constraints, overlapping operational requirements, or regulations (Fricke & Schultz, 2008). For instance, the following activities cannot begin until deboarding is completed:

- Catering
- Cleaning
- Refuelling

Similarly, the boarding process cannot begin until these processes are finished (Meijer, 2021). Such dependencies result in multiple paths of activities, with the longest sequence of tasks forming the critical path. The critical path plays a decisive role in determining the turnaround time, as delays in any of its activities cascade through the entire turnaround process. Consequently, this might adversely affect both on-time performance and punctuality, further amplifying disruptions.

An example of a turnaround's critical path is illustrated in Figure 2. In the given example, cleaning and refuelling are completed before catering, but boarding must still wait for the catering process to finish. Since catering is a part of the longest sequence of tasks, it is part of the critical path in this example.

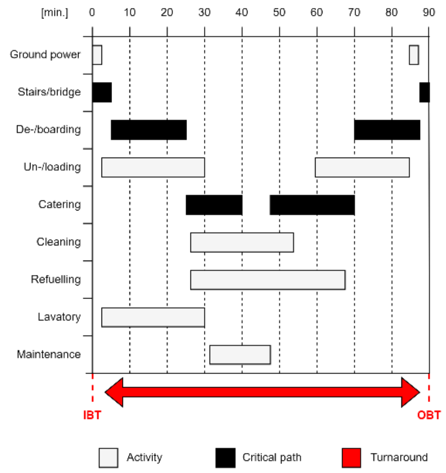

Figure 2: Example of a Turnaround's Critical Path.

Once the activities along the critical path are completed and the aircraft's blocks are removed, the OBT is reached, signifying readiness for the pushback (EUROCONTROL, n.d.-c). The pushback is the process of moving a fully loaded aircraft, including passengers, pilots, and cargo, as part of the departure procedure.

During pushback, a tug driver uses a specialized ground vehicle which is either attached to or supports the aircraft's nose landing gear, known as a tug, to manoeuvre the aircraft from its nose-in parking position to the taxiway (Skybrary, n.d.-a). Once in position, the tug driver disconnects the tug, allowing the aircraft to start taxiing using its own engine power to reach to the runway for take-off (Du, Brunne, & Kolisch, 2014). The pushback is required at all parking stands that do not support self-manoeuvring, unless the aircraft can reverse itself and local procedures allow for it (Skybrary, n.d.-b).

2.1.2. Aircraft Towing During the Turnaround

In a standard turnaround, the aircraft remains at the same position throughout the entire process, departing from the same gate it arrived at. As a result, all aircraft servicing activities are performed at this single location, represented as Position A in Figure 3. This figure highlights the segment of the aircraft movement cycle where a standard turnaround takes place.

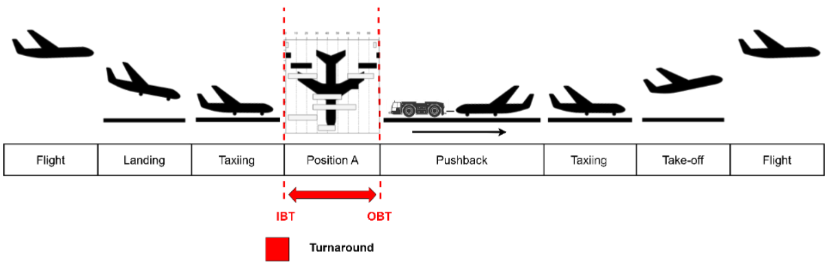

Figure 3: Aircraft Movement Cycle Containing a Standard Turnaround.

However, aircraft do not always remain in the same position throughout the entire turnaround process. In some cases, the turnaround may span multiple locations across the airport. Common airport locations between which aircraft may be shifted during their turnaround typically include (Schmidt, 2017):

- Gate positions
- Remote positions
- Maintenance areas

Shifts between positions can occur for various reasons, often depending on airport characteristics, operational needs, or technical requirements. These shifts may happen multiple times and in varying sequences during a single turnaround.

For instance, when an aircraft has a long block time and the gate is needed for an incoming flight, the aircraft may be temporarily relocated to a remote position, after which it is relocated back to a gate position. This practice is common in airports with high traffic volumes and limited gate availability, where the goal is to maximize gate utilization, ensure that incoming flights can park on time, and prevent delays, thus optimizing airport operations (Du, Brunne, & Kolisch, 2014).

Another example is when repairs or maintenance activities cannot be performed at the gate. In such cases, the aircraft is shifted to a maintenance area to facilitate the necessary work (Du, Brunne, & Kolisch, 2014).

When a turnaround involves position shifts, all required aircraft servicing handling activities must still be completed. However, due to the position shifts, these activities must be redistributed across the different locations. Figure 4 illustrates this with an example of a turnaround spanning three locations at which aircraft servicing activities are conducted: starting at a gate position, followed by a temporary remote position, and finally returning to a gate position for departure. The figure also highlights how these position shifts are achieved: through aircraft towing.

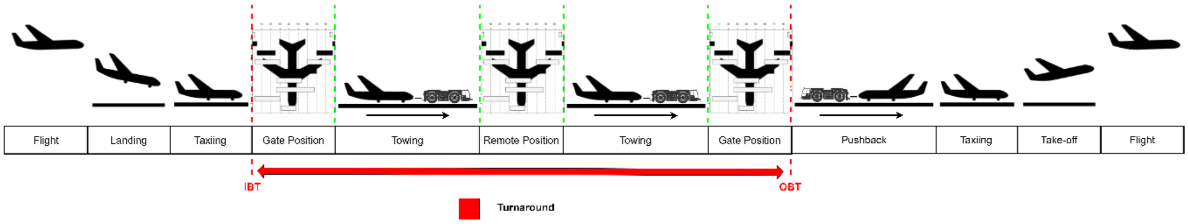

Figure 4: Aircraft Movement Cycle Containing a Turnaround Spanning Multiple Locations.

Towing is a process distinct from the pushback, despite sharing similarities. Towing involves moving an empty aircraft on the ground from one position to another, as shown in Figure 4. In contrast, the pushback involves moving a fully loaded aircraft, including pilots, passengers, and cargo, from the gate to the taxiway as part of the departure procedures, also illustrated in Figure 4. Unlike taxiing, towing does not rely on the aircraft's main engines. Instead, movement is entirely facilitated by a tug, making towing a more economical and environmentally friendly option (Du, Brunne, & Kolisch, 2014; Skybrary, n.d.-a).

Towing is a critical component of the turnaround process, playing a vital role in ensuring a smooth and timely workflow. Seamless integration of towing within the overall turnaround plan is essential for maintaining operational performance and punctuality. However, towing is inherently one of the most challenging processes in the turnaround, requiring precise coordination and careful management.

Effective collaboration with other aircraft servicing activities, gate planning, and air traffic control is crucial for successful towing operations. Any breakdown in coordination across these areas can introduce significant disruptions, reducing the efficiency and predictability of towing, and ultimately impacting the entire turnaround process.

The following subchapters will examine each of these areas, emphasizing the need for improved coordination and how it contributes to making towing more efficient and predictable.

2.1.2.1. Coordination of Aircraft Towing with Other Aircraft Servicing Activities

Unlike standard turnarounds, where all activities are performed at a single location, the towing process adds complexity to the critical path. When towing between two locations, no other aircraft servicing activities, such as ground handling or maintenance, can take place. Therefore, it is crucial that all preceding tasks are completed on schedule to avoid overlap with the towing process in the critical path. Any delays in these activities can delay the start of the tow, leading to unpredictable and extended towing timelines.

Additionally, the duration of the tow directly affects the critical path, as longer towing times can delay subsequent activities. This highlights the importance of completing preceding tasks promptly to minimize disruptions. Efficient coordination of the aircraft towing process with other servicing activities not only streamlines the tow but also enhances its predictability. This improved predictability enables planners to schedule subsequent tasks more effectively, ensuring they start on time and proceed as planned.

When a turnaround spans multiple locations across the airport, the required aircraft servicing activities must be carefully distributed to the appropriate locations. Not all activities can be performed at every location, and this varies by airport. For example, activities like passenger deboarding typically occur at gate positions immediately after arrival, whereas passenger boarding occurs closer to departure time (Fitouri-Trabelsi, Cosenza, Moudani, & Mora-Camino, 2014). Similarly, activities are generally restricted to designated maintenance areas, while activities such as catering are more flexible and can be performed at both gate and remote locations, depending on the airport.

For instance, towing an aircraft to a maintenance area or long-term storage may require additional considerations regarding activity distribution. In such cases, it's not always clear how long the aircraft will stay in a particular location. Therefore, activities such as toilet servicing, cabin cleaning, and catering removal should be completed before the aircraft is towed, to avoid contamination if the aircraft remains in that area for an extended period.

Conversely, activities like loading fresh catering and refilling water supplies are best done closer to departure, making it ideal to complete them after returning from a maintenance area. This is particularly important when maintenance work in the hangar could affect the quality of onboard supplies, such as water (World Health Organization, 2009).

Further complicating the process, some airport locations lie outside the Security Restricted Area (SRA). For example, maintenance areas are typically located outside the SRA, requiring a security search when an aircraft re-enters the SRA to ensure compliance with security regulations (Council of the European Union, 2001).

In general, several variables can influence the distribution of activities across different locations. This means that for each position from which an aircraft is towed, the tow may depend on different preceding activities, and at each position the aircraft arrives at, different subsequent activities may rely on the completion of the tow. This underscores the need for effective coordination with other aircraft servicing activities, since any critical path activity that is not coordinated well, may disrupt the entire course of the turnaround.

2.1.2.2. Coordination of Aircraft Towing with the Airport's Gate Planning

Effective towing not only requires coordination of aircraft servicing activities over multiple locations, it also requires careful coordination with the airport's gate planning, particularly at busy airports where aircraft positions are limited and optimized to accommodate as many aircraft as possible (Bi, Wang, Ding, Xie, & Zhao, 2022). At such airports, incoming flights or tows are often scheduled to occupy a position immediately after another tow or flight has vacated the position.

This emphasizes the importance of good coordination between gate and tow planning, as any delays in tows that vacate a position within a tight gate plan can lead to delayed arrival times for incoming aircraft. Similarly, initiating a tow too early, or encountering delays with the aircraft meant to vacate the tow's destination, can leave the position occupied. This directly delays the tow movement itself, as additional time is required to clear the position before proceeding to the intended location (Cheng, 1998).

The coordination between tow planning and gate planning is interdependent with the coordination between tow planning and aircraft servicing activities, as these elements converge within the towing process. Effective tow planning requires balancing both aspects because poor management of either can disrupt the tow, resulting in an unpredictable timeline and cascading delays along the critical path.

If tow planning is well-aligned with gate planning but poorly coordinated with other service activities, delays in those activities can still disrupt operations and create issues for gate planning. Conversely, if tow planning is well-coordinated with service activities but not with gate planning, problems such as an occupied gate or scheduling mismatches can lead to delays. During these delays, no other activities can proceed, as they cannot overlap with the towing process, resulting in an inefficient use of time that could have been better spent on other processes.

2.1.2.3. Coordination of Aircraft Towing with the Airport's Air Traffic Control

The towing process relies on the same taxiways and infrastructure used for regular taxiing. Consequently, it is affected by various factors, including taxiway capacity, which is further influenced by conditions such as weather, the volume of arriving and departing aircraft, the number of active taxiing aircraft, runway occupancy times for arrivals and departures, the direction of take-offs and landings, and the location of the terminal (Park & Kim, 2023). Moreover, towing necessitates precise coordination with air traffic controllers to prevent conflicts with other taxiway traffic (Skybrary, n.d.-a).

Effective coordination with air traffic control is essential not only for ensuring the safety and efficiency of towing operations but also for maintaining the smooth flow of traffic on the taxiways. This becomes especially critical given that aircraft typically move faster than towing operations (Soltani, Ahmade, Akgunduz, & Bhuiyan, 2020). Unplanned or unexpected tow movements can disrupt the flow of taxiing aircraft, leading to delays that affect not only the tow, but also the subsequent activities along the critical path.

2.2. Methods

For this thesis, a qualitative research approach has been chosen. The nature of the research requires a detailed understanding of the operation, and the associated risks, which cannot be fully obtained from existing literature and online sources. While desk research in both internal and external provides valuable context, the available information is insufficiently specific to achieve the desired level of detail. Therefore, additional qualitative methods, such as interviews, will be employed.

2.2.1. Desk Research

Desk research forms a key starting point for this study, as it helps to outline the theoretical framework and the first chapters of this research. By analysing secondary sources, such as internal reports and academic articles, a broad overview of existing insights is created. However, desk research has limitations, especially when in-depth, specific data is required. This makes supplementary methods necessary (Yin, 2014).

2.2.2. In-depth Interviews

To fill the gaps in the available literature, semi-structured in-depth interviews are used. This method is ideal for gaining detailed insights that are difficult to collect through desk research alone (Brinkmann & Kvale, 2015).

In contrast to structured interviews, semi-structured interviews allow for more adaptability, as the interviewer can ask additional questions based on the interviewee's responses (Hogeschool van Amsterdam, n.d.-a). This can uncover more complex, in-depth insights, contributing to the richness of the data.

2.2.3. Focus Groups

Although focus groups are often used to explore group dynamics and collective opinions (Morgan, 1996), this method is less suitable for this research. The specific nature of the research objectives requires individual depth, which is difficult to achieve in a group setting. Additionally, the presence of other participants may affect the behaviour of respondents.

2.2.4. Observations

Observations are used to complement interviews, especially in situations where direct interactions are not feasible, such as during active operational functions. Therefore, to study behaviour in its natural context, observations allow researchers to gain a deeper understanding of real-time actions (Angrosino, 2007). This is particularly useful in this research, as it provides real-time insights into the dynamics of aircraft towing operations, capturing behaviours and interactions that are difficult to gather through interviews alone. By monitoring key aspects like coordination and timing, observations contribute valuable insights that enrich the study, revealing operational details that might not be captured through interviews, thus adding significant context to the research (Yin, 2014).

2.2.5. The Best Approach

The combination of desk research, in-depth interviews, and observations provides the best approach to achieve the required level of detail for this research. Desk research lays the foundation, while interviews and observations offer the depth and specific insights necessary for qualitative research that demands both context and detail (Yin, 2014; Brinkmann & Kvale, 2015).

3. Schiphol's Operational Landscape

Schiphol Airport, officially known as Amsterdam Airport Schiphol (AAS), is the largest airport in the Netherlands and has established itself as one of Europe's major hubs for civil aviation, serving millions of passengers and airlines annually (Dutch Safety Board, 2017), connecting to 301 destinations, including 124 intercontinental routes (Schiphol, 2025).

3.1. Taxiway and Runway Configuration

With six runways, Schiphol offers flexible configurations to accommodate variable wind conditions and traffic intensity. The runways are:

- **Polderbaan (18R/36L)**
- **Kaagbaan (06/24)**
- **Buitenveldertbaan (09/27)**
- **Aalsmeerbaan (18L/36R)**
- **Zwanenburgbaan (18C/36C)**
- **Oostbaan (04/22)**

Schiphol is designed with efficiency and functionality in mind, with all commercial aviation arrival and departure positions located within the area enclosed by the runways, commonly referred to as Schiphol-Centre (Service Owner Aircraft A/AO&AP, 2024).

3.2. Schiphol's Terminal

Schiphol features a single central passenger terminal under one roof. This design enables quick transfers, a necessity given its role as a major hub. In 2024, Schiphol accommodated 24,3 million transfer passengers out of a total of 66,8 million travellers (Schiphol, 2025).

The terminal is divided into Departure Halls 1, 2, and 3. These departure halls provide access to the two border zones into which Schiphol is organized, managing passenger flows based on their destination and origin: Schengen and Non-Schengen (Schiphol, 2024-a).

- **Departure Hall 1**: Serves passengers traveling to Schengen destinations.
- **Departure Hall 2**: Serves passengers traveling to Non-Schengen destinations
- **Departure Hall 3**: Primarily serves non-Schengen destinations, except for the M-Pier, which serves Schengen destinations.

Transfer passengers moving between these border zones must pass through passport control to switch from one area to the other (Schiphol, 2023).

3.3. Schiphol's Piers

Schiphol's terminal features several piers, each serving specific departure halls and border zones (Amsterdam Airport Online, n.d.). The layout of the piers is as follows:

- **A-Pier**: Currently under construction and not yet operational.
- **B-Pier and C-Pier**: Connected to Departure Hall 1, and serve Schengen destinations.
- **D-Pier**: Connected to both Departure Halls 1 and 2, this pier is divided into two levels:
    - The upper level is connected to Departure Hall 1, and serves Schengen destinations.
    - The lower level is connected to Departure Hall 2, and serves Non-Schengen destinations.
- **E-Pier**: Is connected to Departure Hall 2, and serves Non-Schengen destinations.
- **F-Pier and G-Pier**: Connected to Departure Hall 3, and serve Non-Schengen destinations.
- **H-Pier and M-Pier**: Is a single swing pier connected to Departure Hall 3, designed to handle both Schengen and Non-Schengen flights.

- The **H-Pier**: is for Non-Schengen
- The **M-Pier**: is for Schengen

3.4. Schiphol's Gate Positions

Each pier provides direct access to various gate positions. These gate positions are typically the most preferred locations for passenger flights, offering convenience for both passengers and airlines. They are particularly advantageous for airlines managing a high volume of transfer passengers, as they facilitate seamless connections and efficient operations.

At gate positions, all ground handling activities can be conducted. Additionally, minor maintenance tasks that do not require the use of a hangar may also be performed at gate positions, provided that permission is granted by the AAS gate planner (AAS Gate Planner 1, 2024).

However, Schiphol's success as one of the busiest airports in Europe also brings significant challenges. Schiphol's limited physical space at its gate positions increasingly strains its ability to meet growing demand from airlines and passengers while upholding standards of safety, sustainability, reliability, and a high-quality airport experience (Royal Schiphol Group, 2023).

When the gate positions reach capacity, flights are reassigned to less preferable zones, such as remote positions (Schiphol, 2024-a). The layout of Schiphol's specifically highlighting gate positions, remote positions, and maintenance area Schiphol-East, is shown in Figure 5.

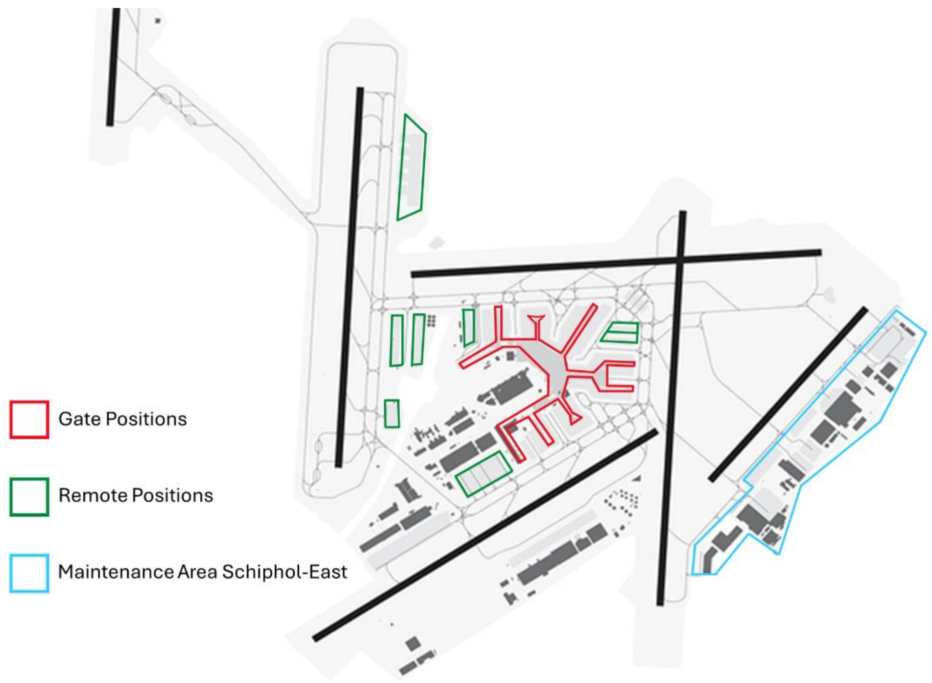

Figure 5: Schiphol's Layout, Specifically Highlighting Gate Positions, Remote Positions and Maintenance Area Schiphol-East.

3.5. Schiphol-Centre's Remote Positions

Remote positions serve as an alternative to gate positions at Schiphol Airport. These stands are utilized when operational demands exceed gate capacity or when no suitable gate at a pier is available (Schiphol, 2024-a). While remote positions are critical for maintaining operational flexibility, they are generally less favourable due to the additional time and logistical challenges required for transporting passengers to and from the terminal via buses (Schiphol, 2024-a).

Not all remote positions are designed for passenger flights to arrive at and depart from. Some are exclusively used for buffering. Buffering refers to the temporary parking of aircraft that are not immediately needed at a gate or for specific operations, such as arriving, departing or maintenance.

The remote positions and their functions are distributed across several platforms, as outlined below (Schiphol, 2024-b; Service Owner Aircraft A/AO&AP, 2024):

- **A, D, E, G, J, and Y-Platforms**: Used for both buffering and arriving/departing passenger flights.
- **P-Platform**: Used for de-icing and buffering.
- **U-Platform**: Used exclusively for buffering.

As illustrated in Figure 5, most remote positions are located at Schiphol-Centre. However, the U-Platform is located north of this area, but is still considered to be part of Schiphol-Centre as it remains accessible for remote ground handling activities and is included within the airside Security Restricted Area-Critical Part (SRA-CP). The SRA-CP is the airport's restricted and protected area, to which access is strictly controlled, and where all individuals are screened for prohibited items for security reasons (Schiphol, 2023).

The ground handling activities at remote positions at Schiphol-Centre depend on whether the position is being used for buffering or for an arriving/departing flight.

When a position is designated for an arriving or departing flight, and this is permitted for that specific platform, all ground handling activities can take place there. However, when a remote position is used for buffering, certain activities cannot be performed. This is because some operations, such as passenger boarding and deboarding, can only occur at positions where aircraft are arriving or departing.

On the other hand, minor maintenance tasks that do not require a hangar can be carried out at remote positions, whether the position is used for buffering or for an arriving/departing flight. Unlike gate positions, no permission from the AAS gate planner is needed for these activities at the remote positions (AAS Gate Planner 1, AAS Gate Planning interview 1, 2024).

3.6. Schiphol's Maintenance Area

Situated on the easternmost side of Schiphol, as shown in Figure 5, Schiphol-East serves as Schiphol's maintenance area. This area is home to a large business park housing the offices of various companies, including those of KLM, Schiphol's primary home carrier. Alongside these offices, KLM has multiple hangars in this area, where aircraft maintenance activities requiring a hangar are carried out. These include (Hangar Lead, 2024):

- **Hangar 10**: Currently being renovated.
- **Hangar 11 & 12**: A- & B-checks (planned maintenance) and aircraft on the ground for maintenance or repairs (unplanned maintenance) for KLM aircraft.
- **Hangar 14**: C-checks and modifications for KLM aircraft.
- **Hangar 73**: A- & B-checks (planned maintenance) and aircraft on the ground for maintenance or repairs (unplanned maintenance) for KLC aircraft.

Schiphol-East encompasses not only the business park and hangars but also the M-Platform (Service Owner Aircraft A/AO&AP, 2024). While technically a collection of remote positions, the M-Platform is no longer considered part of Schiphol-Centre due to its inaccessibility for standard ground handling operations. Access to this platform requires traversing the manoeuvring area, which necessitates specific airfield authorization and a radio capable of monitoring designated communication channels (Service Owner Aircraft, 2023).

Moreover, Schiphol-East is classified as an Airside Demarcated Area (ADA), which has a lower security status compared to the Security Restricted Area-Critical Part (SRA-CP) that defines Schiphol-Centre (Schiphol, 2023).

Due to these constraints of the M-Platform, it is typically used only as a buffering area for aircraft being moved to or from the hangar, and is considered to be part of the maintenance area. Therefore, no ground handling activities are conducted here.

When an aircraft is repositioned to Schiphol-East, it must be empty. Not only must it be empty of pilots passengers and cargo before being repositioned, it must also be empty of residual waste and other goods. This reduces the risk of contamination from perishable goods or pests and ensures that any necessary cabin maintenance can be conducted without obstructions. Furthermore, an empty aircraft allows for a more efficient security search, which is required after re-entering the SRA-CP.

3.7. Operational Coordination Systems

Schiphol is widely recognized as a forward-thinking airport that embraces cutting-edge technologies to enhance efficiency and foster collaboration among its stakeholders. Innovation is one of Schiphol's core values, reflected in its close partnerships with various organizations to introduce innovative concepts. By leveraging advanced digital tools and optimizing processes, Schiphol aims to deliver exceptional service to passengers and other customers (Royal Schiphol Group, 2023).

Two key systems employed by Schiphol to enhance airport operations are Eurocontrol's ACDM system and Deep Turnaround. These systems improve coordination and transparency among stakeholders, enabling better informed decision making through the use of real-time and predictive data.

3.7.1. Airport Collaborative Decision Making at Schiphol

Schiphol employs Eurocontrol's ACDM, which facilitates joint decision-making among all operational partners, including the airport, air traffic control, airlines, and ground handling. This system relies on shared information related to the flight and aircraft handling processes at the airport (Schiphol, n.d.).

ACDM's primary goal is to make operational partners work together more effectively in order to improve efficiency and resilience, by ensuring that asset and resource capacities are utilized as efficiently as possible through enabling real-time data sharing among all parties involved (EUROCONTROL, n.d.-b; Schiphol, 2024). This is particularly important for Schiphol, where high demand and the limited availability of gate positions poses a significant challenge (Royal Schiphol Group, 2023).

A key aspect of ACDM is the milestone approach. This method tracks flight progress within the ACDM platform through a series of continuous events, known as milestones. It connects arriving and departing traffic by continuously updating and refining milestones across the various stages of the flight: inbound, turnaround, and outbound. This ensures a smooth and coordinated flow of operations throughout the entire flight movement cycle (EUROCONTROL, n.d.-e).

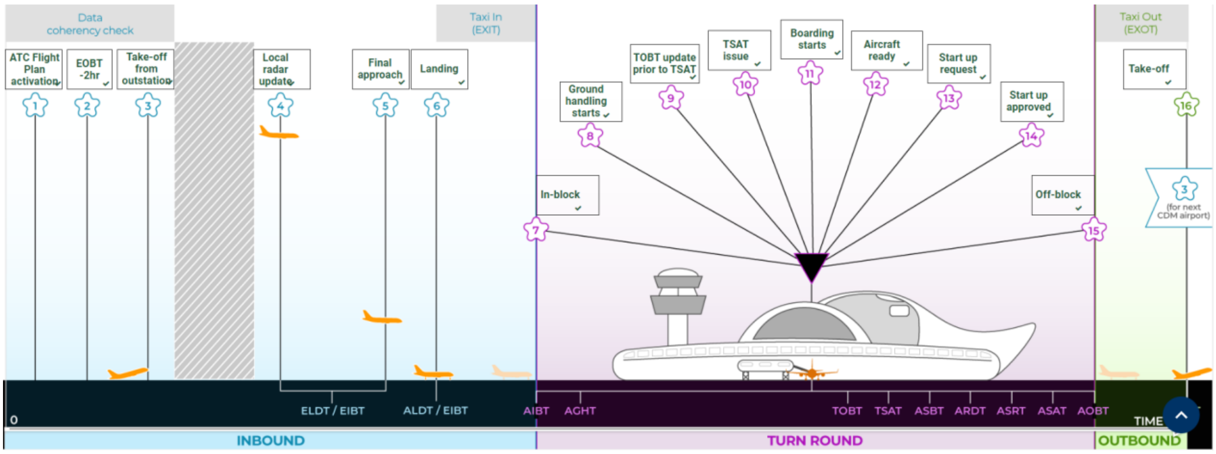

Figure 6: The Milestone Events (EUROCONTROL, n.d.-d).

There are 16 milestones in total (EUROCONTROL, n.d.-d), as shown in Figure 6, which outlines their distribution across each stage of the flight movement cycle. This distribution is particularly useful for airport operators, as the IBT is one of the timestamps that is continuously updated. For instance, even when the aircraft is still in flight, hours before the actual IBT, an estimated IBT can already be calculated by using the estimated landing time and the variable taxi time element, based on aircraft's local radar update (EUROCONTROL, n.d.-f).

By estimating the IBT, airport operators can proactively plan turnaround activities, improving scheduling accuracy and minimizing inefficiencies, disruptions, and delays caused by poor coordination. Furthermore, by using the IBT and the planned activities, the OBT can be predicted.

With the right guidelines in place, all relevant activities can be scheduled to ensure timely completion. From the OBT, departure traffic predictions can be made, which then helps estimating a target take-off time (EUROCONTROL, n.d.-g). Based on this target take-off time, and the OBT, a Target Start-up Approval Time (TSAT) can be derived (EUROCONTROL, n.d.-c).

Within ± 5 minutes from the TSAT, called the TSAT window, pilots are expected to report "Ready" to the air traffic controller (Schiphol, 2024). By monitoring the TSAT windows of all departing aircraft, air traffic controllers can accurately anticipate when an aircraft will request pushback and be on the taxiway.

The collaborative sharing of these timestamps enhances the efficiency of the turnaround process, streamlines operations at taxiways, and improves flight predictability through real-time data sharing (IATA, 2018).

3.7.2. Deep Turnaround at Schiphol

Building on the principles of ACDM, Schiphol recently introduced the Deep Turnaround initiative. This innovation further improves operations by combining historical data with real-time AI-driven image processing to optimize turnarounds, leading to greater efficiency, sustainability, and performance (Schiphol, n.d.; Royal Schiphol Group, 2023).

Deep Turnaround enables the prediction of process progression along the critical path of turnarounds, allowing for proactive decision-making and the prevention of delays (Royal Schiphol Group, 2023). By forecasting turnaround processes along this critical path, the system can use the IBT timestamp from ACDM, along with the remaining processes, to accurately predict the OBT (Schiphol, n.d.). As a result, airport operations are becoming more predictable and transparent, enabling stakeholders to make informed decisions and reducing delays and inefficiencies caused by miscommunication or lack of clarity.

3.7.3. Limitations of Schiphol's Operational Coordination Systems

Despite its advantages, Deep Turnaround is currently limited to gate positions, which means it does not address processes such as towing movements or operations at remote positions or maintenance areas. Additionally, towing movements lack specific ACDM timestamps comparable to those assigned to flight movements, such as the IBT and OBT used for arriving and departing flights.

These limitations disrupt the continuity of ACDM by excluding towing movements and processes outside the gate areas from airport activity coordination. Consequently, the entire turnaround process is not managed with the same level of transparency for stakeholders, which prevents full optimization. This gap can lead to inefficiencies, particularly when aircraft operations span multiple airport locations during a turnaround.

4. The Influence of Schiphol's Operational Landscape on KLM's Turnaround Activities

Schiphol's specific operational landscape plays a significant role in shaping KLM's turnaround processes. Typically, most of KLM's turnaround activities are concentrated at a single location, a gate position. However, as Schiphol's largest airline (Woerkom, 2024), and its home carrier, KLM frequently shifts its aircraft across various airport locations.

Table 2 highlights the frequency of towing tasks performed by KLM during turnarounds at Schiphol. In 2023, KLM's ATD conducted 25.552 towing movements during 127.451 turnarounds, underscoring the critical role of towing at Schiphol (MovingDot, n.d.), especially for KLM.

Flight Type	Tow tasks	Turnarounds
ICA	3.612	7.089
Europe	15.035	58.247
Commuter	6.903	62.093
Other	2	22
Total	25.552	127.451

Table 2: KLM ATD's Tow Tasks Compared to KLM's Turnarounds in 2023

This subchapter will explore the range of aircraft servicing activities conducted by KLM during turnarounds, as well as the various airport locations where these activities occur. Additionally, this section will discuss factors that may require special consideration in the allocation and distribution of these activities. For clarity, these servicing activities are categorized into ground handling activities and maintenance activities.

4.1. KLM's Ground Handling Activities

KLM's ground handling services are provided by various service providers, ensuring efficient turnaround operations. Aircraft typically arrive and depart from gate positions, although remote positions are often used for KLM Cityhopper (KLC) flights. Key services include passenger handling, baggage and cargo handling, catering, cabin quality management, water and toilet servicing, and aircraft refuelling. These activities often depend on the aircraft's position (gate or remote) and whether it is buffered or being towed. The following sections provide an overview of each service and its specific requirements during the turnaround process.

4.1.1. KLM's Passenger Handling Service

During the turnaround process, guiding passengers on and off the aircraft is required for both boarding and deboarding. These two activities are the first and last steps performed in the cabin during the turnaround.

At KLM, the boarding process involves both gate staff and cabin crew, who share responsibility for ensuring everything is ready on time to guarantee a timely departure (KLM, 2024-s). The deboarding process, on the other hand, is typically managed by a deboarding cabin agent or an arrival service agent (KLM, 2019-a).

Deboarding must always occur at the aircraft's arrival position, while boarding takes place at the departure position. Consequently, these processes can only be carried out at gate or remote positions when the aircraft is either arriving or departing from them. They cannot take place when the aircraft is buffered.

As a result, deboarding must be completed before the first tow, and boarding can only commence once the last tow has occurred.

4.1.2. KLM's Baggage and Cargo Handling Service

During the turnaround process, the aircraft is loaded and unloaded with baggage and cargo. These are the first and last processes to occur on the aircraft's position.

At KLM, these activities are performed by the following departments (Zadelhoff, 2024):

- Platform K1, responsible for KLC's flights.
- Platform K4, responsible for the european flights.
- Platform K5, responsible for the intercontinental flights.

Similar to the boarding and deboarding processes, the unloading of baggage and cargo must always occur at the position where the aircraft arrives. Conversely, the loading of baggage and cargo must take place at the position where the aircraft departs. As such, these processes can only be carried out at gate or remote positions when the aircraft is either arriving or departing, and not when the aircraft is buffered.

Therefore, unloading must be completed before the first tow, and loading can only begin once the last tow has occurred.

4.1.3. KLM's Catering Service

Catering is an essential part of the turnaround process, involving the loading of meals, drinks, and other supplies required for the outbound flight, as well as unloading the remaining items from the inbound flight. These activities are performed by KLM Catering Services (KCS) (KCS Task Allocator, 2024).

Both the loading and unloading of catering do not need to take place immediately after arrival or just before departure, although it is desirable that loading does not occur too far in advance of departure. These activities can take place at either a gate position or a remote position, regardless of whether the aircraft is buffered or not. The only requirement when the aircraft is buffered is that the aircraft must be powered, and must have cooling available (KLM, 2023-j). Ideally, unloading is done first, allowing the loading of fresh items closer to departure. In some cases, loading and unloading occur simultaneously (KCS Task Allocator, 2024).

This means unloading can occur after the aircraft has been towed from a arrival position, to either a gate or remote position, and loading can begin before the aircraft is towed from a gate or remote position to the departure position. However, this does not apply when the aircraft is being towed to maintenance area Schiphol-East. No catering is allowed onboard when the aircraft is repositioned to Schiphol-East. This means that catering unloading must be completed, and inflight sales must be removed at Schiphol-Centre before the aircraft is towed. Deviation from this rule is only allowed in exceptional cases (KLM, 2019-b). Additionally, catering can only be loaded again after the aircraft returns to Schiphol-Centre, as catering activities cannot take place at Schiphol-East, and are preferably done close to departure.

4.1.4. KLM's Cabin Quality Service

Cabin quality for KLM and its partners is managed by the cleaning companies Asito and Klüh. They are responsible for several activities, these include: cabin cleaning and inspection, board supply, and security searches. The primary distinction between Asito and Klüh lies in their responsibilities. Asito manages processes for widebody aircraft, which involve longer lead times. Klüh, on the other hand, handles processes for narrowbody aircraft (Klüh Task Allocator, 2024; Asito Task Allocator, 2024).

Cabin cleaning and inspection is an activity that is required for every turnaround. This activity does not need to take place immediately after arrival or just before departure. It can take place at either a gate position or a remote position, regardless of whether the aircraft is buffered or not, as long as the aircraft is powered (KLM, 2024-t). However, if the aircraft is being towed to Schiphol-East during the turnaround, cabin cleaning and inspection must be completed beforehand due to the procedures regarding Schiphol-East.

Board supply involves the unloading of dirty blankets and pillows, and the loading of clean blankets and pillows for passengers. The frequency of this activity which depends on whether the aircraft is a widebody or a narrowbody. For widebodies, this must happen every turnaround, whereas for narrowbodies, this is only required three times per week (KLM, 2024-j; KLM, 2024-u). Just like cabin cleaning and inspection, this activity does not need to take place immediately after arrival or just before departure. It can take place at either a gate position or a remote position, regardless of whether the aircraft is buffered or not. However, if the aircraft is being repositioned to Schiphol-East during the turnaround, the procedures for Schiphol-East require that dirty blankets and pillows be unloaded beforehand, while clean blankets and pillows must be loaded afterward.

Security searches are not required during each turnaround, as they are only required under certain circumstances. These include (KLM, 2024-k; KLM, 2024-l):

- On flights from non-EU-compliant countries.
- On flights to the United States.
- On aircraft that have been outside the SRA-CP during the turnaround.

Security searches are typically performed on the aircraft's departure location, as it is an activity that must be performed before departing from Schiphol (KLM, 2024-u). Therefore, it is typically performed at a gate position, or a remote position if the aircraft is intended to depart from there. Additionally, it must always be performed after the aircraft has been towed from Schiphol-East, as this is outside the SRA-CP. The area to be searched must also be free of waste and used onboard supplies, such as pillows, blankets, and headrest covers (KLM, 2024-l).

4.1.5. KLM's Aqua and Toilet Service

Although water servicing and toilet servicing are technically two separate services, they both fall under the responsibility of KLM's Aircraft Handling and Support Unit (AHSU).

Aqua servicing involves draining water from the aircraft tanks, after which it will be refilled with fresh potable water from the water truck's tank (KLM, 2022-c).

If the ground time after arrival is less than four hours, the water is only refreshed. However, this must be done as close to departure as possible. As a result, it is typically performed at a gate position or, if the aircraft is departing from there, at a remote position (KLM, 2022-c).

If the ground time after arrival however exceeds four hours, the aircraft must be drained and refilled at a later stage. When an aircraft is relocated between airport locations during the turnaround, this is typically required since turnaround's that involve relocations generally have longer ground times. Draining can be performed either a gate position or a remote position, regardless of whether the aircraft is buffered, as long as the aircraft is powered (KLM, 2022-c).

Toilet servicing, on the other hand, involves draining and flushing the waste tank, as well as refilling it with deodorizing fluid for onboard toilets. These activities can be performed at either a gate position or a remote position, regardless of whether the aircraft is buffered. However, due to hygiene regulations, it is prohibited to position or park a toilet truck and water truck next to each other. As a result, toilet servicing cannot overlap with water servicing activities, except for a small group of larger aircraft types where sufficient spacing can be maintained (KLM, 2024-v).

4.1.6. KLM's Aircraft Refuelling Service

KLM's aircraft refuelling service, managed by the Aircraft Refuelling Department (ARD), includes both defueling and refuelling activities (KLM, n.d.-b).

Defueling involves extracting fuel from an aircraft's tanks. This process is typically carried out for payload-related reasons, such as when the aircraft is too heavy for departure or towing. However, defueling may also be required for maintenance purposes (KLM, 2021-c).

Therefore, defueling can take place in various scenarios, at virtually any position:

- To ensure the aircraft is not too heavy when towed from its arrival position, either from a gate or remote position.
- For maintenance activities on remote positions while the aircraft is buffered.
- For maintenance activities at Schiphol-East.
- Before departure if the aircraft exceeds its take-off weight limit, either at a gate or remote position.

Fuelling, on the other hand, is required in most turnaround scenarios since the aircraft must be fuelled before departure. Additionally, fuelling may be necessary if the aircraft lacks sufficient fuel for safe towing or for maintenance purposes, whether at Schiphol-Centre or Schiphol-East. This means that fuelling, like defueling, can occur at virtually any position.

Furthermore, depending on operational requirements, it may also be decided that an aircraft must be fuelled or defueled before being towed to a different location.

4.2. KLM's Maintenance Activities

KLM's maintenance services are provided by various service providers. Typically, smaller maintenance and routine checks that are performed for every turnaround can be performed at Schiphol-Centre, while larger maintenance is typically performed in the hangars at Schiphol-East. The following sections provide an overview of KLM's maintenance services and its specific requirements during the turnaround process.

4.2.1. KLM's Technical Service

KLM's technical service is responsible for the majority of maintenance activities on all non-KLC KLM flights that can be performed at Schiphol-Centre. This includes work packages and pre-flight inspections (Lead Ground Engineer, 2024).

Work packages often consist of deferred defects, which are issues that cannot be quickly resolved due to the need for additional parts. These defects are recorded in a logbook, and for each turnaround, the lead ground engineer assigns a team to perform a work package, solving deferred defects. This can involve both internal and external maintenance on the aircraft (Lead Ground Engineer, 2024). The maintenance can be performed at gate or remote positions, regardless of whether the aircraft is buffered. However, to conduct external maintenance at a gate position, permission must be obtained from the AAS gate planner (AAS Gate Planner 1, AAS Gate Planning interview 1, 2024).

Pre-flight inspections, on the other hand, are mandatory checks that must be performed before every flight, therefore, these inspections must occur during each turnaround. If the aircraft has been moved or towed, it must undergo a new pre-flight inspection upon its return, as it needs to be checked after being relocated (Lead Ground Engineer, 2024). Consequently, pre-flight inspections can only be carried out at gate or remote positions when the aircraft is either arriving or departing, meaning they cannot take place if the aircraft is buffered.

4.2.2. KLM’s Inflight Entertainment and Connectivity Service

KLM’s inflight entertainment and connectivity service is performed by Panasonic Avionics. Activities performed by Panasonic Avionics include routine checks, tech-log checks, step checks, media and software loading, and inflight entertainment repairs. Of these activities, the routine and tech-log checks must be performed every turnaround, while the others do not (KLM, 2023-i).

All of these activities happen within the aircraft. Therefore, these can be performed at gate or remote positions, regardless of whether the aircraft is buffered or not.

5. The Initiation of Towing Movements Between Airport Locations During KLM's Turnarounds at Schiphol

This chapter focuses on the initiation of towing movements during KLM's turnarounds at Schiphol, referred to as the strategic phase. Typically, this phase begins one day before the actual tow execution, though in the case of ad-hoc tows, the process may occur on the same day as the operation.

During this phase, towing movements between airport locations can be initiated by AAS gate planning, airlines, or ground handlers. At Schiphol, KLM functions as both the airline and the ground handler. This chapter will focus on how these parties can initiate towing movements, the specific circumstances under which they do so, the key individuals involved, and how these initial actions lay the foundation for the planning process that follows in the tactical phase. This will include how the movement is further refined, scheduled, and prepared for execution in the subsequent stages of the operation.

5.1. The Role of AAS' Gate Planning in Initiating KLM's Towing Movements

The gate planner at Schiphol plays a key role during the strategic phase, which typically occurs one day before the operation. He is responsible for creating the gate schedule for the following day. Additionally, the gate planner serves as the primary point of contact for airlines and ground handlers regarding gate management issues and works to facilitate their operations as efficiently as possible (Ravenswaaij, The, & Brown, 2017; AAS Gate Planner 1, 2024; AAS Gate Planner 2, 2024).

Given Schiphol's limited physical space, when demand exceeds capacity, and all gate positions are occupied, flights may be reassigned to less desirable zones, such as remote stands. To optimize the availability of preferred gate positions for airlines, the airport's gate planners may initiate towing movements. For instance, aircraft with extended block times may be towed from a gate to a remote position shortly after arrival to free up valuable gate space. This is done while considering space constraints, work instructions, and requests from ground handlers (Schiphol, 2024-a).

When the aircraft is scheduled to depart, another towing movement is initiated to return it from the remote position to the gate. The Regulation Aircraft Stand Allocation Schiphol (RASAS) (Schiphol, 2024-a), governs this process, setting out the conditions when these aircraft must be towed according to the ground tow standard. Additionally, it outlines the framework, principles, and responsibilities for gate and stand management (Schiphol, 2024-a).

In addition to this, RASAS (Schiphol, 2024-a) dictates that when an aircraft departs from a different border zone than the one it arrived in, a tow movement between gate positions must be initiated by the gate planner. For example, if an aircraft arrives at a Schengen gate but is scheduled to fly to a non-Schengen country, it must be moved to a non-Schengen position.

AAS gate planners use the Gate Management System (GMS) to create and adjust the gate plan one day in advance (AAS Gate Planner 1, 2024; AAS Gate Planner 2, 2024). The GMS gate plan visually indicates whether an aircraft is arriving at or departing from a gate via a tow. Once this is established, it is the responsibility of the airline to ensure their ground handlers are promptly informed (Schiphol, 2024-a).

5.2. The Role of KLM in Initiating KLM's Towing Movements

At Schiphol, airlines and ground handlers, play a key role in initiating towing movements. KLM acts as both the airline and the ground handler, with its Hub Control Centre (HCC) overseeing the ground handling operations, which encompass Ground Services, Passenger Services, Apron Services, Baggage Services, and Catering Services (Zadelhoff, 2024; KLM, n.d.-a; Duty Flow Manager, 2024).

Within the HCC, the Hub Control Team (HCT) is responsible for coordinating operations. The Duty Flow Manager (DFM), a key member of the HCT, supervises Apron Services, which encompasses the aircraft towing process. The DFM's responsibilities are divided into two main functions: Flow Management (long-term) and Flight Management (short-term). Flow Management, which takes place during the strategic phase, plays a crucial role in the initiation of towing movements (Zadelhoff, 2024; KLM, n.d.-a; Duty Flow Manager, 2024).

During Flow Management, if there is a mismatch between workload demands and available resources in KLM's ATD, the DFM may proactively initiate tows to alleviate pressure later (KLM, 2023-e; Zadelhoff, 2024; Duty Flow Manager, 2024). For example, if an aircraft completes maintenance at Schiphol-East in the evening and the next flight is scheduled for the next afternoon, the DFM might decide to tow the aircraft to a remote position at Schiphol-Centre overnight. This ensures the aircraft is closer to a gate position the next day, reducing the time required for towing due to distance and the need to cross two runways (Duty Flow Manager, 2024).

KLM manages its airline operations globally through its Operations Control Centre (OCC), which is dedicated to the coordination of the airline's fleet. The Operations Control Team (OCT) within the OCC is responsible for safeguarding the KLM network, with a particular focus on the HCC. The OCT collaborates closely with the HCT to evaluate the feasibility of flight schedules and address potential challenges, such as capacity constraints, weather disruptions, or delays in turnaround operations. In response to these challenges, the OCT may implement operational measures, such as delaying or cancelling flights, or initiating tows, in the form of performing an aircraft swap, or deploying a standby aircraft (KLM, 2023-e; Zadelhoff, 2024; Duty Flow Manager, 2024).

In such scenarios, aircraft that were buffered at remote positions, may be used to prevent cancellations. These aircraft can be towed from their remote positions to a gate and deployed for other operations, ensuring that flights continue as scheduled.

Airlines may also initiate towing movements in response to maintenance requirements, both planned and unplanned. At KLM, planned maintenance requests typically originate from the OCC and E&M, while unplanned maintenance requests come from KLM's technical services at Schiphol-Centre (Hangar Lead, 2024; Lead Ground Engineer, 2024). These tows typically occur between gate positions and the maintenance area at Schiphol-East, but occasionally, the aircraft may be towed to a remote position before or after being towed to the maintenance area.

5.3. The Coordination Between Amsterdam Airport Schiphol's Gate Planning and KLM in Initiating KLM's Towing Movements

At Schiphol, airlines cannot communicate directly with the airport's gate planners. All interactions must go through the airline's ground handler (AAS Gate Planner 2, 2024). For KLM, this means that all tow requests are coordinated through the Aircraft Allocation Coordinator (AAC) within KLM's HCC. The AAC serves as a liaison between KLM's HCC, AAS Apron Control, and AAS gate planning (KLM, n.d.-b).

When a tow is required to or from the maintenance area, the AAC is notified either by monitoring maintenance planning in Sirocco or through email requests from KLC (Aircraft Allocation Coordinator, 2024).

Occasionally, such requests originate from the OCC. As the DFM acts as the link between the OCT and the HCT, these requests are often routed to the AAC via the DFM. Similarly, repositioning tows initiated by the DFM are also handled through the AAC.

However, not all tows to or from the maintenance area can be fully integrated into the GMS, as certain tow origins and destinations at Schiphol-East fall outside the scope of AAS's gate planning. For instance, KLM's hangars and their associated hangar platforms at Schiphol-East are not under Schiphol's jurisdiction. However, if the origin or destination of a tow to or from the maintenance area falls within Schiphol's jurisdiction, coordination is still required to ensure that gate planners are informed when the towed aircraft will either vacate or occupy a gate.

Airlines are also responsible for ensuring their ground handlers are informed in a timely manner (Schiphol, 2024-a). In KLM's case, this enables the AAC to coordinate tow requests with AAS gate planners effectively. By doing so, KLM ensures that its towing requirements are reviewed and incorporated into the gate plan (Aircraft Allocation Coordinator, 2024).

Furthermore, the AAC plays a key role in ensuring efficient aircraft positioning and minimizing unnecessary tows by submitting KLM's preferred positions and towing requests to AAS gate planners (KLM, n.d.-b). However, the AAS gate planners have the final authority on gate management decisions (Ravenswaaij, The, & Brown, 2017; AAS Gate Planner 2, 2024).

5.4. Stakeholders in the Initiation of KLM's Towing Movements and Their Information Flows

The primary stakeholder of the initiation of KLM's tow movements in the strategic phase of KLM's towing process is KLM's tow allocator. This individual is responsible for assigning tasks to operators in the tactical phase of the towing process to ensure the timely execution of towing operations (KLM, 2024-i). However, in order to assign the tasks, he must stay informed about newly initiated and organized tow movements from the strategic phase.

The tow allocator's main source of information is the GMS, which they monitor continuously for new tow movements or positional changes (KLM, 2024-i). However, as not all maintenance tows can be integrated entirely in the GMS, the tow allocator also relies on other sources to stay updated about maintenance tows.

Through the MTOPS system, the tow allocator can track tow requests originating from E&M, although these requests are occasionally communicated by phone. Tow requests from KLC's hangar, on the other hand, are typically sent via email (KLM, 2024-i).

Additionally, the Aircraft Allocation Coordinator (AAC) is required to notify the tow allocator promptly in the case of ad-hoc tow requests (KLM, n.d.-b).

Figure 7 summarizes the information flows in the towing process coordination and illustrates how this information ultimately reaches the tow allocator. The figure also uses different colours to indicate which stakeholders are located in the same space, highlighting the possibility of face-to-face communication. For instance, the DFM and the AAC can interact directly with the tow allocator, as the tow allocator is positioned in the allocator room adjacent to the HCC, where the AAC and DFM are stationed.

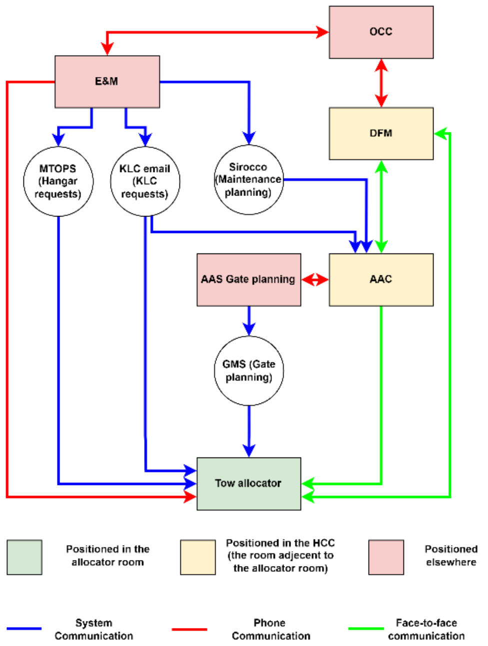

Figure 7: Information Flows From the Process Coordination, to the Process Coordination's Stakeholders.

5.5. Risks in the Initiation of KLM's Towing Movements

The tow allocator's dependence on multiple systems and information sources, including GMS, MTOPS, face-to-face communication, phone calls, and emails, introduces several risks that can compromise the efficiency and accuracy of towing operations. The primary risk involved is the potential for missing out on relevant information, as each system necessitates constant monitoring and manual processing, which increases the likelihood of overlooking critical details or making errors. Additionally, verbal communication, whether through phone calls or face-to-face communications, adds another layer of risk, as such information is susceptible to misinterpretation and is easily forgotten. These risks are particularly significant when handling ad-hoc tows, which demand quick action and decision-making.

6. The Planning of Towing Movements Between Airport Locations During KLM's Turnarounds at Schiphol

Following the initiation of towing movements between airport locations during KLM's turnaround at Schiphol in the strategic phase of the towing process, this chapter focuses on the planning of such towing movements in the tactical phase of the towing process. In this phase, the towing movement transitions from being initiated to being fully planned. In this phase, the towing operation is detailed, including aspects such as timing, the deployment of necessary resources such as towing vehicles and personnel, and ensuring coordination with other processes to avoid potential conflicts. This stage is crucial for refining the plan and addressing any potential challenges, so that the execution of the towing process can proceed smoothly in the operational phase.

6.1. The Steps in the Planning of KLM's Towing Movements

As discussed in chapter 5.4, the tow allocator is responsible for assigning tasks to operators in the tactical phase of KLM's towing process to ensure the timely execution of towing operations (KLM, 2024-i). This phase typically begins during the night shift bridging the day ahead and the day of execution.

During this night shift, the tow allocator starts planning all tows that were initiated for the following day. To accomplish this, the allocator relies on a range of information systems and sources, as detailed in chapter 5.4, which provide tow details, including an initial, provisional movement time and the tow destination, which are subject to further confirmation and adjustment as the process progresses.

The tow allocator manually enters these tow details into the Flight Information Royal Dutch Airlines (FIRDA) system. FIRDA then forwards the tow details into an automated scheduling system called the Communicatie en Hub-Indelings Programma (CHIP), translated as the Communication and Hub Allocation Program (KLM, 2023-i).

CHIP retrieves additional data from the GMS, specifically regarding the arrival time of the next aircraft at the stand. Using this information, CHIP creates a time window during which the tow can take place. CHIP then uses its build-in optimizer to optimize the tow time by aligning it with other processes that also rely on CHIP (CHIP Expert, 2025).

When sufficient space is available in the tow overview, CHIP automatically allocates the provisional task to an available time slot and assigns it to a specific operator, though the task is not yet published to the operator. If there is insufficient space, the tow allocator manually adjusts the schedule to create room for the task.

Once this initial planning is complete, the tow allocator ensures the goal of the process planning is met by ensuring the timely execution of all towing operations (KLM, 2024-i). To do this, the tow allocator continues to scan his information sources and systems for additional required tows, and monitors the tow overview. If optimizations can be done manually, if the tow task conflicts with other tasks, or if changes in the planning are required due to unforeseen circumstances, such as delays of tows that are already in the operational phase, or ad-hoc tows, the tow allocator adjusts the planning accordingly.

When the tow task is nearing execution and ready to be assigned to an operator, the tow allocator publishes the task in CHIP, after which the operational phase begins.

6.2. Stakeholders in the Planning of KLM's Towing Process at Schiphol and Their Information Flows

In the tactical phase of the towing process, additional stakeholders become involved once the tow allocator has planned the tow.

AAS Gate Planning, along with KLM's HCC, OCC, and E&M, can all initiate towing movements, making them key stakeholders in the towing process. However, once the towing movement is initiated, only the DFM and the AAC within the HCC remain actively involved in planning the movements. The other stakeholders rely on their own planning systems (e.g., gate planning, maintenance planning, fleet planning) and expect that the towing process will be carried out effectively to align with their schedules. If any of these parties require updates or additional information, they can contact the DFM, AAC, or the tow allocator for changes or status updates.

Other stakeholders in tow planning are the task allocators responsible for aircraft service activities that are most likely to overlap with towing. These activities are typically the ones that are not tied directly to the aircraft's arrival or departure, which allows them to take place at both gate and remote positions, regardless of whether the aircraft is buffered.

When an aircraft is towed during a turnaround across multiple locations, task allocators must identify the most suitable location for each activity. To do this effectively, they need to know the exact timing of the tow. This information allows stakeholders to schedule their activities around the tow, as towing times determine the duration the aircraft spends at a particular airport location.

As discussed in chapter 4, the departments responsible for activities fitting these criteria include:

- KCS
- Klüh
- Asito
- AHSU
- ARD
- KLM Technical Service
- Panasonic Avionics

6.2.1. KLM's AAC

In addition to coordinating initiated towing movements between AAS Gate Planning and KLM, the AAC is responsible for executing, monitoring, and adjusting aircraft stand allocations on the day of operations in response to the day's dynamics (KLM, n.d.-b). The AAC's primary interest in both the planning of the towing process is ensuring that aircraft arrive at and depart from the correct aircraft stand on time (Aircraft Allocation Coordinator, 2024), in accordance with ground tow standards (Schiphol, 2024-a). If a tow cannot be completed as planned and delays are anticipated, it is essential that the AAC is informed promptly. This allows adjustments to be made, such as notifying the DFM, or the AAS gate planner to account for the delay and submit a request for necessary changes to the gate planning. As a result, the AAC has a vested interested in how towing movements are planned.

The AAC has access to both the GMS and the CHIP board used by the ATD, allowing it to monitor the planning of both systems effectively (Aircraft Allocation Coordinator, 2024).

6.2.2. KLM's DFM

In addition to its proactive role in initiating tow movements during Flow Management in the strategic phase, the DFM oversees and holds ultimate responsibility for Apron Services processes and their allocators from an overarching perspective during the tactical phase of Flight Management (Zadelhoff, 2024; KLM, n.d.-a; Duty Flow Manager, 2024). Therefore, the DFM is interested in any potential delays in the both the tow planning and execution. This allows the DFM to proactively address issues and respond appropriately (Duty Flow Manager, 2024).

The DFM has access to the CHIP board used by the ATD, as well as HCC view. HCC View enables the simultaneous monitoring of all relevant processes, providing a global overview by aggregating data from all CHIP and CaRe users. CaRe is a planning tool specifically used by KCS for scheduling catering activities, while CHIP is used by various allocators, such as cleaning and ground handling services, to plan and coordinate tasks around aircraft. HCC View highlights tasks at risk of exceeding their allocated times using colour codes for quick visual identification, making it easier to spot potential delays (Duty Flow Manager, 2024).

6.2.3. KLM's Aircraft Servicing Activities Task Allocators

Just like the ATD, the majority of task allocators responsible for aircraft servicing activities also use the CHIP planning system. These include:

- Klüh
- Asito
- AHSU
- ARD

CHIP can be configured to display visual indications on other task allocators' monitoring screens when tasks from various aircraft servicing activities using CHIP overlap. However, the implementation of this feature relies on specific configurations and agreements established between the involved parties. For instance, these indications are more extensively coordinated between ATD and Asito compared to the coordination between ATD and Klüh. When an allocator notices an overlap before the tow has started, CHIP can retrieve additional tow information, such as the start time and the tow's origin from FIRDA. After the tow has started, CHIP can also retrieve timestamps of the actual towing process progression. However, this requires some extra steps as it is not directly visible from the task overview (Klüh Task Allocator, 2024; Asito Task Allocator, 2024).

KCS, uses a different planning system than CHIP, namely the Catering Ready (CaRe) system. Similar to CHIP, CaRe is also linked to FIRDA and retrieves information from it. When the KCS allocator needs to determine whether tows are occurring within a turnaround, they can use CaRe to access tow information from FIRDA, such as the start time and the tow's origin. However, this process requires additional steps, as the tow details are not directly visible in the task overview (KCS Task Allocator, 2024).

Panasonic Avionics and KLM's Technical Services both utilize iVop, a planning system specifically designed for managing maintenance tasks. Recently, an Application Programming Interface (API), which acts as a bridge allowing different systems to communicate and exchange data, was developed to integrate iVop with CHIP, enhancing coordination with CHIP users. iVop provides a timeline for each aircraft, spanning from arrival to departure, with shaded areas indicating towing activities along with a single timestamp (Lead Ground Engineer, 2024).

6.2.4. Information Flows

The flow of information, starting with the towing movement details entered into FIRDA by the tow allocator, is illustrated in Figure 8. The arrows indicate communication between systems and phone calls. Additionally, coordination often occurs through face-to-face communication. As shown by the color-coded boxes, most task allocators from various stakeholders are located in the same room, the allocator room, which facilitates direct, in-person coordination.

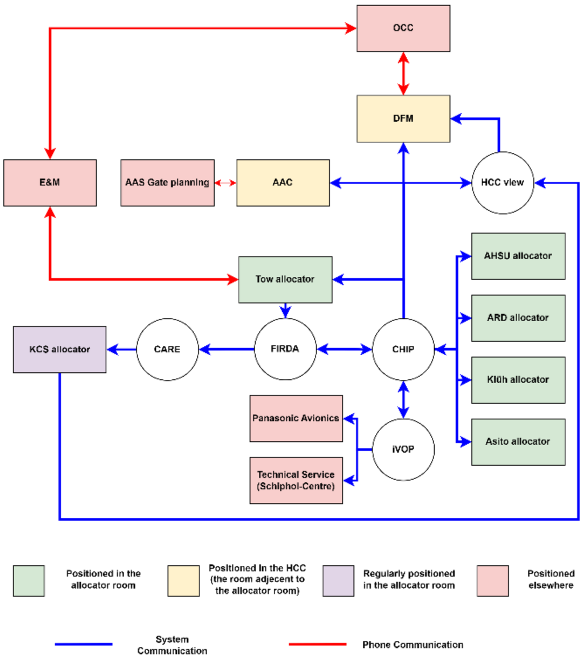

Figure 8: Information Flows From the Process Planning, to the Process Planning's Stakeholders.

Exceptions to this setup include the Panasonic Avionics and Technical Service task allocators, who are located in a different building. Additionally, the KCS task allocator is occasionally an exception, as they are sometimes stationed at KCS instead of in the allocator room.

The allocator room is situated directly next to the HCC, allowing for quick access to the DFM and AAC.

6.3. Risks in the Planning of KLM's Towing Process at Schiphol

Data exchange between systems works reasonably well, with CHIP receiving real-time feedback from other operators using CHIP (Yunita, 2009), and the DFM able to monitor these processes through the broader HCC view. However, there are several issues in the tactical phase of KLM's towing process that impact the efficiency and accuracy of operations.

Within CHIP, updates to process times are communicated to FIRDA and other CHIP users only when changes are deemed "significant" (CHIP Expert, 2025). However, the definition of "significant" is unclear, which means that not all changes may be transmitted in a timely manner. As a result, information about the tow planning may be outdated.

Additionally, there are instances when the tow allocator plans a towing task at a specific time, but this timing is not reflected in other systems, such as FIRDA and the HCC view. Consequently, other stakeholders may remain unaware that a towing operation is taking place (Duty Flow Manager, 2024).

While CHIP has an optimizer that aligns towing times with other processes, manual adjustments are often made by task allocators when the planning does not align perfectly with the workflow. These adjustments, if deemed "insignificant" or not properly reflected in other systems, may cause task overlaps. This issue is particularly problematic since initial towing times are set during the night shift, but most towing movements occur during the day. Therefore, it is possible that these times have been outdated for hours, during which a lot of changes could have happened.

Moreover, CaRe is only linked to FIRDA, not directly to CHIP (Duty Flow Manager, 2024; CHIP Expert, 2025). Similar to CHIP, FIRDA only updates when tow time changes are considered "significant." Even when updates occur, FIRDA only adjusts the start towing time and does not retrieve timestamp data from the towing process in CHIP (CHIP Expert, 2025). CaRe, in turn, must access this data from FIRDA, but the frequency of these updates is unclear. Furthermore, the data in CaRe can only be accessed by searching within the system (KCS Task Allocator, 2024). As a result, outdated times may remain in CaRe, and since updates are not easily visible, they may not be properly accounted for.

Furthermore, tow initiations from the strategic phase, such as those from AAS gate planning, KLM's OCC, and E&M, are initiated based on their own schedules (e.g., gate planning, maintenance planning, fleet planning). Since only the initial tow time is passed to the tow allocator in the strategic phase of the tow, and then transferred to FIRDA and CHIP, this initial towing time becomes disconnected from its source, as no feedback exists between these systems. On top of that, since manual adjustments are often made by task allocators when the planning does not align perfectly with the workflow, the planned towing time may no longer align with the initial time.

Lastly, when any of the schedules from the tow initiators are adjusted, these changes are not automatically relayed into FIRDA and CHIP as well. This typically involves gate planning and E&M. If there are delays in aircraft vacating the tow's destination gate or in maintenance activities, the towing schedule does not receive feedback from the gate planning or E&M systems. As a result, the towing time may no longer align with the actual situation.

Any of these risks can lead to misalignments in activities during the operational phase. These misalignments can, in turn, cause inefficiencies and disruptions, making the tow unpredictable.

Given that the towing process involves multiple parties, each of whom may vary with each tow due to different location considerations for aircraft servicing activities, and that coordination with all of these parties must be carefully managed, this risk is further underscored.

7. The Execution of Towing Movements Between Airport Locations During KLM's Process at Schiphol

Following the planning of towing movements between airport locations during KLM's turnaround at Schiphol in the tactical phase of the towing process, this chapter focuses on the execution these tows in the operational phase of the towing process. This phase involves the actual execution of the towing process on the scheduled day. This is where the plans and resources are put into action, ensuring that the towing process is completed as intended.

The operational phase of KLM's towing process at Schiphol can be divided into three key stages:

1. **Pre-Tow Procedure Stage**
   The objective of this stage is to prepare the aircraft for towing.

2. **Towing Stage**
   The objective of this stage is to reposition the aircraft from point A to point B safely, efficiently, and in a timely manner.

3. **Post-Tow Procedure Stage**
   The objective of this stage is to ensure the aircraft is ready for subsequent operations.

7.1. The Role of KLM in KLM's Towing Movements

At Schiphol, aircraft are towed while they are empty. When towing an empty aircraft, no pilots are present, as the aircraft is not scheduled for departure. However, Schiphol regulations (Service Owner Aircraft A/AO&AP, 2024) require a trained and qualified individual to be stationed in the cockpit to operate the brakes of the towed aircraft.

For the brakes to function, aircraft often require electrical power to drive pumps that generate the necessary hydraulic fluid pressure (Skybrary, n.d.-c). Electrical power is not only essential for operating the brakes but also for the aircraft's lighting systems, which ensure visibility during towing operations (KLM, 2024-g). This is particularly important as Schiphol (Service Owner Aircraft A/AO&AP, 2024) requires the anti-collision lights to be illuminated during daylight hours, known as the Uniform Daylight Period (UDP), from 15 minutes before sunrise to 15 minutes after sunset, and when there are no low-visibility operations (BZO). Outside the UDP, or during BZO, both the anti-collision lights and the navigation lights must be turned on to ensure the aircraft remains visible to other personnel and equipment (Service Owner Aircraft A/AO&AP, 2024).

To comply with these requirements, the towing stage of KLM's towing process at Schiphol must be executed by certified tow-couples, comprising a tug driver and a brake operator, employed by one of Schiphol's various aircraft towing service providers (MovingDot, n.d.).

During the towing stage, the tug driver operates the tug and is responsible for manoeuvring the aircraft and for any damage resulting from oversteering or over-torquing. Meanwhile, the brake operator is seated in the cockpit and ensures that aircraft movement requirements are met by managing all cockpit-related activities associated with towing (KLM, 2024-g). Both maintain continuous communication with each other and monitor relevant AAS Apron Control frequencies, adapting to the tow's location (KLM, 2024-f).

In addition to their roles during the towing stage, the tug driver and brake operator are also responsible for the pre- and post-tow procedure stages. During these stages, they may be assisted by a handyman. The handyman performs preparatory and support tasks essential for the towing operation, such as ensuring the availability of necessary handling equipment. This role is typically filled by tug drivers, temporary staff like brake operators, or employees with limited operational capabilities (KLM, 2024-h).

7.2. The Role of AAS and LVNL in KLM's Towing Movements

While the pre- and post-tow procedure stages can be performed by the tow-couple alone, during the towing stage, the tow-couple must navigate taxiways and often cross active runways, depending on the route. Therefore, the towing stage relies on coordination with air traffic controllers from both AAS and LVNL.

LVNL oversees airside safety and operational flow on taxiways and runway with focus on efficient traffic flows, meaning that towing activities take place within their area of responsibility (MovingDot, n.d.; MovingDot; NLR, 2019).

Although LVNL is ultimately responsible for efficient traffic flows on taxiways and runways, AAS manages Schiphol's overall airport infrastructure as well as some movements on the platforms and taxiways, including tow movements (MovingDot; NLR, 2019)

On the taxiways, LVNL's ground controller is responsible for coordinating aircraft traffic but does not directly manage towing activities. Instead, the direct coordination of towing movements on the taxiways is delegated to AAS's Apron Control, whose responsibility is to ensure that towing operations are conducted as safely and efficiently as possible. To ensure this, the apron controller maintains communication with both LVNL and the tow-couples (MovingDot, n.d.).

However, when the route includes crossing a runway, direct coordination between the tow-couple and LVNL's runway controller assistant is required. This is required on the following routes (Service Owner Aircraft A/AO&AP, 2024):

- Schiphol-Centre to Schiphol-East (or vice versa): Towing on this route involves crossing the Aalsmeerbaan and Oostbaan.
- Schiphol-Centre to the S-platform (or vice versa): Towing on this route involves crossing the Kaagbaan.
- Schiphol-Centre to the U-platform (or vice versa): Towing on this route involves crossing the extended area near the threshold of runway 09 (the end of the Buitenveldertbaan), using taxiways C or D.

7.3. Steps of the Pre-Tow Procedure Stage in the Execution of KLM's Towing Movements

The pre-tow procedure stage commences when the tow-couple receives the tow task in CHIP on their hand held terminal. Upon receipt, the tug driver selects "Confirm" to acknowledge and accept the task (KLM, 2024-b).

After confirming, the tug driver selects a suitable vehicle in CHIP and performs the required checks, including a vehicle and system inspection, a brake test, a Ground Power Unit (GPU) test, and compatibility verification between the tug and the aircraft to be towed (KLM, 2024-b). If any of these criteria are not met, the tug driver selects an alternative tug. Once all criteria are satisfied, the driver marks "Vehicle checked" in CHIP.

The tug driver and brake operator then board the tug. The driver sets CHIP to "Driving" and proceeds to the designated aircraft stand.

At the aircraft stand, the tug driver conducts another brake test and positions the tug in front of the aircraft's nose wheel. The driver then marks "Arrived" in CHIP (KLM, 2024-b).

While the brake operator gets out of the tug and places the communication cable and bypass pin (or activates the steering towing switch instead of placing the bypass pin when towing an Embraer) (KLM, 2024-b) a handyman, if available, may begin assisting the tow-couple with preparatory tasks from this point onward (KLM, 2024-h). Although the tow-couple is primarily responsible for these steps, the handyman's support can improve operational efficiency, particularly in high-pressure scenarios.

The tug driver then selects "Started" in CHIP to indicate the beginning of stand-related activities and exits the tug to inspect the nose gear extension and retraction in accordance with the work place instructions (KLM, 2024-m).

If a Pre-Conditioned Air (PCA) unit, a device used to cool, ventilate, or heat an aircraft's cabin, is connected to the aircraft, the tug driver and brake operator work together to disconnect and store it properly (KLM, 2024-r).

Next, both board the aircraft. The brake operator checks whether gear safety pins are required. These pins are always mandatory for towing KLC Embraer and Transavia aircraft. (KLM, 2024-n; KLM, 2024-b). For KLM aircraft, gear safety pins are only required under specific conditions (KLM, 2024-b; KLM, 2022-b; KLM, 2023-f; KLM, 2023-g; KLM, 2023-h; KLM, 2024-o; KLM, 2024-p):

- When towing an aircraft to or from the hangar.
- When the fuel level is below a in the relevant checklist specified threshold on Boeing 737, 747, 777, and 787 models.
- When a hydraulic fault is present on Boeing 737, 747, 777, 787 models, as well as Airbus A321 and A330 models.

If gear safety pins are needed, the brake operator provides them to the tug driver unless they have already been installed.

Before closing the aircraft door, the passenger cabin must be checked for any customs items during a tow to Schiphol-East, and must ensure no personnel other than technical staff remain onboard (KLM, 2024-f). If personnel are present, they are informed that the aircraft will be towed and will be asked to disembark as soon as possible. After all personnel has left, the tug driver closes the aircraft door and removes the bridge or stairs.

Once the bridge or stairs have been removed, the tug driver installs the gear safety pins in the aircraft's gear if required. Then, it needs to be made sure that the aircraft remains powered during the towing process. This can be achieved either through connecting the tug's GPU plug, or by starting the aircraft's Auxiliary Power Unit (APU), which is a small onboard engine that provides electrical power for functions other than propulsion (KLM, 2023-i). In addition to generating electrical power, the APU supplies bleed air, enabling pneumatic functions such as air conditioning during towing (Skybrary, n.d.-d). However, the GPU does not support these pneumatic functions, and requires connecting a plug, making the APU more valuable and less time consuming in specific scenarios.

Despite its advantages, APU usage is restricted to specific conditions due to its negative impact on air quality and the noise pollution it causes. Examples include (KLM, 2023-i; ILT, n.d.):

- When the outside air temperature, as indicated in the Meteorological Aerodrome Report, is below -5°C or above 25°C.
- If no cleaner, functional alternatives are available.
- When required to ensure safe working conditions onboard the aircraft.
- Shortly after arrival or just before departure from the aircraft stand.

Under such conditions, the brake operator starts the APU. When towing a Boeing 787, this step is always necessary because the aircraft requires two external power plugs, while the tug only provides one. Once running, the brake operator clears the tug driver to disconnect the external powers, typically using hand signals (KLM, 2024-b).

If the APU is not used, the tug's GPU must provide power instead. In this case, the brake operator ensures that all aircraft systems are powered down before clearing the tug driver to disconnect the external power sources (KLM, 2024-b).

Once the disconnection of the external powers has been completed, the tug driver attaches the tug to the aircraft's nosewheel, and connects the tug's GPU if necessary (KLM, 2024-b).

Meanwhile, the brake operator continues to manage all cockpit-related activities by following the aircraft's towing checklist, while the tug driver will start performing the pre-departure servicing checklist, ensuring the following are checked (KLM, 2024-q; KLM, 2024-b):

- The area is clear of any foreign object debris.
- All ground processes have been completed, and ground service equipment has been removed.
- There is sufficient manoeuvring space.
- All doors and latches are closed.
- There is no visible damage.
- he

Once these checks are complete the tug driver selects "pre-departure servicing checklist completed" in CHIP, and removes the pylons. After the brake operator verifies that the aircraft's parking brake is set, the chocks can also be removed. With approval from the brake operator, the aircraft's nosewheel can then be lifted, after which the aircraft's brakes can be released again, and the aircraft's anti-collision light is turned on by the brake operator. At this point, the tug's flashing lights and transponder are activated, signalling readiness for the tow. This also indicates that it is unsafe for other personnel to enter the aircraft position, as the tow may commence at any moment (KLM, 2024-b).

7.4. Steps of the Towing Stage in the Execution of KLM's Towing Movements

The towing stage commences when the tug driver requests the tow to the apron controller. This request is made in accordance with the Handbook for Towing Operations (Service Owner Aircraft A/AO&AP, 2024), and can only be submitted after all pre-tow procedures have been completed. The request includes (Apron Controllers, 2024):

- Aircraft registration
- Current position
- Destination
- Tug registration

When a tow is requested by the tug driver, the apron controller checks in the Central Information System Schiphol (CISS), on their tow list, or with the gate planner to verify that the new position is correct and available. The apron controller then creates the tow in CISS. The following details are entered (Apron Controllers, 2024):

- Aircraft registration
- New position
- Tug registration

- Previous position

Entering the information into CISS is essential as it links these details to the transponder of the tug, enabling it to be labelled on the ground radar. This also records that the aircraft is vacating its current position (Apron Controllers, 2024).

If the new position is correct and available, there are no approaching conflicts on the taxiways, and no other aircraft are obstructing the relevant bay, the apron controller informs the tug driver to start the tow. Occasionally, this approval is given even if the position is not yet free but is expected to become available shortly to save time (Apron Controllers, 2024). Once towing begins, the tug driver selects “start towing” in CHIP.

Under normal circumstances, the apron controller operates independently within their designated area, adhering to established procedures and issuing instructions to the tug driver. These instructions are read back by the tug driver, as specified in the Handbook for Towing Operations (Service Owner Aircraft A/AO&AP, 2024), and subsequently executed (Apron Controllers, 2024).

However, if the ground controller issues conflicting or supplementary instructions, the apron controller must comply, as the ground controller holds ultimate authority over the area. For instance, the ground controller may coordinate with the apron controller when a taxiing aircraft deviates from its standard route and poses a potential conflict with towing traffic at the time of deviation (LVNL, 2024-b; Apron Controllers, 2024).

Under special conditions, such as BZO, when the tower’s view is obscured, the apron controller is not permitted to use ground radar as they are not certified for it. In these cases, all tow requests must be coordinated with the ground controller. If the ground controller approves the tow’s movement, the apron controller instructs the tug driver to follow the standard route. For deviations or if approval is not granted, the ground controller communicates the instructions or clearances to the apron controller, who passes them to the tug driver (Apron Controllers, 2024).

During towing, the tow often moves to an area outside the jurisdiction of the initial apron controller. This can occur in the following three situations:

1. **When the tow moves into another apron controller’s area**.
   In this scenario, the current apron controller instructs the tug driver to switch to the next apron controller’s channel. Once switched, the tug driver contacts the new apron controller (Apron Controllers, 2024).

2. **When the tow moves into an area without an apron controller**.
   In this scenario, the apron controller must coordinate with the ground controller of the area the tow is moving into. The current apron controller remains in contact with the tug driver throughout this transition, so the tug driver does not need to switch channels (Apron Controllers, 2024).

3. **When the tow must cross a runway**.
   In this scenario, the apron controller instructs the tug driver to switch to the runway controller assistant’s (tower) channel. Once switched, the tug driver contacts the assistant to request clearance to cross the runway (Runway Controller Assistant, 2025).

   If the runway is not in use, the assistant can independently assess the situation and grant clearance for the tow to cross. However, when the runway is in use, this must be coordinated with the runway controller. The assistant evaluates when a crossing might be possible and

> waits for an opportune moment to present the request to the runway controller without disrupting their work. The runway controller then decides whether the crossing can occur. For safety, the assistant must explicitly read back the runway controller's decision (Runway Controller Assistant, 2025).
>
> When the tow is permitted to cross, the stop bars are turned off, and no take-offs or landings are allowed during the crossing. At such times, crossings at other holding points may still be allowed. Aircraft are typically allowed to taxi into take-off position but must be informed that a crossing is in progress and that they must wait if necessary. In BZO, this process differs, as no activities are permitted on the runway during a crossing (Runway Controller Assistant, 2025).
>
> Once clearance to cross the runway is granted by the runway controller, the assistant communicates this to the tug driver. The tug driver must read back the clearance, after which the tow may proceed to cross the runway (Runway Controller Assistant, 2025).
>
> During the crossing, if the tow will immediately transition onto a busy taxiway, the assistant contacts the ground controller to coordinate this. In most cases, a standard route is followed after the crossing. However, if there is a deviation from the standard route, the assistant can immediately coordinate with the apron controller. The assistant then relays the clearance, coordinated with the ground or apron controller, to the tug driver (Runway Controller Assistant, 2025).
>
> After the aircraft has completely cleared the runway, the tug driver reports this, and the runway controller assistant reads back the confirmation. The tug driver is then actively transferred back to the apron controller (Runway Controller Assistant, 2025).

Following such situations, the apron controller continues to guide the tug driver, handing over responsibilities as needed, until the tow nears its destination.

As the tow nears its final position, the apron controller either provides final clearance directly or waits for the tug driver to report in. Once the tug driver checks in, the apron controller then issues the final clearance, granting permission to move the aircraft into position. If required, the apron controller specifies a stop line: a marking indicating where the aircraft's nose wheel should be placed to ensure proper alignment within the parking area (KLM, 2024-b; Apron Controllers, 2024).

After issuing the final clearance, the apron controller ends the tow in CISS. This action removes the tug's label from the ground radar and updates the aircraft's location to its new position in the system (Apron Controllers, 2024).

The tug driver then checks whether the aircraft position is clear, proceeds to move the aircraft into the designated position, and ensures it is properly aligned with the stop line if needed. Once the aircraft is correctly positioned, the tug driver instructs the brake operator to set the aircraft's parking brake and switches off the tug's transponder (KLM, 2024-b).

7.5. Steps of the Post-Tow Procedure Stage in the Execution of KLM's Towing Movements

The post-tow procedure stage begins once the aircraft is correctly positioned, the aircraft's parking brake is set, and the tug's transponder is switched off. At this point, the tug driver may lower the aircraft's nosewheel and deactivate the tug's flashing lights (KLM, 2024-b), signalling that it is safe for other personnel to enter the aircraft position. From this moment, other ground processes can start again. The brake operator also turns off the aircraft's anti-collision light, further indicating safety for personnel. If a handyman is available, they may begin assisting the tow-couple with tasks at this stage.

The tug driver then selects "Ready" in CHIP, indicating that the aircraft is ready for further operations.

Next, the tug driver placed the blocks and pylons. Once completed, the tug driver informs the brake operator that the blocks are in place (KLM, 2024-b).

If the tug's GPU was used, the brake operator powers down the aircraft and clears the tug driver to disconnect the GPU and detach the tug from the aircraft's nosewheel (KLM, 2024-b). If the APU was used instead, the brake operator only needs to clear the tug driver to disconnect the tug from the aircraft's nosewheel, since in this case, the tug's GPU was not connected.

Following this, the tug driver connects the external power sources to provide the aircraft with electrical power (KLM, 2024-b).

If it is uncertain whether the external powers work, and are connected in the right way for the aircraft to use them, the brake operator and tug driver verify this with each other, typically using hand signals. If the APU was used, it can now be turned off by the brake operator.

The tug driver then places a bridge or stairs, depending on what is available at the aircraft position. After opening the aircraft's door, the safety gear pins are handed over to the brake operator, who stores them in the cockpit if they were required (KLM, 2024-b). Additionally, personnel conducting cabin processes can enter the aircraft again, meaning these processes can commence

If a PCA unit is available at the aircraft position, the tug driver and brake operator work together to connect it to the aircraft (KLM, 2024-r).

Finally, the communication cable and bypass pin are removed (or the steering towing switch is deactivated instead of removing the bypass pin when towing an Embraer) (KLM, 2024-b).

Once all post-tow procedures are completed, the tow-couple boards the tug again. The tug driver selects "Finished" in CHIP, signalling that the task has been completed and the tow-couple is ready for a new assignment (KLM, 2024-b).

7.6. Stakeholders in the Execution of KLM's Towing Movements and Their Information Flows

Similar to the planning of the towing process in the tactical phase, the execution in the operational phase of KLM's towing movement involves many of the same stakeholders, including tow initiators and various task allocators. However, there are subtle differences in the interests of these parties and the systems they utilize during this phase. Additionally, new stakeholders become involved in the execution phase, such as the operators carrying out other aircraft servicing activities, the handman, AAS apron control, and LVNL.

7.6.1. KLM's Tow Allocator

The tow allocator is not directly involved in the execution of the towing process beyond assigning tasks and serving as a point of contact in case of disruptions. However, the tow allocator actively monitors the status of tows during the operational phase to adapt the planning of other towing movements to unforeseen circumstances, such as delays (KLM, 2024-i).

To track the status of tows, the tow allocator relies on various time stamps entered by tug drivers in CHIP. Additionally, cameras installed at gate positions provide a visual means of monitoring progress during the pre- and post-tow procedure stages.

During the towing phase, the tow allocator has access to Wilbur, a relatively new system implemented by AAS to enhance efficiency and transparency through real-time dashboards and the integration of ACDM and Deep Turnaround (Schiphol, 2020). Using Wilbur, the tow allocator can track the location of a tow in real-time based on the tug's transponder data and the label created by the apron controller in CISS.

7.6.2. KLM's AAC

In addition to its role and interest in the coordination and planning of the towing process, the AAC remains interested in the execution of the tow, for the same reasons it had in the planning.

However, to track the execution of the tow, the AAC now uses its systems differently. Now, similar to the tow allocator, the AAC can follow the various time stamps filled in by the tug driver in CHIP, and has access to the cameras at the gate positions, and Wilbur (Aircraft Allocation Coordinator, 2024).

Additionally, when a tow has been requested to the Apron Controller and the tow details are entered into CISS, GMS retrieves this information and provides an indication. The AAC can interpret this as a signal that the aircraft is about to vacate the aircraft stand (Aircraft Allocation Coordinator, 2024).

7.6.3. KLM's DFM

The DFM remains interested in the execution of the tow, driven by the same reasons as during the planning. Additionally, if a disruption arises and escalates during the tow, the DFM assesses the situation based on several factors: the time remaining until departure, the availability of alternatives, and the time required to implement those alternatives. This assessment helps determine when the aircraft can realistically be positioned at the gate (Duty Flow Manager, 2024).

After making this assessment, the DFM identifies the next steps along the critical path and coordinates these with the HCT and relevant allocators. For example, the catering team might be instructed to prioritize loading supplies in the front and middle sections of the aircraft to enable earlier boarding. If cleaning is required, the AHSU can be directed to connect the bridge, granting cleaning crews faster access to the aircraft (Zadelhoff, 2024; Duty Flow Manager, 2024).

With these considerations in mind, the DFM provides an informed estimate of the expected departure time. This estimate is then discussed with the OCT, which evaluates the financial and operational implications of the delay. The OCT determines whether the associated costs are acceptable, whether an aircraft change is necessary, if crew duty times will be exceeded, or if a reserve crew is available. If none of these options are feasible, the OCT may decide to cancel the flight (Duty Flow Manager, 2024).

To track the execution of the tow, the DFM, similar to the tow allocator, can follow the various time stamps filled in by the tug driver in CHIP, and has access to the cameras at the gate positions, and Wilbur. Furthermore, the timestamps from CHIP are also relayed to the DFM's HCC view system.

7.6.4. KLM's Aircraft Servicing Activities Task Allocators

Similar to the planning during the tactical phase of the tow, the task allocators for all aircraft servicing activities with potential overlaps remain interested during the execution of the tow. However, their focus shifts to activities that will follow the tow.

Task allocators from Klüh, Asito, AHSU, and ARD, who utilize CHIP, can track the timestamps entered by the tug driver in the system. In contrast, task allocators from KCS, Panasonic Avionics, and KLM's Technical Services cannot monitor these timestamps. Therefore, they lack a means to track the tow's progress, as they are only provided with the start towing time.

However, most of these task allocators are located in the same room as the tow allocator, allowing them to easily retrieve information by walking over, or even by using the tow allocator's cameras. For allocators based elsewhere, information can be obtained by contacting the tow allocator via phone.

7.6.5. KLM's Aircraft Servicing Activities Task Operators

During the execution of the tow, operators responsible for various aircraft servicing activities also become key stakeholders. It is crucial for these operators to know the exact timing: when their activity must be completed before the tow begins or when they can start their activity after the tow concludes.

Operators from Klüh, Asito, AHSU, and ARD, like the tug driver, use handheld terminals where their tasks are allocated through CHIP. In the mobile version of CHIP, they can access the start towing time and track timestamps entered by the tug driver. However, locating this information in the system can be challenging.

In contrast, operators from KCS, Panasonic Avionics, and KLM's Technical Services cannot monitor these timestamps as they do not use CHIP. Instead, Panasonic Avionics and KLM's Technical Services operators use iVop, which provides a timeline for each aircraft, spanning from arrival to departure. This timeline includes shaded areas indicating towing activities, along with a single timestamp (Lead Ground Engineer, 2024). In contrast, KCS operators do not have access to a similar timeline.

7.6.6. KLM's Handyman

For supporting tasks related to the pre- and post-tow procedures, it is essential for the handyman to know when towing will occur, so that he can assist there.

The handyman, like the tug driver, uses a handheld terminal where their tasks are allocated through CHIP. In the mobile version of CHIP, the handyman can access the start towing time and track timestamps entered by the tug driver. However, locating this information in the system can be challenging.

Additionally, the handyman always carries a fixed walkie-talkie number, which allows the tow-couple to reach him when needed. He can also take a portable VHF radio in his vehicle, enabling him to listen to apron control frequencies and track the destination of towing movements.

7.6.7. KLM's E&M

For KLM's E&M, it is crucial to know when aircraft are arriving and departing from the hangars, so space can be made and the doors opened to allow the aircraft to enter or exit (Hangar Lead, 2024). As a tow initiator, E&M uses its maintenance planning to know when to expect a tow, since the tow should be carried out accordingly.

To actually track towing movements, E&M utilizes Wilbur and cameras installed near the hangars to monitor activities on the platforms outside. For towing movements to Hangars 10, 11, 12, and 14, the brake operator calls the towing team at Schiphol-East in advance to let them know the tow is on its way to the hanger, who then relay this to the respective hangar's personnel (Hangar Lead, 2024). Similar to the handyman, the towing team at Schiphol-East is also equipped with a VHF radio. For towing movements to Hangar 73, the brake operator directly contacts the hangar.

7.6.8. AAS Gate Planning

The gate planner's primary interest in the towing process is that ground handlers tow the correct aircraft to and from the correct positions on time, in compliance with the ground tow standards (Schiphol, 2024-a). Adhering to these standards is essential for achieving the gate planner's goals of maintaining a static planning approach wherever possible and effectively facilitating airlines and ground handlers (AAS Gate Planner 1, 2024; AAS Gate Planner 2, 2024).

To know when an aircraft is about to be towed, the gate planner can access the cameras and also observe the aircraft directly from the tower window. Additionally, similar to the AAC, the gate planner receives an indication in GMS when the aircraft is about to vacate the stand (Ravenswaaij, The, & Brown, 2017; AAS Gate Planner 1, 2024; AAS Gate Planner 2, 2024). If further details are needed, the gate planner can contact the AAC, who acts as the point of contact for KLM, to obtain additional information by reaching out to the tow allocator.

7.6.9. AAS Apron Control

The role of the apron controller during the towing stage has already been discussed. However, to stay informed about towing operations, the apron controller continuously scans the taxiways for any traffic. This is done by checking the ground radar (for verification) and visually observing the area outside. The apron controller also listens to both his own towing channel and the ground controller's channel for his area, as well as the runway controller's assistant's runway channel (Apron Controllers, 2024).

To anticipate towing operations, the apron controller has a short towing list, which, however, is limited as it only includes tows to non-departure positions (Apron Controllers, 2024).

If the apron controller has sufficient time, he may check the CISS staff pages to see if there are upcoming departures at positions where aircraft have recently arrived. If no such departures are scheduled, it's possible that a tow will take place. To confirm this, he can select the specific aircraft stand, which shows incoming and outgoing aircraft. If an aircraft arrives earlier than expected and another departure is scheduled, he can be certain that a tow is imminent (Apron Controllers, 2024).

Additionally, the apron controller can ask the gate planner if any towing movements are expected in the near future (Apron Controllers, 2024).

7.6.10. LVNL

The roles of LVNL's ground controller and runway controller assistant have already been discussed. To stay informed about towing operations, these controllers continuously scan the taxiways for any tow traffic. This is done by checking the ground radar and visually observing the area outside. Additionally, the controllers can receive updates from the apron controller (Runway Controller Assistant, 2025).

7.7. Risks in the Execution of KLM's Towing Movements

In the execution of KLM's towing process, the coordination and planning come into action, where any miscoordinations, in the strategic, tactical, or operational phase may result in inefficiencies and disruptions.

7.7.1. Risks in the Pre-Tow Procedure Stage

The first risk in the pre-tow procedure stage may occur when picking up an aircraft from a hangar at Schiphol-East. If the brake operator informs the Schiphol-East tow team or the hangar personnel too late, and they have not been actively monitoring Wilbur or the VHF channel to track the tow, the hangar personnel may still be occupied with making space or opening the hangar doors when the tow-couple arrives.

It is also possible that, upon arrival, the aircraft in the hangar is not yet ready for towing. In such cases, the tow team must wait, which can result from the risks identified during the planning phase.

Another risk arises at Schiphol-Centre when the bridge or stairs need to be removed, but operators performing activities within the cabin, typically from Asito, Klüh, Panasonic Avionics, or KLM's Technical Services, are still busy. This issue often stems from a lack of coordination due to risks identified during the planning phase, causing operators to remain unaware of the actual towing timeline.

Even when the towing process is properly planned and coordinated, and operators are working with an accurate towing timeline, delays can still occur. Operators using CHIP can find the start towing time in their handheld terminals. However, this time can be misleading, as operators may believe they have until the start towing time to finish their tasks. According to Parkinson's Law (Parkinson, 1955), people will tend to take the full time allotted to complete a task.

In reality, the start towing time marks when the towing stage begins. Pre-tow procedures, such as removing the bridge or stairs, must still be completed after the operators disembark. If operators only leave the aircraft at the start towing time, these procedures must then be carried out while the tow should already be underway, leading to disruptions.

Shortly afterward, a similar risk may occur when towing from Schiphol-Centre. This happens when the blocks need to be removed, but operators performing activities on the aircraft position, typically from KCS, AHSU, or ARD, are still working. The causes and effects of this inefficiency mirror those of the earlier scenario involving cabin operators.

When towing from Schiphol-Centre, the handyman plays a crucial role in improving efficiency. However, the absence of the handyman often results in reduced efficiency. This is a significant risk, as it is particularly challenging for the handyman to maintain an overview of all ongoing towing movements.

Firstly, the handyman must know which aircraft is being towed before checking its status. Furthermore, the VHF radio, which is essential for staying informed, is only available in the handyman's vehicle. This limits the handyman's ability to stay updated on towing activities when away from the vehicle.

Such risks at a gate position can result in a delayed tow, potentially causing problems for incoming aircraft that must wait until the parked aircraft is towed away. This creates an even greater risk than delayed flights, as a 20-minute separation is planned between departing and arriving flights, whereas only 10 minutes is allocated for aircraft being towed (MovingDot; NLR, 2019).

An additional risk, specifically environmental, stems from the lack of clarity among airport stakeholders regarding the precise timing of towing operations. This makes it difficult to enforce APU usage regulations. Unlike departing flights, where APU rules are tied to the OBT, towing operations lack similarly strict guidelines, resulting in avoidable environmental inefficiencies.

7.7.2. Risks in the Towing Stage

The first risk in the towing stage arises when the tug driver requests a tow from the apron controller. If a planning-related risk causes misalignment between gate planning and tow planning, and the tug driver fails to account for the TSAT of the aircraft occupying the destination gate (a step requiring additional, less common actions), there is a risk that the assigned gate remains occupied. This misalignment can result in unnecessary waiting time for the aircraft, during which other servicing activities could have otherwise been completed (KLM, 2021-b).

Another risk is that it is difficult for apron controllers, ground controllers, and the runway controller's assistant to predict when a tow will be on the taxiway or runway. Unlike departing flights, tows do not have a flight plan, OBT, or TSAT window (MovingDot; NLR, 2019). This makes it challenging for apron and ground controllers to anticipate towing movements in advance, potentially leading to waiting times or inefficiencies on the runway. Additionally, the runway controller’s assistant may be unable to account for the tow during runway crossings, which can result in further delays.

Another risk during the towing stage is the potential congestion on the taxi- and runways. A runway that needs to be crossed may be in use, or adverse weather conditions may cause delays, making the flow of operations less efficient.

When approaching the destination, there is also a risk that equipment or other obstacles may be in the way at the aircraft position, preventing the tow from proceeding.

7.7.3. Risks in the Post-Tow Procedure Stage

Similar to the first risk of the pre-tow procedure stage, when an aircraft arrives at a hangar, but the brake operator informs the Schiphol-East tow team or the hangar personnel too late, and they have not been actively monitoring Wilbur or the VHF channel to track the tow, the hangar personnel may still be occupied with making space or opening the hangar doors when the tow arrives.

When towing to Schiphol-Centre, just like during the pre-tow procedure stage, the handyman plays a crucial role in improving efficiency. However, the absence of the handyman often results in reduced efficiency. This is a significant risk, for the same reasons as during the pre-tow procedure stage.

Similar to the environmental risk of the pre-tow procedure stage, there is a lack of clarity among airport stakeholders regarding the precise timing of towing operations, which makes it difficult to enforce APU usage regulations. Unlike arriving flights, where APU rules are tied to the IBT, towing operations lack similarly strict guidelines, resulting in avoidable environmental inefficiencies.

The final risk in the towing process, which relates to subsequent activities, is the lack of clarity regarding the arrival time of the tow at the aircraft position. Task allocators and operators performing aircraft servicing activities often do not have a way to track the tow’s progress, as they are only provided with the start towing time. This issue is particularly problematic when the tow is disrupted at any point during the process. As a result, operators may have to wait for the tow to arrive, leading to wasted time during which they could have been performing other tasks.

8. Conclusion

This research aimed to find out how aircraft towing can become a more efficient and predictable element of the turnaround process, by addressing risks that may cause disruptions and uncertainty in the towing process, through improving its coordination. This objective was pursued using the TRIZ methodology, and the following research sub-objectives were fulfilled:

1. Develop a comprehensive understanding of the turnaround process.
2. Examine aircraft towing and its role within the turnaround process, distinguishing it from pushback operations.
3. Assess the importance of effective towing coordination in turnaround efficiency.
4. Investigate Schiphol Airport's operational landscape, specifically:
    - Key locations relevant to towing operations.
    - Innovative coordination systems used.
5. Evaluate the impact of Schiphol's operational landscape on KLM's turnaround activities.
6. Analyse KLM's towing operations at Schiphol, identifying the different steps and key stakeholders involved across:
    - The strategic phase of towing.
    - The tactical phase of towing.
    - The operational phase of towing.
7. Analyse the coordination risks across:
    - The strategic phase of towing.
    - The tactical phase of towing.
    - The operational phase of towing.

Through qualitative desk research on external literature, a comprehensive understanding of the turnaround process was achieved, aircraft towing and its role within the turnaround process were examined, distinguishing it from pushback operations, and the importance of effective towing coordination in turnaround efficiency was assessed

The aircraft turnaround encompasses all essential ground handling activities performed between an aircraft's arrival IBT and departure OBT. Efficient turnaround operations are crucial for maintaining airline punctuality, operational efficiency, and profitability. Activities within the turnaround follow a structured sequence, where dependencies between tasks define the critical path, impacting the overall turnaround time.

Where typical turnarounds are conducted at one airport locations, aircraft towing plays a key role in turnarounds that span multiple locations, such as gate positions, remote stands, or maintenance areas. Unlike pushback, which moves a fully loaded aircraft to the taxiway for departure, towing relocates an empty aircraft using a tug, often for operational efficiency, space optimization, or maintenance purposes.

Proper integration of towing within the turnaround process requires careful coordination with ground handling activities, airport gate planning, and air traffic control. Misalignment in any of these areas can lead to inefficiencies, cascading delays, and reduced turnaround predictability. By ensuring seamless coordination, towing can be optimized to support smooth airport operations while minimizing disruptions.

Schiphol Airport's operational landscape was investigated through primarily using qualitative desk research on both internal and external literature. Schiphol's operational landscape consists of key locations relevant to towing, including gate positions, remote positions, and the maintenance area at

Schiphol-East. While Schiphol employs advanced coordination systems such as ACDM and Deep Turnaround, these primarily optimize flight movements and turnaround processes at gate positions. However, towing operations lack equivalent timestamps within ACDM, limiting transparency and coordination. This gap in integration reduces efficiency in managing aircraft movements beyond gate areas, particularly at remote positions and maintenance facilities.

the impact of Schiphol's operational landscape on KLM's turnaround activities was evaluated through a mix of in-depth interviews with stakeholders, qualitative desk research on internal literature, and observations. Schiphol's layout, with its maintenance area, and various gate and remote positions, significantly influences KLM's turnaround processes. The need for frequent aircraft relocations, including towing movements, affects the way in which critical services such as passenger handling, baggage and cargo loading, catering, and maintenance activities can be distributed. Since this distribution may vary per turnaround, efficient coordination of activities across different areas of the airport is essential for smooth turnarounds.

The different steps, information flows and key stakeholders involved in KLM's towing operations were identified through a mix of in-depth interviews with stakeholders, qualitative desk research on internal literature, and observations. This analysis covered the strategic, tactical, and operational phases of towing. To initiate, plan, and execute a tow movement at Schiphol, a wide range of stakeholders and systems are involved throughout all the necessary steps. Each tow, initiated by AAS gate planning, KLM's HCC, OCC, or E&M, is communicated through different systems and ultimately reaches the tow allocator. The tow allocator then plans the tow, coordinating with the, for each tow varying, aircraft servicing activities involved, due to the different location considerations for these aircraft servicing activities. This coordination occurs through multiple communication channels and systems. Once the tow is planned, the tow allocator assigns the tow-couple the task, which they will execute under the guidance of the apron controller. During the execution, any misalignments due to miscoordinations may result in in inefficiencies and disruptions in the towing process, causing it to be an inefficient and unpredictable element of the turnaround.

The coordination risks in KLM's towing operations were analysed through a combination of in-depth interviews with stakeholders, qualitative desk research on internal literature, and direct observations. This analysis covered the strategic, tactical, and operational phases of towing. It was found that various stakeholder systems, such as those from ATD, gate planning, E&M, and other operators, often lack sufficient feedback mechanisms, leading to misalignments. The absence of integration between these systems frequently causes disruptions, resulting in increased uncertainty in towing schedules and related activities. As a consequence, actual towing times are often unclear, creating confusion among those responsible for coordinating ground services. When towing times are clear, operators often fail to recognize the need to complete their processes well before the scheduled towing time, further contributing to delays and operational inefficiencies. These risks are further amplified by Schiphol's practice of using shorter separation times at the gate position for towing operations, as well as the difficulties in enforcing APU restrictions concerning towing activities.

Ultimately, the research demonstrates that the main objective, which aimed to find out how aircraft towing can become a more efficient and predictable element of the turnaround process, by addressing risks that may cause disruptions and uncertainty in the towing process, through improving its coordination, can be achieved by integrating the various stakeholder systems more effectively. This integration would ensure that these systems provide each other with accurate and timely feedback, making towing times more precise.

The increased accuracy of towing times would, when made more transparent to all relevant stakeholders, provide stakeholders with a clearer understanding of the tow movement's timeline, thereby reducing uncertainty. Additionally, raising awareness among operators about the importance of completing their tasks well before the scheduled towing times would help prevent delays and ensure that all necessary actions are taken in a timely manner. By focusing on these areas, the research highlights that improvements in system integration, transparency, and stakeholder awareness can significantly enhance the efficiency and predictability of the towing process, ultimately leading to smoother and more reliable turnaround operations.

9. Recommendations

Based on the conclusions drawn from this research, several recommendations have been formulated to making towing a more efficient and predictable element of the turnaround process, through improved coordination.

These recommendations are categorized into long-term and short-term actions.

9.1. Long-term Recommendations

This section outlines the long-term recommendations, which are presented in chronological order of implementation.

9.1.1. Integrating Planning Systems

Currently, towing time must be manually entered into FIRDA to create the tow movement in CHIP, with no feedback received from the tow initiators' systems or operators like KCS. It is recommended that these systems be better integrated. This would allow towing tasks to be automatically generated in both FIRDA and CHIP, receiving dynamic feedback from other planning systems, ensuring the tasks are up to date and accurate.

9.1.2. Treating the Towing Time as an ACDM Timestamp

It is recommended that the dynamic towing time be treated as an ACDM timestamp in the form of a Tow-OBT. This timestamp should be made available to all airport parties, enabling stakeholders to plan effectively around it.

9.1.3. Setting Clear Guidelines for Operators

Clear guidelines should be established for operators on how far in advance of the Tow-OBT their tasks should be completed. This will ensure that the tow-couple has adequate time to finalize pre-tow procedures between the completion of the last activity and the Tow-OBT. It is also recommended to distinguish between processes that need to be completed when the stair or bridge is removed, and those that must be finished when the blocks are cleared. This would create better understanding among operators and reduce conflicts, even when task allocation is carefully planned.

9.1.4. Establishing a Tow-Window

A TSAT-window for tow movements should be established based on the Tow-OBT, combined with data from Deep Turnaround cameras. As the Tow-OBT approaches, the cameras can detect the presence of the tug, removal of the bridge, and clearance of pylons. This data should trigger a Tow-Window for the apron controller, ground controller, and runway controller assistant, allowing them to anticipate the tow movement early, something that is currently very hard to do.

9.1.5. Predicting Tow Movement Arrival Times

It is recommended to integrate tow time formulas, similar to taxi-time formulas, into the OBT system. These formulas should predict the arrival time of the tow movement at its destination based on the aircraft and tug type, creating a Tow-IBT. In cases where the tow movement crosses a runway, it would be beneficial to predict when the movement will reach the crossing point, allowing the runway controller to account for it. Like the Tow-OBT, the Tow-IBT should be treated as an ACDM timestamp, ensuring all airport stakeholders can plan accordingly.

9.1.6. Applying Stricter APU Restrictions

Based on the Tow-OBT and IBT, stricter APU restrictions should be implemented, similar to the restrictions applied to flight OBT and IBT times. This will help reduce noise and CO_2 emissions at the airport.

9.1.7. Providing a Tow List to the Handyman

A list of all Tow-OBTs and IBTs should be made available to the handyman. This will allow him to know exactly where and when he can assist, thereby improving efficiency.

9.2. Short-term Recommendations

This section outlines the short-term recommendations, which can be implemented while the long-term recommendations are still in progress. These short-term actions aim to provide immediate improvements and operational benefits in the interim. These are presented in chronological order of implementation.

9.2.1. Raising Awareness Among Operators

Before a Tow-OBT is created that is transparent and accessible to all, and before guidelines are established for operators regarding how far in advance of the towing time they need to complete their tasks, it is recommended that awareness be raised among operators who already have access to the start towing time. This would help them understand how much time in advance they need to be ready, ensuring better preparation and smoother operations in the interim.

9.2.2. Utilizing Wilbur for Tow Movement Tracking

Before a Tow-IBT is implemented, it is recommended to make use of Wilbur, which provides an airside map for tracking tow movements based on the transponder of the tug, combined with the label created by the apron controller in CISS. While this does not directly generate a Tow-IBT, stakeholders can use this tool to estimate how long it will take for the tow to reach a specific location. Raising awareness about the availability and usage of Wilbur is crucial, as it is accessible to all airport personnel and can help enhance operational coordination.

Bibliography

AAS Gate Planner 1. (2024, October 18). AAS Gate Planning interview 1. (V. v. Dijk, Interviewer)

AAS Gate Planner 1. (2024, October 18). AAS Gate Planning interview 1. (V. v. Dijk, Interviewer)

AAS Gate Planner 2. (2024, October 18). AAS Gate Planning Interview 2. (V. v. Dijk, Interviewer)

Aircraft Allocation Coordinator. (2024, October 17). Aircraft Allocation Coordinator Interview. (V. v. Dijk, Interviewer)

Amsterdam Airport Online. (n.d.). *Discover Airlines and Terminals at AMS Airport*. Retrieved from airport.online: https://airport.online/amsterdam-schiphol/en/airlines-and-terminals

Angrosino, M. (2007). *Doing Ethnographic and Observational Research.* SAGE Publications Ltd. doi:https://doi.org/10.4135/9781849208932

Apron Controllers. (2024, October 18). Apron Controllers Summary.

Asadi, E., & Fricke, H. (2022). Aircraft total turnaround time estimation using fuzzy critical path method. *Journal of Project Managment*, 241-254. doi:doi: 10.5267/j.jpm.2022.4.001

Asito Task Allocator. (2024, November 1). Asito Interview. (V. v. Dijk, Interviewer)

Bi, J., Wang, F., Ding, C., Xie, D., & Zhao, X. (2022, February). The airport gate assignment problem: A Branch-and-Price Approach fow improving utilization of jetways. *Computers & Industrial Engineering, 164*. doi:https://doi.org/10.1016/j.cie.2021.107878

Brinkmann, S., & Kvale, S. (2015). *InterViews - Learning the Craft of Qualitative Research Interviewing.*

Cheng, Y. (1998, April 1). Solving push-out conflicts in apron taxiways of airports by a network-based simulation. *Computers & Industrial Engineering, 34*(2), pp. 351-369. doi:https://doi.org/10.1016/S0360-8352(97)00282-9

CHIP Expert. (2025, January 9). CHIP Interview. (V. v. Dijk, Interviewer)

Council of the European Union. (2001). Civil Aviation Security. Brussels. Retrieved from https://data.consilium.europa.eu/doc/document/ST-14082-2001-INIT/en/pdf

Dingemanse, K. (2021, October 26). *Observatie als methode in je scriptie | Uitleg & voorbeelden*. Retrieved from Scribbr: https://www.scribbr.nl/onderzoeksmethoden/observaties/

Du, J. Y., Brunne, J. O., & Kolisch, R. (2014, October). Planning towing processes at airports more efficiently. *Transportation Research Part E: Logistics and Transportation Review, 70*, 293-304. doi:https://doi.org/10.1016/j.tre.2014.07.008.

Dutch Safety Board. (2017). *Investigation into air traffic safety at Amsterdam Airport Schiphol.* Retrieved from onderzoeksraad.nl: https://onderzoeksraad.nl/en/onderzoek/investigation-into-air-traffic-safety-at-amsterdam-airport-schiphol/

Duty Flow Manager. (2024, October 31). Duty Flow Manager Interview. (V. v. Dijk, Interviewer)

EUROCONTROL. (n.d.-a). *Understanding Airport CDM > What is Airport CDM?* Retrieved from learningzone.eurocontrol.int: https://learningzone.eurocontrol.int/ilp/pages/wbtfullscreen.jsf?courseId=20789713&parentCourseId=0&mediaId=9819067&runningLanguage=en-GB&openMode=same-page&isOpenedFromSyllabus=true

EUROCONTROL. (n.d.-b). *Airport collaborative decision-making*. Retrieved from eurocontrol.int: https://www.eurocontrol.int/concept/airport-collaborative-decision-making

EUROCONTROL. (n.d.-c). *Airport CDM elements > Pre-departure Sequencing.* Retrieved from learningzone.eurocontrol.int: https://learningzone.eurocontrol.int/ilp/pages/wbtfullscreen.jsf?pollingMode=on&runningLanguage=en-GB&openMode=same-page&libraryItem=false&mediaId=9691874&courseId=20789713

EUROCONTROL. (n.d.-d). *Airport CDM elements > The Milestone Approach.* Retrieved from learningzonde.eurocontrol.int: https://learningzone.eurocontrol.int/ilp/pages/wbtfullscreen.jsf?pollingMode=on&runningLanguage=en-GB&openMode=same-page&libraryItem=false&mediaId=9691779&courseId=20789713

EUROCONTROL. (n.d.-e). *Milestone Approach for the turn-round process*. Retrieved from learningzone.eurocontrol: https://learningzone.eurocontrol.int/ilp/pages/wbtfullscreen.jsf?courseId=20789713&parentCourseId=&runningLanguage=en-GB&mediaId=9691766&libraryItem=false&openMode=same-page

EUROCONTROL. (n.d.-f). *Airport CDM Elements > Variable Taxi Time - Arrival Traffic*. Retrieved from learningzone.eurocontrol: https://learningzone.eurocontrol.int/ilp/pages/wbtfullscreen.jsf?pollingMode=on&runningLanguage=en-GB&openMode=same-page&libraryItem=false&mediaId=10217244&courseId=20789713

EUROCONTROL. (n.d.-g). *Airport CDM elements > Variable Taxi Time - Departure traffic*. Retrieved from learningzone.eurocontrol: https://learningzone.eurocontrol.int/ilp/pages/wbtfullscreen.jsf?pollingMode=on&runningLanguage=en-GB&openMode=same-page&libraryItem=false&mediaId=10217274&courseId=20789713

Fitouri-Trabelsi, S., Cosenza, C. A., Moudani, W. E., & Mora-Camino, F. (2014). Managing uncertainty at airport ground handling. *Airports in Urban Networks*. Retrieved from https://www.researchgate.net/publication/266963224_Managing_Uncertainty_at_Airports_Ground_Handling

Fricke, H., & Schultz, M. (2008). *Improving Aircraft Turn Around Reliability.* Institute of Logistics and Aviation. Retrieved from https://www.researchgate.net/profile/Michael-Schultz-20/publication/263038959_Improving_Aircraft_Turnaround_Reliability/links/56c719a708ae8cf82904319f/Improving-Aircraft-Turnaround-Reliability.pdf

Hangar Lead. (2024, November 26). Hangar Lead Interview. (V. v. Dijk, Interviewer)

Hogeschool van Amsterdam. (n.d.-a). *Professional Skills - Interviews.* Retrieved from Mijn HvA: https://dlo.mijnhva.nl/d2l/le/content/485015/viewContent/1584189/View

Hogeschool van Amsterdam. (n.d.-b). *Professional Skills - Descriptive Statistics*. Retrieved from mijnhva: https://dlo.mijnhva.nl/d2l/le/content/485015/Home

IATA. (2018). *AIRPORT – COLLABORATIVE DECISION MAKING (A-CDM): IATA RECOMMENDATIONS.* Retrieved from https://www.iata.org/contentassets/5c1a116a6120415f87f3dadfa38859d2/iata-acdm-recommendations-v1.pdf

IATA. (2023). *IATA Reference Manual for Audit Programs - Edition 13.*

ILT. (n.d.). *Gebruik hulpmotoren (Auxiliary Power Units)*. Retrieved from ilent.nl: https://www.ilent.nl/onderwerpen/schiphol/wet-en-regelgeving/apu-gebruik#:~:text=De%20auxiliary%20power%20unit%20(APU,de%20platforms%20en%20geven%20geluidsoverlast.

KCS Task Allocator. (2024, November 3). KCS Interview. (V. v. Dijk, Interviewer)

KLM. (2019-a, December 10). *Aviobrug - Luie trap*. Retrieved from MyKLM: https://myklm.klm.com/en/web/ps/aviobrug-luie-trap?_gl=1*1y7ziue*_ga*NzUxNDg5NjI1LjE2OTkwMDQwODY.*_ga_7LCW2B5FHB*MTczNzg4NzM2MC4xMzIuMS4xNzM3ODg3NTE5LjAuMC4w*_fplc*b1dHUlIwYnd6ZEtneCUyQjJrdTNlUGRHczRTRTclMkY3ZWhSZXNiRXE4eG5aeSUyQllDb2haJTJCUmpyZlJWR2J0TzY

KLM. (2019-b, September 5). *WPI - Hangaar*. Retrieved from MyKLM: https://myklm.klm.com/en/web/as/hangaar

KLM. (2021-a). *GOMS 4.11.5 Towing - Stersleep.* SPL/A3.

KLM. (2021-b). *GOMS 5.6 CDM - Collaborative Decision Making.*

KLM. (2021-c, November). *GOMS 4.3.3.2 Defuel Procedure.*

KLM. (2022-a, June 8). *WPI Towing - Positioning Tow*. Retrieved from myklm: https://myklm.klm.com/en/web/as/towing-positioning-tow

KLM. (2022-b, November 16). *KLM Cockpit Towing Checklist B737-700/800/900.* Retrieved from MyKLM: https://myklm.klm.com/documents/28883/5618515/CCL%20-%20B737%20-%20700%20800%20900.pdf

KLM. (2022-c, May 30). *Procedure - Waterservice*. Retrieved from MyKLM: https://myklm.klm.com/en/web/as/waterservice

KLM. (2023-a, September 22). *WPI Towing - Remote Holding*. Retrieved from myklm: https://myklm.klm.com/en/web/as/towing-remote-holding

KLM. (2023-b, June 1). *WPI Towing - Technische Sleep*. Retrieved from myklm: https://myklm.klm.com/en/web/as/towing-technische-sleep

KLM. (2023-c, September 28). *WPI Pushback*. Retrieved from myklm: https://myklm.klm.com/en/web/as/pushback1

KLM. (2023-d, November 20). *WPI - Handheld Terminal*. Retrieved from myklm: https://myklm.klm.com/en/web/as/hht-kn?_gl=1*73kvc5*_ga*NzUxNDg5NjI1LjE2OTkwMDQwODY.*_ga_7LCW2B5FHB*MTcyODkwMzQ5OS4yOS4xLjE3Mjg5MDQ3NDYuMC4wLjA.

KLM. (2023-e, November 28). *OCC & HCC organisatie*. Retrieved from MyKLM: https://myklm.klm.com/en/web/flight-ops/occ-hcc-organisatie?_gl=1*tivhs9*_ga*NzUxNDg5NjI1LjE2OTkwMDQwODY.*_ga_7LCW2B5FHB*MTczMzMwNTAwOC43Mi4xLjE3MzMzMDUwMTYuMC4wLjA.

KLM. (2023-f, May 8). *KLM Cockpit Towing Checklist B777-200/300ER.* Retrieved from MyKLM: https://myklm.klm.com/documents/28883/5617302/CCL%20-%20B777%20-%20200-300.pdf

KLM. (2023-g, May 4). *KLM Cockpit Towing Checklist B787-9.* Retrieved from MyKLM: https://myklm.klm.com/documents/28883/5617312/CCL%20-%20B787-9%20KLM.pdf

KLM. (2023-h, May 8). *KLM Cockpit Towing Checklist B747.* Retrieved from MyKLM: https://myklm.klm.com/documents/28883/13894139/CCL%20-%20B747%20-%20400%20ERF%20Martinair.pdf

KLM. (2023-i). *BCP - IT - CHIP - Uitval bij Regie.* Retrieved from https://myklm.klm.com/en/web/gs/bcp-it-chip-uitval-bij-regie

KLM. (2023-i). *Customer Support Manual Line Maintenance Panasonic Inflight Entertainment & Connectivity Systems.* Retrieved from https://myklm.klm.com/documents/28859/357122/Panasonic%20CSM%20Rev%2051%20December%2023.pdf/c7ccfe6c-80d7-e4c3-5f4d-1da14b71a2dc?version=1.0&t=1703236100000&_gl=1*qi0sid*_ga*NzUxNDg5NjI1LjE2OTkwMDQwODY.*_ga_7LCW2B5FHB*MTczNjAwMTE1NS45OS4xLjE3MzYwMDEyMzIuM

KLM. (2023-i, December 13). *WPI APU*. Retrieved from MyKLM: https://myklm.klm.com/en/web/as/apu

KLM. (2023-j, October 12). *WPI - Buffer procedure*. Retrieved from MyKLM: https://myklm.klm.com/en/web/as/buffer-procedure

KLM. (2024-a, May 23). *WPI - Werkzaamheden Shiftleader*. Retrieved from myklm: https://myklm.klm.com/en/web/as/werkzaamheden-shiftleader

KLM. (2024-b, September 5). *WPI - Checklist Tugdriver - Towbarless Slepen*. Retrieved from myklm: https://myklm.klm.com/en/web/as/checklist-tugdriver-towbarless-slepen

KLM. (2024-c, June 7). *WPI - Checklist Brake-Operator*. Retrieved from myklm: https://myklm.klm.com/en/web/as/checklist-brake-operator#Algemeen

KLM. (2024-d, May 23). *WPI Towing - Maintenance Tow*. Retrieved from myklm: https://myklm.klm.com/en/web/as/towing-maintenance-tow

KLM. (2024-e, March 19). *WPI Towing - Tow-in*. Retrieved from myklm: https://myklm.klm.com/en/web/as/towing-tow-in

KLM. (2024-f, March 19). *WPI Towing - Algemeen*. Retrieved from myklm: https://myklm.klm.com/en/web/as/towing-algemeen

KLM. (2024-g). *KLM GOM Ramp Handling 4.9 - Aircraft Towing.* SPL/A3.

KLM. (2024-h, July 12). *WPI - Handyman*. Retrieved from myklm: https://myklm.klm.com/en/web/as/handyman

KLM. (2024-i, June 24). *WPI Sleep & Pushback ATD Informatiepagina*. Retrieved from myklm: https://myklm.klm.com/en/web/as/wpi/sleep-pushback-atd-informatiepagina?_gl=1*e23ahv*_ga*NzUxNDg5NjI1LjE2OTkwMDQwODY.*_ga_7LCW2B5FHB*MTcyODg5OTAxNi4yOC4xLjE3Mjg5MDA5NzEuMC4wLjA.

KLM. (2024-j, May 30). *WPI - Dekens/kussens ICA*. Retrieved from MyKLM: https://myklm.klm.com/en/web/as/dekens-ica

KLM. (2024-k, September 2). *KZ - Cabin Security Search - NON-EU*. Retrieved from MyKLM: https://myklm.klm.com/en/web/as/kz-cabin-security-search-non-eu

KLM. (2024-l, September 2). *KZ - Cabin Security Search - TSA*. Retrieved from MyKLM: https://myklm.klm.com/en/web/as/kz-cabin-security-search-tsa

KLM. (2024-m, March 13). *WPI - Vliegtuig categorieën.* Retrieved from MyKLM: https://myklm.klm.com/en/web/as/vliegtuigcategorien

KLM. (2024-n, February 21). *KLM Cockpit Towing Checklist Embraer 175/190/195-E2.* Retrieved from MyKLM: https://myklm.klm.com/documents/d/as/embraer-175-190-195e2-pdf

KLM. (2024-o, December 2). *KLM Cockpit Towing Checklist A320.* Retrieved from MyKLM: https://myklm.klm.com/documents/d/as/a320-neo-pdf

KLM. (2024-p, May 28). *KLM Cockpit Towing Checklist A330-200/300.* Retrieved from MyKLM: https://myklm.klm.com/documents/d/as/ccl-a330-200-300-pdf

KLM. (2024-q, April 11). *WPI - Pre Departure Servicing Checklist*. Retrieved from MyKLM: https://myklm.klm.com/en/web/as/pdsc

KLM. (2024-r, October 30). *WPI PCA -unit - Algemeen*. Retrieved from MyKLM: https://myklm.klm.com/en/web/as/pca?_gl=1*85cug1*_ga*NzUxNDg5NjI1LjE2OTkwMDQwODY.*_ga_7LCW2B5FHB*MTczNzQ4ODY2Ny4xMjkuMS4xNzM3NDg4NzA5LjAuMC4w

KLM. (2024-s, April 8). *Boarding - ICA Instapprocedure*. Retrieved from MyKLM: https://myklm.klm.com/en/web/ps/boarding-ica-instapprocedure?_gl=1*153d0n1*_ga*NzUxNDg5NjI1LjE2OTkwMDQwODY.*_ga_7LCW2B5FHB*MTczNzg4NzM2MC4xMzIuMS4xNzM3ODg3MzY1LjAuMC4w*_fplc*b1dHUlIwYnd6ZEtneCUyQjJrdTNlUGRHczRTRTclMkY3ZWhSZXNiRXE4eG5aeSUyQllDb2haJTJCUmpyZ

KLM. (2024-t, August 13). *KZ - Cabinestroom en Verlichting*. Retrieved from MyKLM: https://myklm.klm.com/en/web/as/kz-cabinestroom-en-verlichting

KLM. (2024-u, May 15). *Boardsupplies - Kluh*. Retrieved from MyKLM: https://myklm.klm.com/en/web/as/kz-boardsupplies-kluh

KLM. (2024-u). *GOMS 3.5.3. Aircraft Security Search.*

KLM. (2024-v, October 4). *WPI - Toiletservice*. Retrieved from MyKLM: https://myklm.klm.com/en/web/as/toiletservice

KLM. (2024-w). *Normentraject sleeptaken.*

KLM. (n.d.-a). *Job Profile Preview - Duty Flow Manager Apron Services.*

KLM. (n.d.-b). *Job Profile Preview - Aircraft Allocation Coordinator.*

KLM. (n.d.-b). *Tankdienst*. Retrieved from MyKLM: https://myklm.klm.com/en/web/as/wpi-tankdienst

Klüh Task Allocator. (2024, November 1). Klüh Interview. (V. v. Dijk, Interviewer)

Lead Ground Engineer. (2024, November 5). KLM's Technical Service Interview. (V. v. Dijk, Interviewer)

LVNL. (2024-b, December 6). *DIV - OM - Ground Control - Sleepverkeer.*

Meijer, G. (2021). *Fundamentals of Aviation Operations.* Routledge.

More, D., & Sharma, R. (2014, October 8). The turnaround time of an aircraft: a competitive weapon for an airline company. *Decision, 41*, 489-497. doi:https://doi.org/10.1007/s40622-014-0062-0

Morgan, D. L. (1996). Focus Groups. *Annual Review of Sociology, 22*, pp. 129-152. doi:https://doi.org/10.1146/annurev.soc.22.1.129

MovingDot. (n.d.). *Service Owner Pushback And Towing*. Retrieved from movingdot.nl: https://www.movingdot.nl/nl/portfolio/airports/service-owner-pushback-and-towing/

MovingDot; NLR. (2019). *Managing of Turnaround Priorities for Schiphol Airport.* KDC. Retrieved from https://kdc-mainport.nl/wp-content/uploads/2019/09/Managing-of-Turnaround-Priorities-report-MD-NLR-v1.0.pdf

Nieuwenhuisen, D., & Welman, C. (n.d.). *Applications of SWIM.* National Aerospace Laboratory NLR. Retrieved from https://kdc-mainport.nl/wp-content/uploads/2016/06/KDC-Applications-of-SWIM-final-report-1.1.pdf

Oxford Creativity. (2022). Retrieved from triz.co: https://www.triz.co.uk/what-is-triz?hsCtaTracking=751698eb-f22c-4069-8636-cb81e499eb57%7C601a5397-3edf-4cc8-a6be-61552194f993

Park, D. K., & Kim, J. K. (2023, January). Influential factors to aircraft taxi time in airport. *Journal of Air Transport Management, 106*. doi:https://doi.org/10.1016/j.jairtraman.2022.102321

Parkinson, C. N. (1955, November). *Parkinson's Law.* Retrieved from berglas: https://www.berglas.org/Articles/parkinsons_law.pdf

Quixy Editorial Team. (2024, August 16). *Business Process Mapping: Definition, Steps and Tips*. Retrieved from Quixy: https://quixy.com/blog/business-process-mapping/#1-process-flowchart

Ravenswaaij, C. v., The, J., & Brown, S. (2017). *Functional Analysis of Schiphol TWR-C.* MovingDot. Knowledge and Development Centre Mainport Schiphol. Retrieved from https://kdc-mainport.nl/wp-content/uploads/2018/05/Rapport-Functional-Analysis-SPL-TWR-C-v1.0.pdf

Reddi, L. T. (2023, April 14). *Stakeholder Analysis using the Power Interest Grid*. Retrieved from Project Management: https://www.projectmanagement.com/wikis/368897/stakeholder-analysis--using-the-power-interest-grid

Royal Schiphol Group. (2023). *Royal Schiphol Group in 2023.* Retrieved from https://assets.ctfassets.net/biom0eqyyi6b/6K9DrZHqFBVAfxqgi3C6PE/c35615bcdd787614cc7686c866d136c3/Royal_Schiphol_Group_in_2023.pdf

Runway Controller Assistant. (2025, January 22). Runway Controller Assistant Interview. (V. v. Dijk, Interviewer)

Scardaoni, M. P., Magnacca, F., Massai, A., & Cipolla, V. (2021). Aircraft turnaround time estimation in early design phases: Simulation tools development and application to the case of box-wing architecture. *Journal of Air Transport Management, 96*. doi:https://doi.org/10.1016/j.jairtraman.2021.102122

Schiphol. (2020, February 24). *De vooruitziende blik van Wilbur*. Retrieved from Schiphol.nl: https://www.schiphol.nl/nl/innovatie/blog/de-vooruitziende-blik-van-wilbur/

Schiphol. (2023). *Deel 1.1.1 Toegang tot Airside.* Retrieved from https://www.schiphol.nl/nl/download/b2b/1644827565/1YGUnL6FPiuwK8CyGeImMI.pdf

Schiphol. (2023, February 7). *Waarom wordt mijn paspoort niet altijd gecheckt?* Retrieved from Schiphol.nl: https://www.schiphol.nl/nl/blog/waarom-wordt-mijn-paspoort-niet-altijd-gecheckt/

Schiphol. (2024, February 6). *A-CDM Manual Schiphol Airport.* Retrieved from https://www.schiphol.nl/en/download/b2b/1711035334/7ERl8iHeLELDtgFsnK0mGi.pdf

Schiphol. (2024-a). *RASAS - Regulation Aircraft Stand Allocation Schiphol.* Retrieved from https://www.schiphol.nl/en/download/b2b/1554102691/1h2NOsKSncc2uywE8OE02W.pdf

Schiphol. (2024-b). *RASAS zones Winter season 2024/25.* Retrieved from Schiphol.nl: https://www.schiphol.nl/en/download/b2b/1620628576/1uCUwsKIchMdy1nQHX13hI.pdf

Schiphol. (2025, January 7). *66,8 miljoen in 2024 – aantal reizigers op Schiphol neemt verder toe*. Retrieved from nieuws.schiphol.nl: https://nieuws.schiphol.nl/66-miljoen-in-2024-aantal-reizigers-op-schiphol-neemt-verder-toe/#:~:text=Van%20de%2066%2C8%20miljoen,ruim%2012%20miljoen%20unieke%20transferpassagiers.

Schiphol. (n.d.). *Collaborative Decision Making*. Retrieved from Schiphol.nl: https://www.schiphol.nl/en/operations/page/cdm/

Schiphol. (n.d.). *Deep Turnaround - Get a grip on turnaround management*. Retrieved from Schiphol.nl: https://www.schiphol.nl/en/aviation-solutions/deep-turnaround/

Schmidt, M. (2017). A review of aircraft turnaround operations and simulations. *Progress in Aerospace Sciences, 92*, pp. 25-38. doi:10.1016

Service Owner Aircraft. (2023). *Deel 1.2.2. Radiotelefonie (RT).* Retrieved from https://www.schiphol.nl/nl/download/b2b/1645096232/6zUHzF7Xik3DOxMF8rBssK.pdf

Service Owner Aircraft A/AO&AP. (2024). *Uitvoeren sleepbewegingen Deel 1.2.4.*

Skybrary. (n.d.-a). *Aircraft Towing*. Retrieved from skybrary.aero: https://skybrary.aero/articles/aircraft-towing

Skybrary. (n.d.-b). *Pushback*. Retrieved from Skybrary.aero: https://skybrary.aero/articles/pushback

Skybrary. (n.d.-c). *Brakes*. Retrieved from Skybrary.aero: https://skybrary.aero/articles/brakes

Skybrary. (n.d.-d). *Aircraft Bleed Air Systems*. Retrieved from Skybrary.aero: https://skybrary.aero/articles/aircraft-bleed-air-systems

Soltani, M., Ahmade, S., Akgunduz, A., & Bhuiyan, N. (2020, December). An eco-friendly aircraft taxiing approach with collision and conflict avoidance. *Transportation Research Part C: Emerging Technologies, 121*. doi:https://doi.org/10.1016/j.trc.2020.102872

Woerkom, K.-J. v. (2024, January 26). *Stuivertje wisselen in top-10 grootste luchtvaartmaatschappijen op Schiphol*. Retrieved from luchtvaartnieuws.nl: https://www.luchtvaartnieuws.nl/nieuws/categorie/3/airports/stuivertje-wisselen-in-top-10-

grootste-luchtvaartmaatschappijen-op-schiphol#:~:text=KLM%20is%20nog%20altijd%20de,wel%20een%20kleine%20stoelendans%20plaatsvond.

World Health Organization. (2009). *Guide to Hygiene and Sanitation in Aviation.* Geneva. Retrieved from https://www.icao.int/safety/aviation-medicine/Suggested%20Literature/guide_hygiene_sanitation_aviation_3_edition.pdf

Yin, R. K. (2014). *Case Study Research Design and Methods.*

Yunita, T. (2009). *Managing effective and efficient hub operations: a study of ground time management.* Technische Universiteit Eindhoven. Retrieved from https://pure.tue.nl/ws/files/4325424/643240.pdf

Zadelhoff, J. v. (2024). *Handboek DFM.*