Appendix

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- A.1 Approach for data collection and analysis across different studies
- A.2 Participant selection
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A

A.1 Approach for data collection and analysis across different studies

A.1.1 Data collection and analysis of observations
During the observations and conversations held with participants, the researcher has made notes. These notes were used for data analysis. In the SURFdrive, the collected data is stored in the folder named initial observations. The data consists of notes taken during and right after the shadow shifts and unstructured conversations with the different participants.
The data was analyzed using the analysis on the wall method, which is especially useful for collecting insights from research results with different forms and that are not structured [53]. By formulating the insights onto post-its and clustering these insights into themes. This was done in the online FigJam tool.

A.1.2 Data collection and analysis of interview transcripts
The interview transcripts can be found in the SURFdrive, in the folder called Research Transcripts - In-depth Interviews. The interviews were held in Dutch; therefore, the transcripts are also in Dutch.
For the semi-structured interviews, two different interview guides were used, and the interviews were conducted by one researcher. The interviews are audio-recorded and transcribed. Furthermore, the researcher collects some personal information, including the expertise level and job title.
All the data collected during the context research was analyzed using reflexive thematic analysis [10]. Analysis was conducted by the main researcher according to the following workflow based on the work of Braun and Clarke [11]:

- Eliminate errors in the auto-transcription
- Read the full transcription (familiarization)
- Start coding across entire dataset by grouping quotes in codes and code groups
- Search for themes and sub-themes
- Review themes and sub-themes
- Define and name themes
- Write and finalize analysis

Credibility was optimized by applying triangulation. The data and coding process will be supervised by two additional researchers.

A.2 Participant selection

For the selection of participants , we have used purposeful sampling, more specifically key informants sampling [48]. The key informants are employees of RSG with responsibilities regarding the management of the arrival passenger flow at Schiphol Airport.Besides the data mentioned above, we have collected data regarding the seniority (i.e.,experience years) of the interviewees, but this was not a criterion for recruitment. Note that the main researcher has direct access to the company as well as its intranet and documentation. The researcher came by the workplace of the key informants at a moment approved by the manager and asked potential participants in person after explaining the purpose and practicalities of the study (i.e., purposeful sampling).

The voluntary and anonymous nature of participation was highlighted to the participants. And to protect anonymity, the possibility to backtrace quotes to specific participants was minimized by only showing the function title and experience level of participants in the final report.

For the recruitment of the FLM, a similar approach was followed. For the Marechaussee, recruitment was more challenging. And the desired participants, the OKP employees, were not interviewed as there was no permission given for this. To account for this perspective, another employee of the Marechaussee was interviewed, who currently is not working in this function anymore, but previously has performed this role.

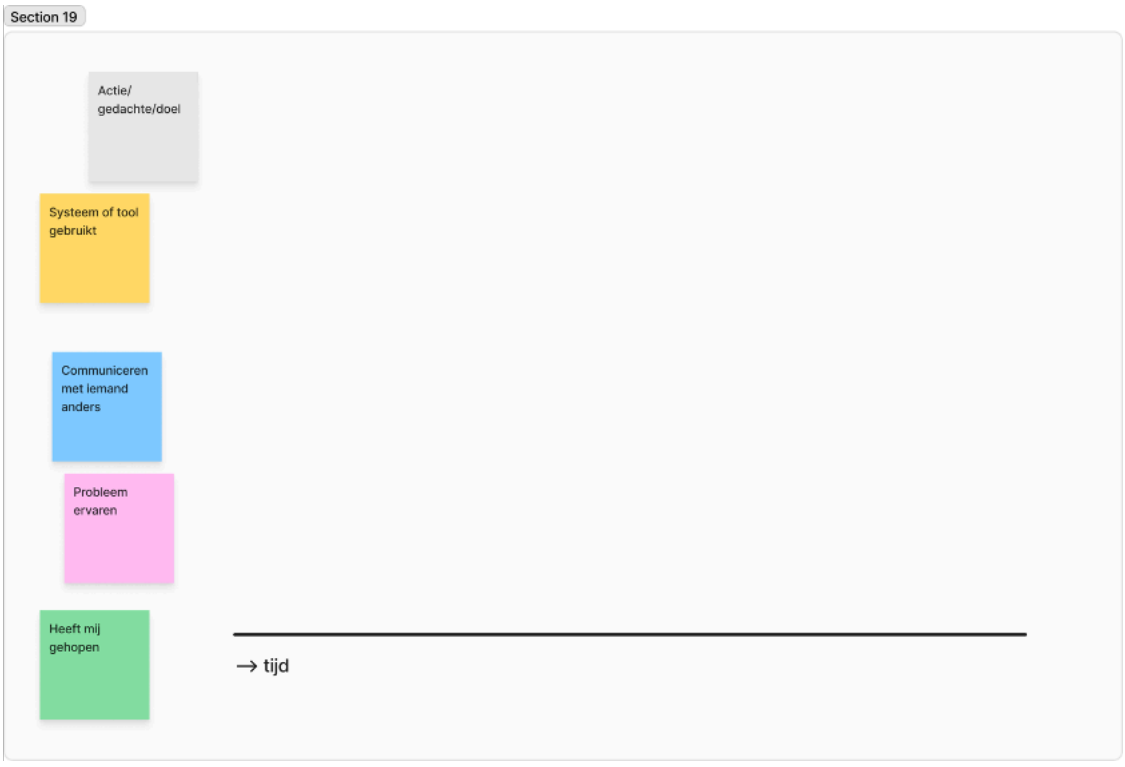
A.3 Ethics and anonymity of participants

This study was approved by the TU Delft Human Research Ethics Committee (reference number 4838). None of the authors had any hierarchical relation with the participants before the study. All participants were given an informed consent form, which was presented by the first author and signed before the interview. Participants were informed that participation was voluntary and withdrawal could be made at any point. Opinions expressed during the interview were confidential and anonymised, allowing participants to speak freely.

A.4 Interview guides and materials used

A.4.1 Interview guide PC PAX

(1) Introduction of the research and researchers
(2) Inform the participant about anonymity, and make sure to sign consent form.
(3) Icebreaker question: how areyou doing?
(4) Can you explain about your function and your role in PAX flow management in the arrival process?
(5) Please think about a recent situation where you had to apply flow balancing? Can you elaborate on this situation, starting from the moment you noticed a problem might occur towards the problem was completely resolved. The participant is asked to write this information down on post-its and stick those on the printed template, which can be seen in the Figure below. During the description of the process, the researcher will ask questions to guide the participant through the process. And once the participant is finished, some of the following questions will be asked to probe for richer information. Follow-up questions:
(a) What triggered you to start collecting more information?
(b) What information did you receive and include? Where did you retrieve the information from?
(c) How did you notice that an action might be needed?
(a) Which stakeholders are involvedin this process? Which information do you exchange with these stakeholders and through whichchannels?
(b) How is your relationship with these stakeholders?
(c) What were your specific goals in this situation?
(d) How did you determine the groups to flow balance and the destination?
(e) What problems did you encounter during the process?
(2) Do you have any final remarks or other comments that you think could be relevant?



A.4.2 Interview Guide for kMar and FLM

(1) Introduction of the research and researcher
(2) Icebreaker question: How are you doing?
(3) Inform the participant about anonymity, and make sure to sign consent form.
(4) Can you explain about your function and your role in PAX flow management in the arrival process?
(5) Wat is voor jullie belangrijk in de communicatie met de andere actoren (PC PAX and kMar or FLM)? Possible follow-up questions:
(a) Op welke manier wordt er gecommuniceerd?
(b) Welke informatie willen jullie ontvangen?
(c) Welke informatie willen jullie geven?
(d) Hoe zou de communicatie verbeterd kunnen worden?
(6) Zou je een concreet voorbeeld kunnen geven van een situatie waarin jullie de samenwerking slecht vonden? En wat, in jouw beleving, zorgdeer toen voor dat de samenwerking slechtwas?
(7) Zou je een concreet voorbeeld kunnen geven van een situatie waarin jullie de samenwerking juist heel goed vonden? En wat, in jouw belevingzorgde er toen voor dat de samenwerking goed was?
(8) Wat is het belangrijkste voor jullie bij het aankomstproces van passagiers? Waar moet een dag aan voldoen om het succesvol te laten zijn?
(9) Do you have any final remarks or other comments that you think could be relevant?

A.4.3 Workshop with designers

The purpose of this study is to formulate guidelines to improve the likelihood of adoption of a DSS in the multi-stakeholder system. To formulate these guidelines, we first aim to design interactions that could address the adoption barriers and subsequently formulate the guidelines.

From two different sources, input was gathered for the ideation of scenarios, first from literature. Several papers where similar adoption barriers are discussed have already proposed solutions for overcoming these barriers, from which inspiration was taken. This is explained later in this section.

And the second source was a workshop that was organized with system developers. This workshop was organized with two aims:

1. Validation and iteration on the potential adoption barriers in the context
2. Receiving input from the DSS developers for potential solution directions for the adoption barriers

The feedback received and discussion that took place during the workshop has resulted in an iteration on the adoption barriers. The barriers, as presented in the previous section, are the final version. An additional goal of this feedback and iteration moment was to make sure the design and development team of Wilbur and ADM are taken along in the process, which should result in more adherence to the project and its outcomes. This adherence is important to the researchers, as this should increase the chances of the organizations actually gaining benefits from this research.

Second aim of the workshop was to gain inspiration and ideas for addressing the identified potential adoption barriers. The system developers were chosen to participate in this workshop as they are fully embedded in the context, which was found to be valuable next to the solutions from the literature.

The research questions we aimed to answer in this workshop are the following:

1. Do the participants recognize the phrased adoption barriers in the context?
2. What improvements can be made to the adoption barriers based on the experience of the participants?
3. What would be ideas for user-DSS interactions and the stakeholder interactions to account for the potential adoption barriers?

Four system developers are recruited for this workshop. This is a difficult-to-access group, as the group is small and has little time available. Therefore, only one workshop session was organized. The participants are listed in Table 3.

This group has been chosen because of their knowledge about ADM and the different stakeholders. As the context is complex and specific, we have chosen to involve the system experts in this workshop as they have the knowledge about the limitations and boundaries of the system.

In the figure below the different steps taken during the workshop are visualized as well as the composition of participants during the different steps as some steps were executed individually and some in groups.

During the workshop, participants were presented with the three potential adoption barriers with explanations; this was shown on slides presented by the researcher. These slides are added in on the next page.

For the brainwriting activity, post-its and pens were handed out. And for the activity of formulating design directions, a template was printed out that the participants could fill in. This template is also added in on the next page.

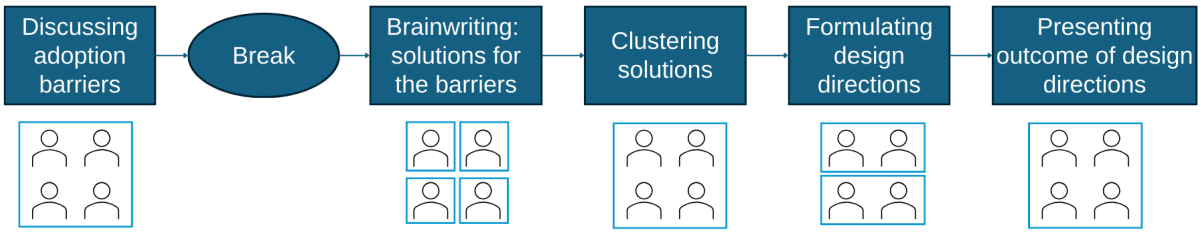
For the data collection, the researcher made notes during the session of the group discussion. Furthermore, the post-its and how they were clustered were photographed, and the filled-in templates were collected as data. In the SURFdrive, the collected data is stored in the folder named initial observations.
The data was analyzed using the analysis on the wall method. By formulating the insights onto post-its and clustering these insights into themes.

A.4.4 Interview guide for validation sessions with key users of the DSS
The study will employ semi-structured interviews with DSS designers. First the goal and purpose of the guidelines is explain, before participants will be presented with the guidelines and asked:

How would you use these guidelines in your current work or project? Do you maybe think of changes that you would make?
How do you envision these guidelines assisting you?
When do you envision yourself using or referring to these guidelines?
And what format would be appropriate for these guidelines?
What improvements do you think could be made to these guidelines to enhance their usability?

The design of this study is based on the validation method used by Cila et al. [16] ; also, inspiration was taken from Uga [70] to make participants think about how they would apply the guidelines in practice. All participants have experience in designing or being involved in the design process of DSS. Therefore they are familiar with the context and to some extend the content of the guidelines and extensive sensitizing was found to be unnecessary. Merely the purpose and aim of the guidelines was explained to participants.

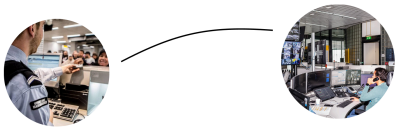
Characteristics	Distribution
Gender	2 Male, 2 Female
Occupation	2 Designers, 2 other roles within design team
Experience level	1 junior (0 - 5 years), 1 medior (5 - 10 years), 2 seniors (10+ years)



A.4.5 Slides with adoption barriers as presented during workshop

slide 1

Different goals for flow balancing



Huidige situatie

- OKP wil de paspoortcontroles zorgvuldig uitvoeren om de veiligheid te waarborgen.
- PC PAX daarentegen wil dat passagiers zo snel mogelijk door de filters gaan om de doorstroom te optimaliseren.
- Vanwege hun verantwoordelijkheid voor de kwaliteit van de controles wil OKP invloed hebben op de beslissingen rondom flowbalancing. Op dit moment wordt deze invloed niet door alle PC PAX volledig geaccepteerd, wat spanningen veroorzaakt tussen beide partijen.

O12: "The Marechaussee operates on person-to-person trust. Don't want to put agreements on paper. After the formal briefing the real story comes."

O10: "Marechaussee wants to have insight and a voice in flow balance actions taken, because it matters to them from which filter is forwarded to which filter."

Effect ADM

- ADM heeft als hoofddoel het verbeteren van de doorstroom van passagiers, wat in lijn is met het doel van PC PAX.
- Hierdoor kan ADM de positie van PC PAX versterken, omdat zij met behulp van objectieve data hun keuzes voor flowbalancing beter kunnen onderbouwen.
- Echter, ADM houdt geen rekening met de veiligheidsdoelstellingen en operationele uitdagingen van OKP.

Adoptiebarriere

- De introductie van ADM kan leiden tot een verdere verslechtering van de (informele) relatie tussen PC PAX en OKP. Waardoor ook het delen van informatie over de bezetting van de kMar kan verminderen, aangezien dit nu gebeurd op basis van informele relaties.
- En dit kan ertoe leiden dat OKP de aanbevelingen van ADM als een bedreiging ziet voor hun veiligheidsprioriteiten en zich in hun autonomie aangetast voelen.

Waarom is dit een probleem?
Een goede samenwerking tussen PC PAX en OKP is cruciaal, aangezien OKP direct invloed heeft op zowel de doorstroom als de veiligheid van passagiers. Wanneer de relatie tussen beide partijen verstoord is, kan dit leiden tot inefficiënte processen en een verminderde effectiviteit van zowel de doorstroom als de veiligheidscontroles.

slide 2

Using subjective information

Huidige situatie

- PC PAX gebruikt nu zowel objectieve informatie (uit Wilbur) als subjectieve informatie (van camerabeelden, OKP en FLM) over bijvoorbeeld toekomstige bezetting van kMar, meningen van FLM, uitvoerbaarheid van acties en eigen ervaring.

PC PAX P2: The occupancy of the kMar on arrival filter 2 was not optimal. (...) So if you see that somewhere is going to be very busy, you can use the cameras to confirm or contradict that. Because sometimes the numbers are correct, but then the throughput time is so fast at a filter (...) and sometimes you don't even need to flow balance then.

PC PAX O2: Looking on cameras to check throughput on filters, as this does not always depend only on number of posts open. (...) Also look at origin of a flight, to estimate what kind of passengers they are. And discuss with FLM occasionally. Based on that determine how fast passengers go through the filters.

Effect ADM

- Met ADM wordt de objectieve data door een algoritme geanalyseerd en komt er een aanbeveling voor flow balancing, die de eerder genoemde subjectieve informatie niet meeneemt.

Adoptiebarriere

- PC PAX vertrouwt de voorspelling en voorgestelde acties niet (of minder), omdat eerder genoemde subjectieve factoren niet worden meegenomen.
- Als ADM-advies en FLM-advies botsen, moet PC PAX kiezen, wat de relatie tussen deze twee partijen kan schaden of de adoptie kan beperken.

Waarom is dit een probleem?
Als PC PAX de aanbevelingen van ADM niet volledig vertrouwt dan is de kans dat zij het systeem gaan gebruiken erg klein.
De relatie tussen PC PAX en FLM is belangrijk om te behouden omdat FLM deels verantwoordelijk zijn voor de uitvoering van de beslissingen en daarom is het belangrijk dat ze hier ook achter staan.

slide 3

Accuracy of ADM recommendations

Huidige situatie

- De informatie over de verwachte bezetting van de kMar, een essentiële factor voor het voorspellen van de drukte in de filters, is voor PC PAX slechts gedeeltelijk beschikbaar. De Marechaussee beschouwt deze gegevens als gevoelig en deelt ze daarom formeel niet met Schiphol.
- Hoewel er op dit moment beperkte informatie wordt verstrekt via informele relaties, is formele datadeling en verwerking hiervan door Schiphol niet akkoord.
- Daarnaast varieert de kwaliteit van de uitvoering van flowbalancing-acties door PA's aanzienlijk, vanwege verschillen in hun bekwaamheid en verantwoordelijkheid.

FLM P6: So it's up to you as floor manager to take that into account as well. And then to point out to the PA that you should listen carefully to your radio, because we are now entering a peak and it is important that when you are called to stop, you stop immediately.

kMar P10: Marechaussee indicates whether capacity could cause a bottleneck that day or not, capacity is not communicated in exact numbers.

Effect ADM

- Het ADM-systeem heeft accurate input over de kMar-bezetting nodig om een realistische voorspelling van de drukte in de filters te maken.
- Wanneer deze input ontbreekt of onbetrouwbaar is, zullen de voorspellingen en aanbevelingen van ADM mogelijk niet aansluiten op de werkelijke situatie.
- Bovendien worden aanbevelingen gebaseerd op het verwachte effect van flowbalancing-acties. Als deze acties door PA's niet zoals verwacht worden uitgevoerd, ontstaat een verschil tussen wat ADM voorspelt en wat er daadwerkelijk gebeurt.

Adoptiebarriere

- Wanneer de voorspellingen en aanbevelingen van ADM inconsistent of onbetrouwbaar blijken te zijn, kan dit leiden tot een gebrek aan vertrouwen bij PC PAX.
- Zonder vertrouwen in de adviezen kan de bereidheid om ADM te gebruiken laag zijn.
- Dit beperkt niet alleen de adoptie van het systeem, maar ook de mogelijkheid om de beloofde voordelen van ADM, zoals betere doorstroming en efficiëntere controleprocessen, te realiseren.

A.4.6 Template used during workshop

How might we ...? *(What problem do we want to solve?)*
What do we want to achieve? *(what is the key outcome we aim to achieve?)*
What are different ideas to achieve this? *(What are some possible solutions for achieving this outcome?)*
Who should be involved in this?
When and where should this be implemented?

A.4.7 Materials used during validation sessions

Guidelines for integration in multi-stakeholder system

Insight in decision making process
Flow processor and decision executors should be able to know which decisions are made and what the reason for these decisions is, to enable them to pursue their operational goals.

Have opportunity to voice desires
Flow processor and decision executors should have the opportunity to give input and voice their desires supporting their goals during the decision making process, at an early stage where the initial plan is made, but also right before the execution.

At standard interaction moments
Flow processor and decision executors should have standard interaction moments, that fit within their and the decision makers current workflows and are formally agreed on.

Discussing options for integral benefit
Decision makers should discuss different decision options with flow processor and decision executors to reach a consensus about a decision that has integral benefits.

Guidelines for user interaction design

Make plan before crucial moment
The DSS should enable decision makers to make an initial decision plan and record this in the DSS before the critical moments, that can be adjusted in case of large changes in predictions.

Show consequences of decisions beforehand
The DSS should provide decision makers with the option to simulate the consequences of flow balancing decisions through simulation of the effects and therefore select the most effectiv…

Altering in case of possible change of plan
DSS should filter changes according to relevance on previously made plan and only alerts decision maker in case it might require reconsideration of the plan.

Explanation of reasoning for decision made
DSS should provide explanations to decision makers that explain why decisions are taken, based on the effect these decisions on the situation.

Confidence in predictions is shown
The DSS should show the quality of the predictions made based on the quality and certainty of the data input used that should enable decision makers to determine whether they can trust the recommendations made.

Gathering subjective insights
The DSS should stimulate decision makers to gather subjective insights, either from their own experience or from stakeholders, helping them to maintain their contextual awareness.

Non-crucial moments for entering insights
The DSS should make sure decision makers can enter contextual insight at non-crucial moments, to ensure this does not disrupt their workflow.

Give feedback after decision-making
The DSS should enable decision makers to give feedback on the recommendations generated by ADM after peak moment has passed, which are used to improve the algorithm further.

A.5 Approved project brief

TU Delft

IDE Master Graduation Project

Project team, procedural checks and Personal Project Brief

In this document the agreements made between student and supervisory team about the student's IDE Master Graduation Project are set out. This document may also include involvement of an external client, however does not cover any legal matters student and client (might) agree upon. Next to that, this document facilitates the required procedural checks:

- Student defines the team, what the student is going to do/deliver and how that will come about
- Chair of the supervisory team signs, to formally approve the project's setup / Project brief
- SSC E&SA (Shared Service Centre, Education & Student Affairs) report on the student's registration and study progress
- IDE's Board of Examiners confirms the proposed supervisory team on their eligibility, and whether the student is allowed to start the Graduation Project

STUDENT DATA & MASTER PROGRAMME

Complete all fields and indicate which master(s) you are in

Family name	Cleton
Initials	S.H.
Given name	Sophie Huguette
Student number	4838300

IDE master(s) IPD ☐ DfI ☐ SPD ✔

2nd non-IDE master

Individual programme *(date of approval)*

Medisign ☐

HPM ☐

SUPERVISORY TEAM

Fill in he required information of supervisory team members. If applicable, company mentor is added as 2nd mentor

Chair	Alessandro Bozzon	dept./section	Sustainable Design Engineering
mentor	Garoa Gomez Beldarrain	dept./section	Design, Organisation and Strategy
2nd mentor	Carien de Heus		
client:	Royal Schiphol Group		
city:	Schiphol	country:	The Netherlands
optional comments			

! Ensure a heterogeneous team. In case you wish to include team members from the same section, explain why.

! Chair should request the IDE Board of Examiners for approval when a non-IDE mentor is proposed. Include CV and motivation letter.

! 2nd mentor only applies when a client is involved.

APPROVAL OF CHAIR on PROJECT PROPOSAL / PROJECT BRIEF -> to be filled in **by the Chair** of the supervisory team

Sign for approval (Chair)

Name Prof. A. Bozzon Date 17/10/2024 Signature 

CHECK ON STUDY PROGRESS

To be filled in **by SSC E&SA** (Shared Service Centre, Education & Student Affairs), after approval of the project brief by the chair. The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total _____ EC

Of which, taking conditional requirements into account, can be part of the exam programme _____ EC

	YES	all 1st year master courses passed
	NO	missing 1st year courses

Comments:

Sign for approval (SSC E&SA)

Name _____ Date _____ Signature _____

APPROVAL OF BOARD OF EXAMINERS IDE on SUPERVISORY TEAM -> to be checked and filled in by IDE's Board of Examiners

Does the composition of the Supervisory Team comply with regulations?

YES		Supervisory Team approved
NO		Supervisory Team not approved

Comments:

Based on study progress, students is …

	ALLOWED to start the graduation project
	NOT allowed to start the graduation project

Comments:

Sign for approval (BoEx)

Name _____ Date _____ Signature _____

Personal Project Brief – IDE Master Graduation Project

Name student Sophie Cleton **Student number** 4838300

PROJECT TITLE, INTRODUCTION, PROBLEM DEFINITION and ASSIGNMENT

Complete all fields, keep information clear, specific and concise

Project title Investigating adoption of DSS in a multi-stakeholder system: a case study in flow management at

Please state the title of your graduation project (above). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

Introduction

Describe the context of your project here; What is the domain in which your project takes place? Who are the main stakeholders and what interests are at stake? Describe the opportunities (and limitations) in this domain to better serve the stakeholder interests. (max 250 words)

Automation of work is a rising trend in many organisations, for example decision support systems (DSS) that have the capability to automate or augment decision-making processes. Many organisations invest resources into the development of these systems, but despite the promised benefits of the systems the adoption is still lacking. Royal Schiphol Group (RSG) is developing different DSSs to improve processes in their operation. Due to the limited space and rising amount of passengers, Schiphol is often running into capacity problems, therefore an augmenting DSS promises a valueable application to support in solving these problems. For instance, we take into account the Passenger's Arrival flow, where the capacity of space is limited in and around the arrival filters (AF). In the AF the Royal Marechaussee (KMar) perform passport checks, in changing speeds, additionally due to flight schedules passengers arrive in peaks, both causing large queues in the terminal.
Process Coordinator Passenger (PC PAX), working in the Airport Control Center (ACC), are responsible to coordinate the passenger flows in the airport, their goal is to reduce the amount of fire safety norm incidents and to minimize waiting and walking time for passengers in the airport. Currently, they control passenger flows by rerouting selected groups of people to different AFs, a management measure called: flow balancing. Flow balancing is performed within Wilbur, an inhouse developed software-product, that uses a range of predictive and realtime datasources to show crowdiness of passengers in certain areas. See image 1 for the arrival flow for passengers.
RSG wants to use augmented decision making in Wilbur in the decision making to control crowdiness in the AFs, providing PC PAX with several recommendations of possible flow balancing actions and a simulation that shows the effect of certain options. This should optimize the effect on the passenger flow through the arrival filters, decreasing the waiting or walking time for passengers and improving the work of PC PAX.
This specific context will be used as a case study to investigate the adoption issue of DSS. See image 2 for an overview of the current stakeholder system.

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introduction (continued): space for images

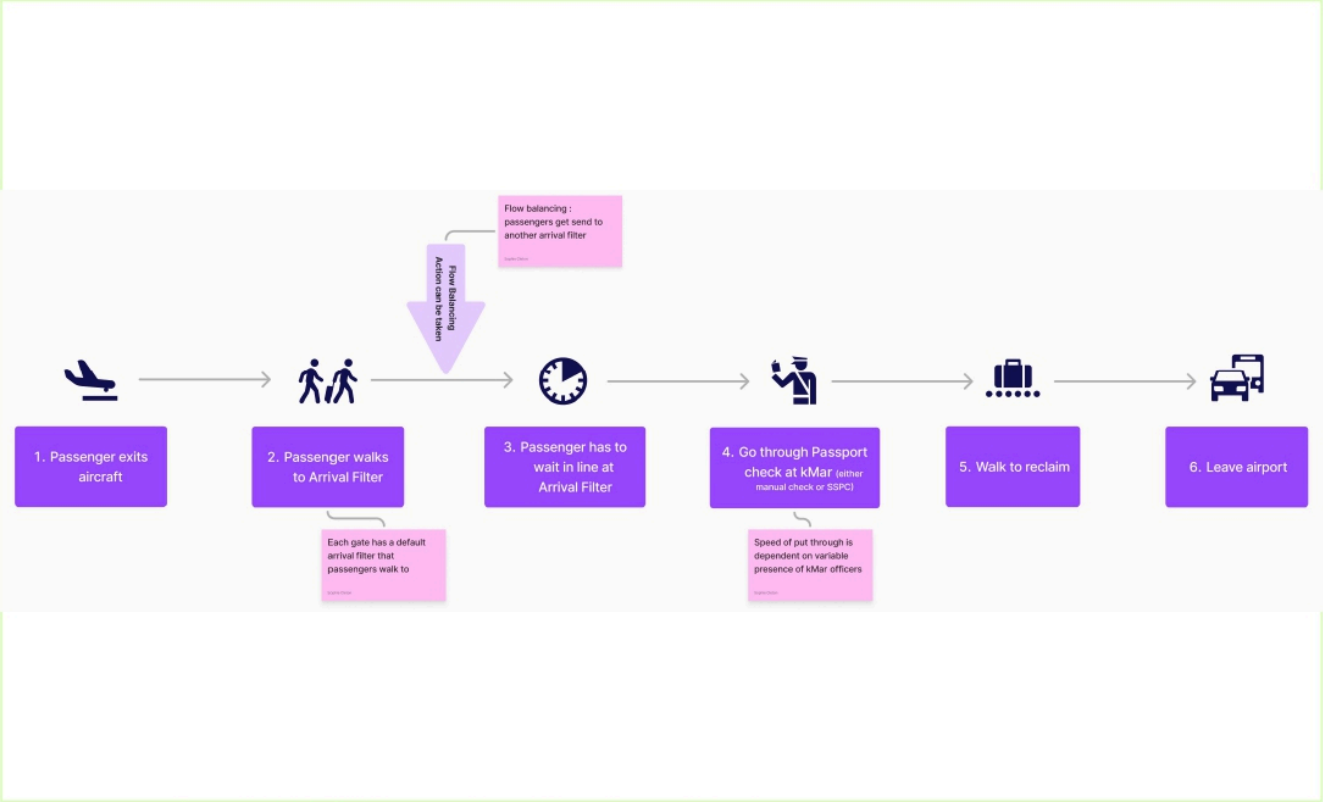

image / figure 1 Landside PAX Flows and Flowbalancing explained

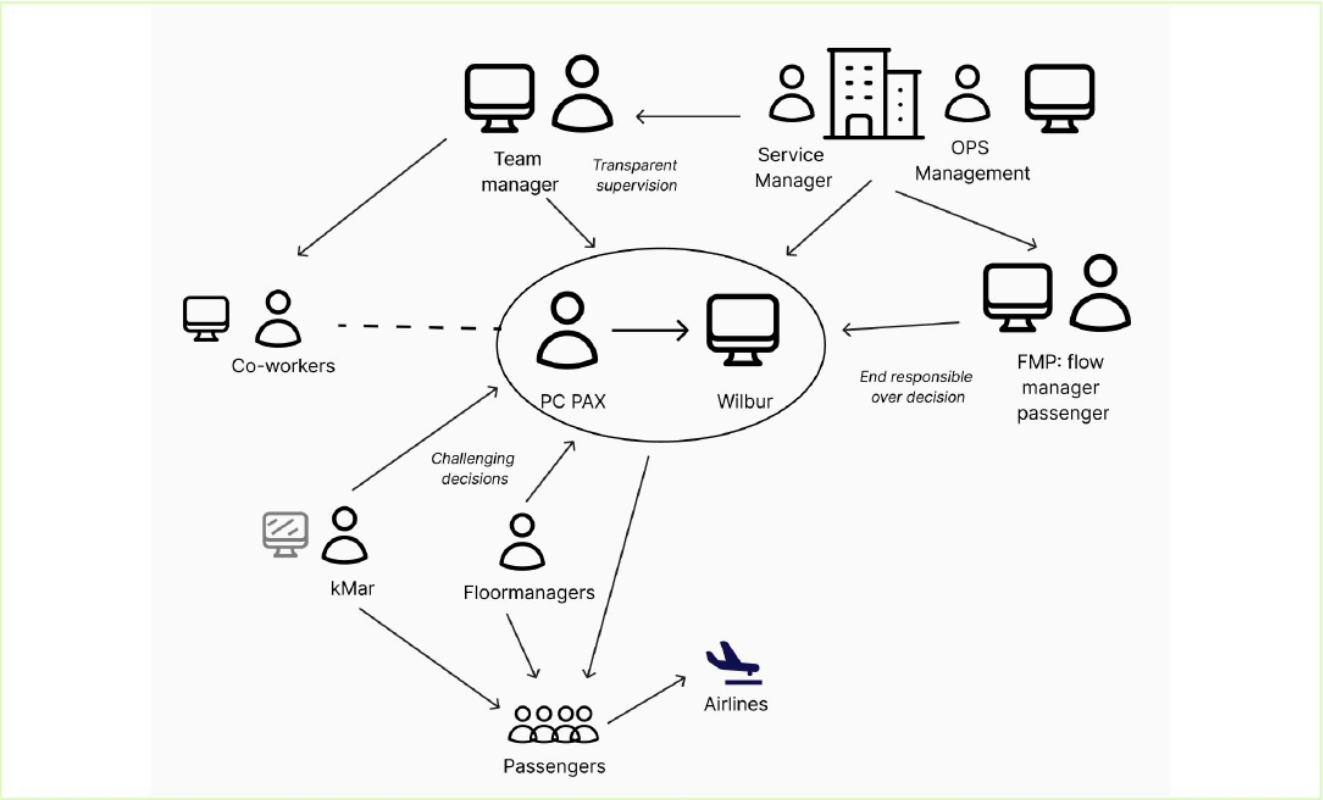

image / figure 2 Simplified overview of current stakeholder system for flow balancing

Personal Project Brief – IDE Master Graduation Project

Problem Definition

What problem do you want to solve in the context described in the introduction, and within the available time frame of 100 working days? (= Master Graduation Project of 30 EC). What opportunities do you see to create added value for the described stakeholders? Substantiate your choice.
(max 200 words)

Adoption is often lacking for DSS, and therefore this also is foreseen for the adoption in the specific context. In a previously performed literature search (1), several barriers and facilitators have been identified for the adoption of DSS. For instance, considering the context of decision-making and involvement of stakeholders in the design process facilitate the adoption by workers.
In the context of our case study, as explain in the introduction, the decision-making performed by the user, PC PAX, is dependent on and contested by other stakeholders. Especially the kMar, have both influence on the processtime of the passenger flows and therefore the occupancy in the AF, but also contest flow balancing actions as it affects their work load. Besides, the kMar and Floormanagers are currently onboarded as new users in Wilbur and therefore Wilbur is becoming a multi-stakeholder system.

The research question of this project is as following:
What should the future work practices of and interaction between key stakeholders in flowbalancing actions taken for arriving passengers at Schiphol Airport look like, given the introduction of augmented decision making in Wilbur?

Assignment

This is the most important part of the project brief because it will give a clear direction of what you are heading for. Formulate an assignment to yourself regarding what you expect to deliver as result at the end of your project. (1 sentence) As you graduate as an industrial design engineer, your assignment will start with a verb (Design/Investigate/Validate/Create), and you may use the green text format:

Design guidelines for the interaction/role of key stakeholders in the decision-making process due to the introduction of augmenting functionalities into a decision support system

Then explain your project approach to carrying out your graduation project and what research and design methods you plan to use to generate your design solution (max 150 words)

For this project I will use the double diamond approach as a method.
The aim of the first diamond will be to understand the decision-making process for flow balancing, the dynamics between stakeholders around this process, the entire stakeholder system (stakeholder values) and the ethonografics of the important stakeholders. In order to achieve this, I will perform qualitative research with the different stakeholders, consisting of interviews, observations and shadow shifts. Besides, I will conduct a literature study on strategies to fit DSS (or other AI, automation technologies) into stakeholder systems by aiming for adoption. Next, the findings will be sythesised, by using different methods like persona's, stakeholder mapping and formulating insights.

The aim of the second diamond is to prototype and validate the guidelines with users and stakeholders. In order to achieve this, I will develop guidelines and prototype them to validate and test these with the key users and different stakeholders in the second converging stage.

Project planning and key moments

*To make visible how you plan to spend your time, you must make a planning for the full project. You are advised to use a Gantt chart format to show the different phases of your project, deliverables you have in mind, meetings and in-between deadlines. Keep in mind that all activities should fit within the given run time of 100 working days. Your planning should include a **kick-off meeting**, **mid-term evaluation meeting**, **green light meeting** and **graduation ceremony**. Please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any (for instance because of holidays or parallel course activities).*

Make sure to attach the full plan to this project brief.
The four key moment dates must be filled in below

Kick off meeting	27 September
Mid-term evaluation	2 Dec
Green light meeting	13 feb 2025
Graduation ceremony	13 maart 2025

In exceptional cases (part of) the Graduation Project may need to be scheduled part-time. Indicate here if such applies to your project

Part of project scheduled part-time	
For how many project weeks	
Number of project days per week	

Comments:

Motivation and personal ambitions

Explain why you wish to start this project, what competencies you want to prove or develop (e.g. competencies acquired in your MSc programme, electives, extra-curricular activities or other).

Optionally, describe whether you have some personal learning ambitions which you explicitly want to address in this project, on top of the learning objectives of the Graduation Project itself. You might think of e.g. acquiring in depth knowledge on a specific subject, broadening your competencies or experimenting with a specific tool or methodology. Personal learning ambitions are limited to a maximum number of five.
(200 words max)

I am excited to start this project, the past weeks I have been getting acquainted with both the topic of decision support tools and the context of Schiphol Airport. Which appeal to me greatly, the complexity of the operations context within the airport is interesting and I am excited to learn more about how to innovate and implement technologies into it. Furthermore, I am excited to learn more about the development of augmented decision making, the technical difficulties and how to match technology with needs and desires of users. And meanwhile managing stakeholder interests, values and opinions. Besides, I am looking forward to experiencing the work of a service designer within a product development team. By working closely together with such a team.

Appendix

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- B.1 Scoping review: Adoption of Decision Support Systems by workers
- B.2 Affinity mapping of results different studies
- B.3 Business process map of decision making process for flow balancing
- B.4 Reasoning for guidelines

B

B.1 Scoping review paper

Adoption of decision support systems by workers: A scoping review

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ABSTRACT

Organisations see opportunities to automate part of the work done by employees, one example is decision making. Decision Support Systems (DSS) are used for that, complexity of decision making can be reduced and performance increased due to the usage of DSS. But adoption by workers is still lacking often, causing resources put into the development to be lost and benefits not gained. Therefore, this work studies the barriers and facilitators of the adoption of DSS through a scoping literature review. Adoption of DSS is understudied outside of the isolated medical field, where a compilation of barriers and facilitators is not available in the literature. Barriers and facilitators in three different phases are found, namely in the design process of the DSS, in the attitude of workers towards the DSS, and the social and technical support for the usage of the DSS. By providing this compilation of barriers and facilitators, this work aims to contribute to the development of DSS that are successfully adopted by workers, ensuring the potential benefits are exploited.

CCS CONCEPTS

• **Do Not Use This Code → Generate the Correct Terms for Your Paper**; *Generate the Correct Terms for Your Paper*; Generate the Correct Terms for Your Paper; Generate the Correct Terms for Your Paper.

KEYWORDS

Decision support systems, adoption, workers, barriers, facilitators

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1 INTRODUCTION

In recent years, many organisations saw the opportunity to automate part of the work done by employees [4]. In this process, Artificial Intelligence (AI) is often used [13]. These organizations see automation as a potential to increase productivity and release employees from repetitive tasks. Therefore not only the benefits of the organisation itself, in terms of profit increase, but also the interests of individual employees should be taken into account for improving their job. [4]

One example of tasks that are automated or enhanced by AI is decision-making. In many organisations, decision-making is a crucial task that is often associated with high complexity and large potential effects. Therefore, there is a lot to win in this field. [13] Decision support systems (DSS) are used to automate decision-making. DSS are computerized information tools or systems that support humans in making decisions by collecting, presenting and integrating useful information from an array of sources and modalities [23]. This way the human user is lead to one or more plausible courses of action, which reduces the complexity of the task. [23]

Although the benefits for different stakeholders in organisations are obvious, the usage of DSS in practice is still low. Even if the performance of the system is higher than workers could accomplish themselves, the adoption by workers is still often lacking [1]. The actual problem is often more tacit [30]. For instance, frequent pitfalls are poor system design, misuse, and reluctance to adopt systems by workers, these all can cause the benefits of the DSS to be undermined [25].

To make sure DSSs can be used to their full potential, we take a close look into the implementation and more specifically adoption phase of DSSs. [13] Adoption is defined by Rogers [29] as the decision made by the envisioned user to make full use of an innovation as the best cause of action. Adoption can be seen as one step further than implementation, ensuring that the system is not only deployed but also embedded within the organisation [28].

Within the literature a lot of attention is given to the development and adoption of Clinical Decision Support Systems (CDSS) [12]. However, a structured overview of barriers and facilitators for adoption for workers in general is still lacking. Such an overview would be relevant for organizations in all domains that are aiming to develop DSS. As this would result in tangible factors to take into account in the design and implementation of such systems. Therefore, a scoping literature review has been performed to map the existing literature and the barriers and facilitators that it describes. This review aims to contribute to the success of worker adoption of DSS in organisations. In order to do so, the following research question will be answered:

> RQ: What are barriers and facilitators for the adoption of decision support systems by workers?

The aim of this paper is to understand the process and requirements of the adoption process of DSS by workers into their jobs. In order

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to understand this process better, a scoping review [24] will be performed to identify the key barriers and facilitators for the adoption of DSS. The scoping was conducted in the ACM digital library. The barriers and facilitators of the adoption will be of great help to get a better understanding of how to design DSS for successful usage by workers and use the full potential they can offer. This paper is structured as following: first, prior work is described, second the method is explained; in the third part, the results of the scoping review are presented, after which we present the discussion and conclusions.

2 PRIOR WORK

2.1 Usage of Decision Support Systems by Workers

Decision support systems are computerized information tools or systems that support humans in making decisions by collecting, presenting and integrating useful information from an array of sources and modalities [23]. DSS aim to reduce errors made by workers and to improve the output of the work they deliver [27].

The application of DSS in the medical field has been extensively studied. For instance, the paper of Sutton et al. [35] provides an overview of the different applications that DSS are used for in medical practice. But it also highlights the downfalls and risks associated with the usage [35].

Decision support systems are often introduced into decision-making processes that require workers to process complex information in a short amount of time. The added value is reducing the complexity and being able to go through more possible scenarios. Aiming to increase the decision quality and efficiency [21].

The usage of artificial intelligence in these systems is common in the past years. It enables the system to analyse and interpret the information to, for example, formulate recommendations to the user. These systems are called Intelligent DST. Often the aim is to create a collaboration between the DSS and the worker that operates it, called augmented DSS. This could be an in between step towards automation. Automation refers to automating the decision-process and removing the human control. Augmentation refers to the addition of a system that support the human decision [21].

Besides the medical field, applications can also be found in the public sector, where DSS are used to screen for child maltreatments [20]. And the aviation domain, to assist pilots in the critical decision to divert to an alternative airport [41].

The scope of this scoping review is adoption by workers, therefore only DSS that are implemented in work environments and used by workers are studied, other application fields, as home applications or applications for customers are out of scope.

2.2 Adoption of decision support systems by workers

Adoption is defined by Rogers [29] as the decision made by the envisioned user to make full use of an innovation as the best cause of action. Adoption can be seen as one step further than implementation, ensuring that the system is not only deployed but also embedded within the organisation [28]. Improving adoption is key if organisations want to make sure the full extent of benefits are exploited for DSS [13].

Adoption of automation in general is still lacking in many fields. Many causes can be assigned for this like non-intuitive interfacing, users lacking programming skills, and high complexity in the systems in place [36]. The paper by Fenwick et al. [14] proposes that often development teams of DSS do not have insight into the human factors that are often key in the adoption of technology by workers. Development and design teams of DSS tend to focus on improving the quality of output of the DSS [2]. For this reason more research should be done in these human factors. As human factors are influencing the adoption to a large part. By listing the barriers and facilitators to adoption experienced by workers, designers and developers of DSS are provided more knowledge to include these human factors into the DSS. The aim is to, thereby improve the adoption of these systems within organization.

3 METHOD

In this section, the method for conducting the scoping review is outlined. A scoping review [24] was used to collect sources discussing the adoption of DSS by workers. Followed by a reflexive thematic analysis to construct an overview of the related barriers and facilitators of adoption from the literature.

3.1 Data Collection and Search Strategy

This literature review is used to map the current knowledge on the adoption of DSS in general. More specifically, the review is used to identify key factors related to the investigated concept, therefore the scoping review was the most suited method for answering the research question [24].

For the search the ACM Digital Library was used for identifying literature papers. This database is focused to the topic of computer science and has a large selection of papers focused on human computer interaction (HCI). The choice to only use the ACM database was made as the aim of the study is to scrutinize how adoption is studied within this community, as well as identify the barriers and facilitators for adoption related to human computer interaction. With this decision, other relevant studies published outside this database are excluded from this review; however, this is justified as the purpose of a scoping review is to map key concepts and identify factors within the specific field of HCI.

The exact ACM search is as follows:

```
[All: adopt*] AND [[All: "decision support system"]
OR [All: "decision support tool"] OR
[All: "decision support technology"]] AND
[All: facilitators enablers] AND
[All: barriers challenges] AND [All: workers]
```

The results were collected, checked for duplicates, but none were found. Also a number of papers identified through snowballing were included, these papers were found in the Scopus database, but are highly relevant to the research question and HCI research domain and therefore also included. Afterwards, through manual screening on records' titles and abstracts for focusing on adoption of DSS, non-relevant papers were excluded. The resulting set was assessed for eligibility on the basis of the full text. The following criteria were used to check results. The papers must:

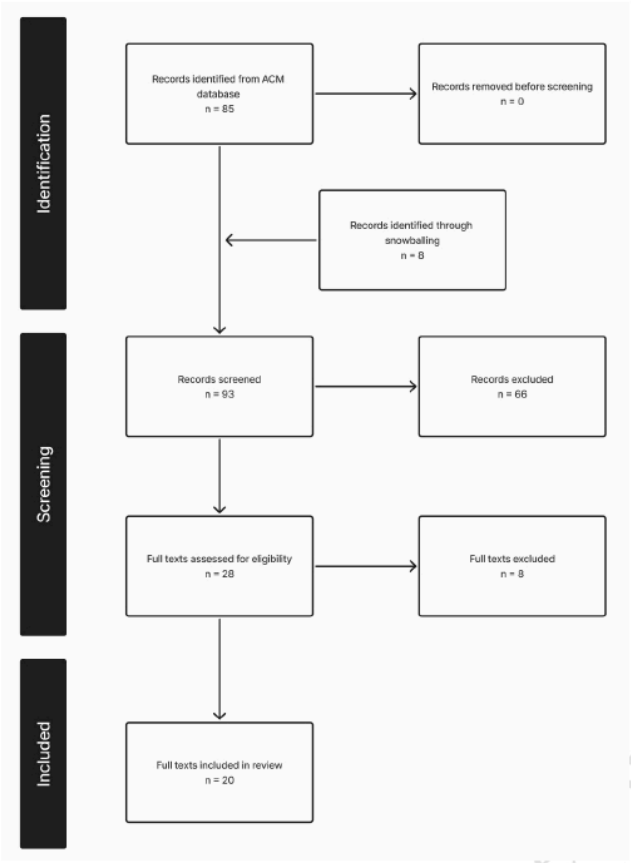

Figure 1: Flow of records through different phases of the data collection process

- Investigate a computerized DSS
- Focus on adoption by workers
- Mention barriers and/or facilitators for the adoption of DSS by workers
- Be an empirical study

The resulting inclusions were once again assessed for eligibility. We then performed one final round of snowballing, screening, and qualitative assessment on the new inclusions. Figure 1 shows the stages of the scoping review with the exact number of papers in every stage.

3.2 Data Analysis and Synthesis

For data analysis, reflective thematic analysis was used, as described by Braun and Clarke [7]. First, all selected papers used were loaded into Zotero were the analysis was performed. All sources were read and passages including a barrier or facilitator were marked as such. Similar passages were grouped and labelled, resulting in themes. Afterwards, these themes were synthesized into the final barriers and facilitators.

4 RESULTS

This section describes the identified barriers and facilitators that were uncovered in the included literature. Table 1 lists and categorizes the papers based on their domain. The largest part of papers are within the healthcare domain, where most research in this field has been done. Furthermore, in Figure 2 the distribution of publishing years of the included papers is visualized.

Table 1: General categories for focus of the papers, based on their domain

Study Focus	Papers
Healthcare	[5, 8, 9, 16–18, 22, 26, 27, 31–34, 37, 38]
Healthcare in Development countries	[34, 39]
Procurement	[19]
Aviation	[42]
Different domains	[23]

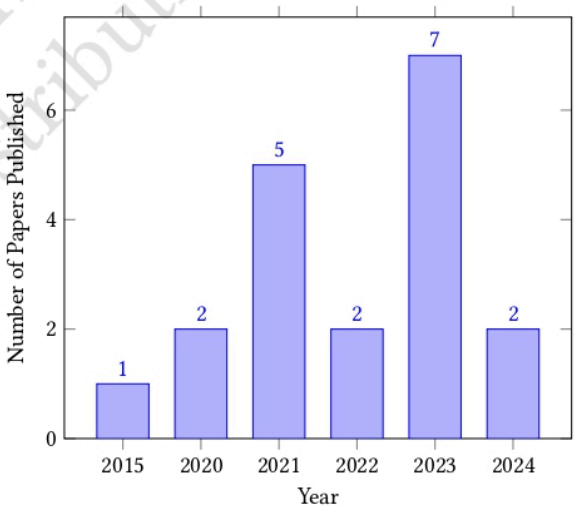

Figure 2: Distribution of papers according to publishing year

4.1 Barriers of Adoption

4.1.1 The design of DSS lacks consideration of the needs, expectations and concerns of stakeholders. Studies have shown that a failure to align the design of DSS with the needs, expectations, and concerns of workers can lead to poor adoption and adherence rates [9, 16, 32, 38]. Not only focus on the users, in this case clinicians but also indirect users, such as patients in healthcare are important to involve in the design process. In the paper by Hussain et al. [16] clinicians raise concerns about the usefulness of the model investigated for lacking patient-centeredness.

4.1.2 The DSS is not adjusted to the knowledge, workflow, and practises of workers. Both in the output and in the interaction with the DSS the user should be able to understand terminology used in the system [5]. But also the guidelines used and the steps the DSS goes through should be inline with what the worker is used to. Sivaraman et al. [33] concluded that users become sceptical of DSS when it deviates from their common practices or even disrupts their workflows [32, 33, 38, 39]. But also, the information provided by the DSS to the worker should be inline with their needs at that certain moment. [37] Misalignment by not adjusting the system to the worker could lead to misunderstanding of the users, which consequently could mean distrust and therefore cause a barrier to adoption [17]. In order to align and fit a DSS in the context, designers should have a deep understanding of the contextual system, relationships between stakeholders and key concepts [38].

4.1.3 Workers have a lack of understanding of the functioning and capabilities of DSS. This is also often referred to as 'black box' algorithms [39]. Workers do not know how the output is generated by the DSS as it does not provide justification. Therefore, users are unable to collaborate with the system and possibly contest the output [27, 39]. Resulting in significantly lower trust in the DSS and therefore adoption is less likely [27]. In the paper of Jung and Shim, for instance, too much tacit knowledge was transferred into the system, increasing its complexity to a level its users could not comprehend [19]. Besides, workers can be unaware of the extent of the usability and capabilities of the DSS [19].

4.1.4 Workers have a low expectation of added value to their performance. This can occur due to different reasons, for example low accuracy [39], uncertainty about the performance [26] or a general lack of confidence about decision support interventions [38]. And more practical concerns, like bugs and errors [34] and low general reliance of the system [16]. Users are critical and even minor mistakes by the DSS can cause them to reject it [19].

4.1.5 Workers experience a perceived loss of professional autonomy due to the introduction of the DSS. This is highlighted as a significant barrier to adoption in several papers [18, 26, 39]. As the system takes over certain tasks with high levels of complexity, this could leave workers with decreased skills [9]. And consequently, the fear of eventually being outdated in the long run [26]. Especially for junior workers this barrier is recognized, as they still have to learn specific capabilities and gain expertise, they might be inclined to over-rely on the technology, which prevents them to learn necessary skills for the job [23]. Besides, Jo et al. [18] found that more senior workers experience undermining of their expertise due to the the system, which hindered their adoption of it.

4.1.6 Workers have high effort expectations for using the DSS. This is especially problematic for workers, for example clinicians in healthcare environments, that have high work pressure and are very limited in time. As they do not have time for extra steps in their workflows and the decision-making processes [17, 19, 39, 42]. For these workers, but also workers with less work pressure, not being able to work efficiently with the system is a barrier to its adoption. Distractions that the delay the users in achieving their goal, adding extensive data work and adding on the task of inputting data are examples mentioned in the literature of DSS that requires more time from workers, leaving them to abandon the DSS [5, 32, 37]

4.1.7 Workers have a resistance to change regarding the introduction of the DSS. Workers rather continue with old ways of working even though the DSS is available as a better alternative [26].

4.1.8 Organizations do not provide the necessary support for using DSS. This includes inadequate training and resources [5, 39], but also a lack of available resources, both human, knowledge-related and financial resources, within the organisation for developing and maintaining a DSS [5, 8, 39]. Having a reliable IT infrastructure and having access to high quality data input for the DSS are important [5, 34, 39].

4.1.9 Workers have a lack of clarity regarding the liability and accountability consequences associated with the usage of the DSS. Related to organisational support, but focused on the hesitation to use the DSS if it is not clear to workers what the legal and accountability implications of usage of the DSS or following of the recommendation given by the system are [8, 16, 26, 39].

4.2 Facilitators of Adoption

4.2.1 The challenges, values and needs of users are taken into account in the design process of DSS. By understanding and addressing the challenges faced by users, designers can create more intuitive and relevant tools that facilitate adoption [] . Design processes that take into account the specific challenges and values of the users facilitate higher adoption rates [] . When DSS is tailored to meet the actual needs of the users, it leads to greater user satisfaction and engagement [33, 37]. More specifically, it could be necessary to include flexibility in the design of the DSS to accommodate for different user needs [18, 27].

4.2.2 Role of DSS is supportive, decision-making happens in collaboration between DSS and worker. Designing DSS with a focus on human-AI cooperation allows for a more integrated decision-making process. Systems that enable collaboration between humans and AI, for example by negotiating, are more likely to be perceived as supportive tools rather than replacements, enhancing user acceptance [33]. Also mentioned in several papers is that leaving the worker in control over the end-decision facilitates in improving their adoption [23, 31, 33, 38, 39].

4.2.3 The DSS is designed to be appropriate and adaptive to the specific context in which the decision-making happens. In the literature, different examples of failed adoption due to a poor contextual fit in the ecosystem that a DSS is placed in are explained [38, 39]. Decision-making is dynamic and not every possible situation can be predicted by designers, leading to the necessity for DSS to be adaptive but still appropriate [22, 42]. In order to accomplish this, the specific context and decision-making process should be investigated and understood thoroughly by the designers.

4.2.4 Workers are able to understand the outcomes and functioning of the DSS. When users have clarity on how the system operates and reasons and know its capabilities and limitations, they are more likely to trust and adopt its recommendations, providing transparency in output is one way of achieving this [5, 23, 31].

Barriers to Adoption	Reference Papers
1. The design of DSS lacks consideration of the needs, expectations and concerns of stakeholders	[9, 16, 32, 38]
2. The DSS is not adjusted to the knowledge, workflow and practices of workers	[5, 17, 32, 33, 37–39]
3. Workers have a lack of understanding of the functioning and capabilities of the DSS	[19, 27, 39]
4. Workers have a low expectation of added value to their performance	[5, 16, 19, 26, 32, 34, 37–39, 42]
5. Workers experience a perceived loss of professional autonomy due to the introduction of the DSS	[23]
6. Workers have high effort expectations for using the DSS	[17, 19, 39, 42?]
7. Workers have a resistance to change regarding the introduction of the DSS	[23]
8. Organizations do not provide the necessary support for using DSS	[8]
9. Workers have a lack of clarity regarding the liability and accountability consequences associated with the usage of the DSS	[8, 16, 26, 39]

Table 2: Barriers to Adoption of DSS by workers

Transparency in the data and parameters used by DSS to users [27, 37] and including a degree of uncertainty [5]. Other ways are providing training and supervision to workers [27, 34] as system and computers skills of workers are a key facilitator [34].

4.2.5 Alignment and integration with existing practices and workflow of workers. Facilitating a smooth integration of DSS into the existing context and workflows of users ensures minimal disruption and encourages adoption. Systems that align well with current practices are more likely accepted by users [37, 39]. For example, in the paper by van Berkel et al. [37], the DSS supported collaboration between team members, which aligned well given the collaborative nature of medical practice. Additionally, defining a clear problem within the context for DSS to solve is a facilitator to adoption [31]. Part of this alignment is the presentation of the right information at the right moment. Encounters that workers have with the DSS should be timed correctly, when and where is it needed by the user [37, 40]. The DSS should fit in the existing work practices and workflow in a seamless and inter operative way [5, 37] Besides, reasoning of DSS should be based on reasoning used by the users of the system, such that workers can interact with the system using their natural information processing strategies [17, 23, 37]. And lastly, the fit within the existing IT system and the integration with other systems already in place is important [18, 27, 39].

4.2.6 During the design of DSS stakeholders are involved. This helps to align the system's functionalities with the needs of all relevant stakeholders [27, 31]. Also, building relationships and closely involving stakeholders in the design process, improves their understanding in the DSS [31]. In the paper of Jacobs et al. [17], the DSS is designed as multi-stakeholder system, improving the service delivered by users and to improve the adherence to recommendations.

4.2.7 Workers have a high performance expectancy for DSS. Users are more likely to adopt a DSS if they perceive that it will significantly enhance their performance, both in efficiency and quality [5, 9, 26, 34, 39]. For instance, in decision-making specifically workers often have to deal with an information overload, DSS can filter and prioritize information reducing this overload [40]. And the recommendations are clearly connected to actionable next steps for the user [17]. Or by enabling a learning curve for workers in their job, the DSS can increase their performance [5, 23, 31].

4.2.8 Workers expect minor effort is needed for using the DSS. When users find the system easy to use and understand, they are more inclined to adopt it [9]. However in the paper by Prakash and Das [26], effort expectancy is not significantly linked as a facilitator to the acceptance of clinicians. Different possible explanations are suggested in the paper, as clinicians might be used to the usage of complex software tools.

4.2.9 Workers trust in the technology and functioning of DSS. According to Verma et al. [38] this is dependent on their contestable experiences with the technology. Prakash and Das [26] found trust to be the main determiner for the likelihood of adoption, as for several other papers [27, 37]. Trust is influenced by the other facilitators mentioned in this review.

4.2.10 Resources are available for the implementation and usage of DSS in the organisation. This plays a critical role in facilitating the adoption of DSS [5, 34]. The papers of Sukums et al. [34], Wang et al. [39], both investigating in development countries, specifically the availability of IT infrastructure, support and adequate computers is highlighted [34, 39]. But also in the paper by Cao et al. [9], facilitating conditions is found to be a facilitator for the adoption.

4.2.11 DSS is approved and endorsed by prominent experts, superiors and co-workers. This boost the credibility of DSS, increasing users' confidence and acceptance of the system [8]. But also social influences within the organisation are important, support and acceptance of superiors and co-workers facilitate the adoption [26, 27]. The identification of early adopters can be a way to increase diffusion [5].

5 DISCUSSION

In this section, we discuss the results presented in the previous section. The findings of this study highlight several key barriers and facilitators for the adoption of decision support systems (DSS) by workers. We could group them in three main categories: methods

Facilitators to Adoption	Reference Papers
1. The challenges, values and needs of users are taken into account in the design process of the DSS	[18, 27, 33, 37]
2. Role of DSS is supportive, decision-making happens in collaboration between DSS and worker	[23, 31, 33, 38, 39]
3. The DSS is designed to be appropriate and adaptive to the specific context in which decision-making happens	[22, 38, 39, 42]
4. Workers are able to understand the outcomes and functioning of DSS	[5, 23, 27, 31, 34, 37]
5. Consideration of the context of decision-making in the design process	[18, 27, 31, 37, 39]
6. DSS fits within the existing workflow of users	[5, 17, 23, 37, 40]
7. During the design of DSS stakeholders are involved	[17, 27, 31]
8. Workers have a high performance expectancy for DSS	[5, 9, 17, 23, 26, 31, 34, 39, 40]
9. Workers expect minor effort is needed for using the DSS	[9, 26]
10. Workers trust in the technology and functioning of DSS	[26, 27, 37, 38]
12. Resources are available for the implementation and usage of DSS in the organisation	[5, 9, 34, 39]
12. DSS is approved and endorsed by prominent experts, superiors and co-workers	[5, 8, 26, 27]

Table 3: Facilitators to Adoption of DSS by workers

and actor involvement in the design phase, attitudes of workers towards DSS, and contextual support for DSS usage. The groups are presented in Table 4. These categories underscore the multifaceted nature of DSS adoption, emphasizing the critical role of the design process, user perceptions, and organizational support. Below the different groups are further explained in detail.

5.1 Design Methods and Actor Involvement in DSS

The first cluster of factors influencing adoption of DST by workers is about how the tool is designed and the actor involvement in the design. These findings resonate with the growing emphasis on user-centred design principles in technology adoption literature [36], which suggest that systems designed with a deep understanding of user needs and perspectives are more likely to be accepted and integrated into workflows. The design phase is likely to influence the other group of factors related to the adoption, the attitude of users towards the DSS. The attitude of users is formed during the design, implementation and usage phase and, partly, influenced by the design of the tool. Furthermore, the factor related to the role of the DST is interesting, as this is implying that full automation is not desirable for decision-making processes. This notion is support by the article of Bradshaw et al. [6], that states that no system could even be capable enough to operate fully autonomous.

5.2 Workers' Attitudes Towards DSS

The second cluster of factors is related to the attitude of users towards the DST, in this case specifically workers. This cluster underscores the importance of addressing cognitive and emotional factors that shape workers' attitudes both during and beyond the design phase of DSS. This notion is supported by the paper of Althuizen et al. [1], that found a negative link between user evaluation and the actual performance of DSS, suggesting that users attitudes towards DSS are not linked to its actual performance and therefore are formed by other factors, as discussed as well in this review.

Besides, the concept of trust, stands out as a central determinant in the adoption process, aligning with prior research that highlights trust as a crucial enabler in human-computer interactions [3]. Ensuring that the system's outputs are interpretable and transparent to users can significantly bolster trust, thereby increasing the system's acceptance and utilization. Question whether understanding the work and the needs of workers would be enough to positively influence the user attitudes or that maybe extra training or attention should be given to shaping attitudes. Also difference between different user groups are not explained.

5.3 Social and Technical Organisational Support

Beyond the intrinsic design and user attitudes, the study also identifies social and technical contextual support as a foundational element for DSS adoption. These aspects serve as the infrastructural backbone that supports the transition from system design to real-world application. This insight aligns with the theory by Rogers [29] on diffusion of innovation theories, which suggest that the social context, including peer influence and organizational backing, plays a significant role in the adoption of new technologies.

Besides, Cheon et al. [10] states that besides the effects on workers, the introduction of DSS into organizations also has influence on power and social dynamics within workplaces. Besides taking this into account in the design, acknowledgement of these changes and risks by the organization is a first step.

We can conclude that organizational support is important for the adoption by workers, the ambition to implement such systems is present but is remains challenging to make it common in daily operations [15] .

5.4 Implications for Practice

Synthesizing these findings, it becomes evident that successful adoption of DSS is contingent upon a cohesive strategy that integrates design considerations, user engagement, and organizational support. The interaction between users and the DSS, facilitated through a design that accounts for their specific challenges and workflows, sets the foundation for building a positive user attitude. This, in turn, is reinforced by trust in the technology, which is

Design methods and Actor involvement in DSS	Workers' Attitudes Towards DSS	Social and Technical Organisational Support
Consideration of needs, expectations and concerns of workers and other stakeholders	Performance expectancy of workers	
Adjustment of DSS to knowledge, workflow and practices of workers	Effort expectancy of workers	Clarity regarding liability and accountability among workers
Appropriate and adaptive to the context specific situation	Trust in the technology and output of DSS	Organizational support for usage of DSS
Role of DSS is supportive, decision-making happens in collaboration between DSS and worker	Resistance to change among workers	Availability of resources for the implementation and usage of DSS
Involvement of stakeholders in the design of DSS	Perceived loss of professional autonomy	Approval of DSS by prominent experts
DSS fits within the existing workflow of users	Fear of deskilling due to the usage of DSS	
	Understanding of outcomes and functioning of DSS	

Table 4: Categories of factors influencing adoption of DSS by workers

shaped not only during the design phase but also through continuous interaction and feedback during its use.

Figure 4 suggests that achieving a high level of trust and alignment between DSS and user expectations is critical for overcoming resistance and fostering acceptance. Furthermore, providing adequate support, resources, and expert endorsement acts as a catalyst that propels the transition from initial resistance to sustained adoption. This paper contributes to the human computer interaction (HCI) community by providing a cohesive list of factors influencing the adoption of decision support systems by workers. Besides, the many papers written about the medical field, these factors are domain wide and therefore an addition to the research community.

Organizations aiming to implement such systems can benefit if the factors are taken into account in the design and implementation phase, as this will improve the benefits gained from the DSS brought to use. Such as, the business value delivered by these systems, which is one of the main strategic purposes [11].

5.5 Limitations and Future Research

While this study provides a comprehensive overview of the barriers and facilitators in DSS adoption, it is important to acknowledge its limitations. The literature search was performed in the ACM database only, therefore relevant studies published in other databases might have been missed. Furthermore, the analysis predominantly focuses on worker perspectives, which may not fully capture the organizational and technical complexities that influence adoption. As this research was a scoping review the search within the focused ACM database and specified to the perspective of workers is justified as this gives an image of the research performed in this area. Future research could explore these dimensions in greater detail, particularly with a larger diversity of domains. Additionally, longitudinal studies examining the evolution of user attitudes over time could yield insights into how trust in DSS develops and changes with prolonged usage.

A FUTURE IMPROVEMENTS

The literature search performed in this paper is not perfect as a selection relevant papers exists in the ACM library, but were not included in the search. This is caused by a low quality search query. To improve the quality it can be improved by adding more synonyms for the words facilitators and barrier. And besides synonyms also the neutral version should be included, such as factors, influences etc. But also included that adoption (and conjugations) and DSS (and alternatives) should be present in the abstract, making sure that this is really the focus of the papers. Especially for adoption this is important, as in a high number of papers in the search adoption was mentioned but in another context and not related to the adoption of the DSS itself. Also the AND in between facilitators and barriers is not necessary, as papers only mentioning barriers or facilitators could also be relevant. Also include the word operator.

Abstract:(Adopt) AND Abstract:("decision support system" OR "decision support tool" OR "decision support technology") AND AllField:(factors OR enablers OR facilitators OR prohibitors OR barriers OR challenges) AND AllField:(worker OR operator)*

This search query gives 27 results, which is a significantly lower amount compared to the one used in the scoping review. This is caused by the restriction of adoption and DSS having to be present within the abstract of the papers. The query above results in 217 papers in the Scopus database. The original query, using in the scoping review, results in 1372 papers in the Scopus database. Interestingly, the search in the Scopus database, gives, besides healthcare applications, also a relative high number of papers in the agricultural domain.

Another alternative query for the ACM database is the following, where the requirement of adoption and DSS in the abstract is removed. This query resulted in 1755 papers within the ACM database. The quality of the papers in this search might be lower, as this is a relatively high amount.

AllField:(Adopt) AND AllField:("decision support system" OR "decision support tool" OR "decision support technology") AND AllField:(factors OR enablers OR facilitators OR prohibitors OR barriers OR challenges) AND AllField:(worker OR operator)*

The last approach that could be taken to improve the search quality is to widen the search, so to reduce the number of search terms. This would generate a significantly larger amount of results, but make sure that no relevant papers are missed. The search query would look as following:

AllField:(Adopt) AND AllField:("decision support")*

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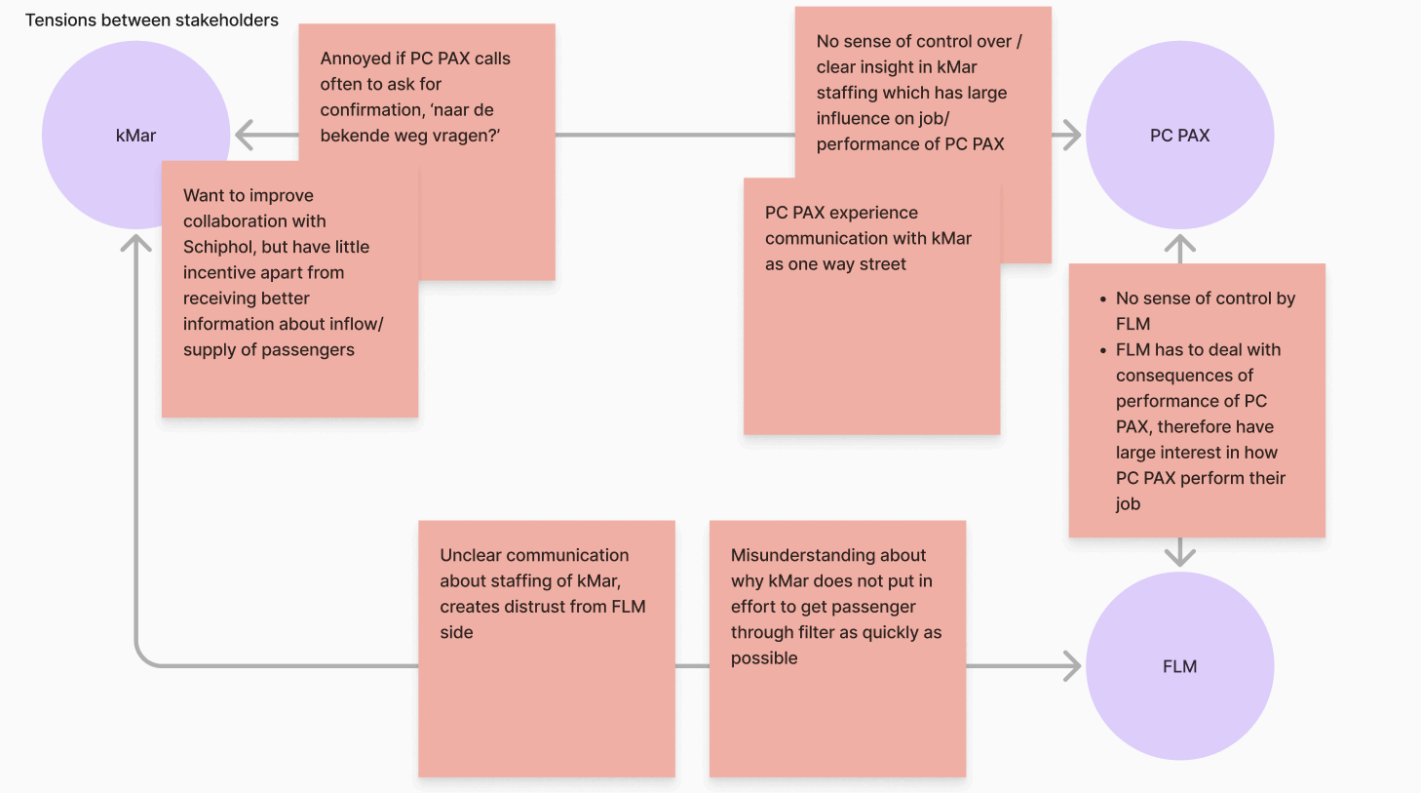
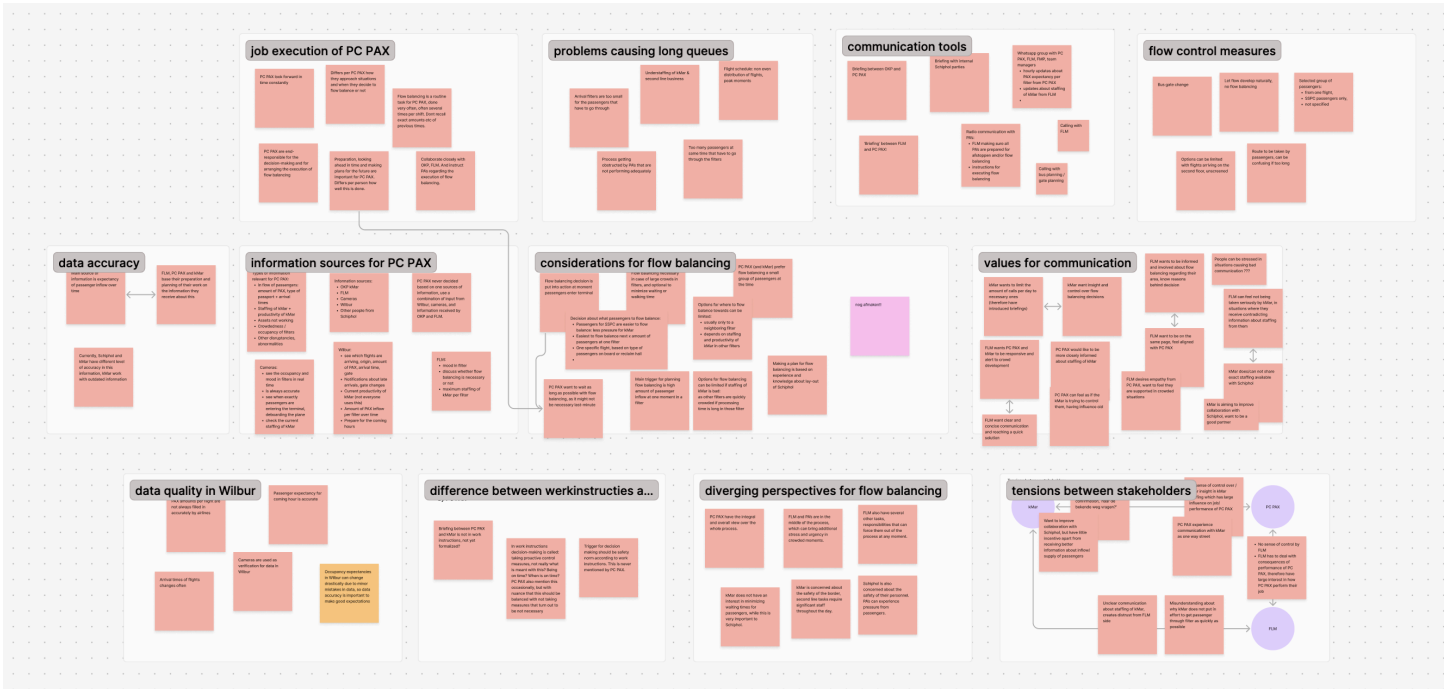
B.2 Affinity mapping of interview results



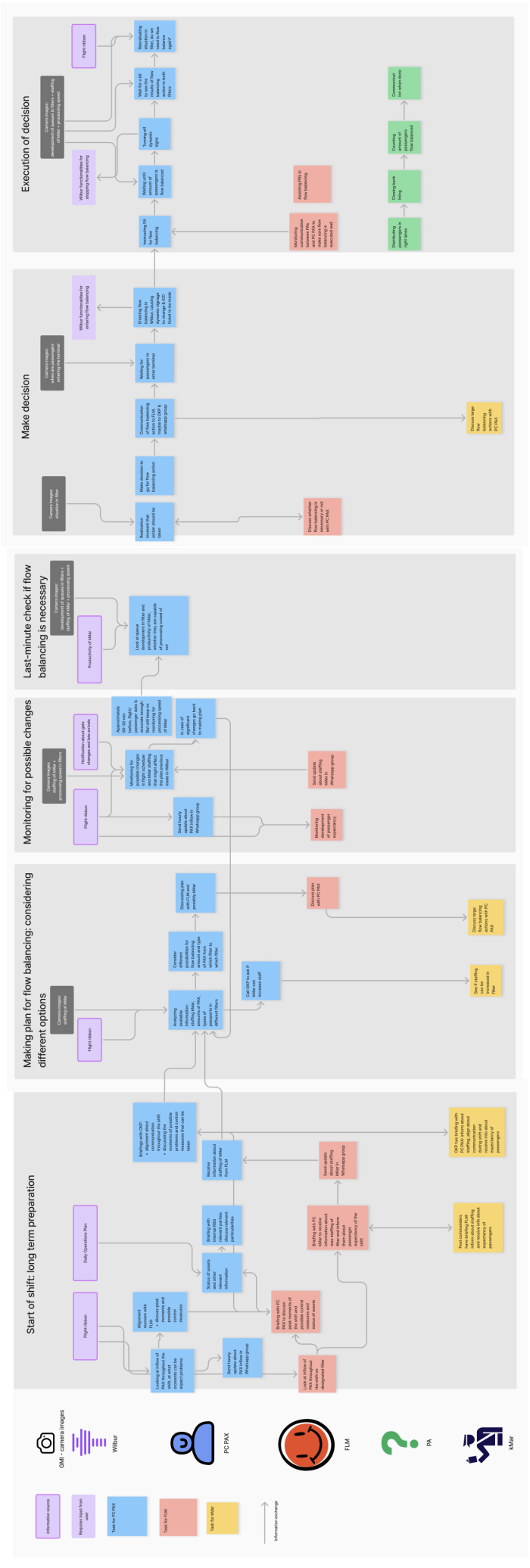



Tensions currently present in decision making process
Changes in workflow and interaction due to introduction of ADM
What is the effect of ADM introduction?
Adoption issues that might occur
Whether flow balancing is necessary or not is can be uncertain until last moment. PC PAX use cameras for final verification.
ADM shows bandwidth that visualizes insecurity of data and predictions
How do PC PAX know when it is necessary to flow balance? Might be the case that prediction is never fully sure it is necessary? Or only up until last moment?
Either still use cameras as verification, meaning there is no prediction benefit OR wait until last moment when it data is sure enough
PC PAX might wait until last moment with exploring options for flow balancing because:
• data is only trusted at last moment
• easier
Causing no time to consult FLM and kMar
over reliance on recommendations, PC PAX do not think anymore
high work load to constantly calibrate trust in the prediction
In the moment of decision-making, there are key differences between the workflows the PO and PC PAX assume.
PC PAX decide for flow balancing when they see the crowd is stagnating on the cameras, while PO wants them flow balance when crowd norm is exceeded
Crowd norm exceeding is the trigger for recommendations
Recommendations/alerts are given more often/ earlier then before
PC PAX might neglect recommendations easily, as they do not agree it is necessary yet
PC PAX might want to flow balance more often, which is difficult for OKP, as they do not desire this.
This also creates more work for FLM.
Recommendations might be often neglected by PC PAX, as they feel it is not necessary yet due to too little certainty or no need for flow balancing
• threshold is too conservative according to PC PAX
OKP and FLM become more hesitant towards PC PAX wanting to flow balance, might question whether this is necessary
Ambiguity about power of OKP over decision making for PC PAX
??
Due to ADM PC PAX might feel more secure about flow balancing issues, reduce the amount of times they ask for permission
OKP is excluded from the process, as PC PAX does not ask for permission anymore, worsening their relationship
Floor Managers have a direct operational need for flow balancing, which can be different to the integral management needs of PC PAX
PC PAX use FLM to gain input about current situation in terminal → discuss whether flow balancing is necessary
Recommendations are scored based on waiting, walking time and to what extend they reduce the crowd norm exceeding
PC PAX is going to compare different flow balancing actions by simulating the effect on the occupancy in the filters at moment problems are foreseen
Current mood in terminal (provided by input from FLM and camera images) is not taken into account for recommendations
PC PAX might feel distrust as this is an important factor they currently take into account
• mental model of PC PAX is not taken into account in the design
FLM might feel distrust of aversion against the usage of ADM, as their view is not heard, expertise not valued
• organizational sensitivity
Effect of flow balancing is hard to predict for PC PAX, possibly partly due to variability in performance of the Passenger Assistants
Effect of flow balancing actions are predicted and visualized so PC PAX can use that in consideration
PC PAX have the possibility to compare the actual effect of flow balancing action with the theoretical effect
If the effect of flow balancing actions is different compared to shown by ADM this might create distrust for PC PAX
(negative) influence of PA performance on effect of flow balancing actions might become visible → FLM are responsible for their performance
FLM might feel pressurized if negative performance of PAs becomes visible
PC PAX and Floor managers can not rely on good information about staffing of kMar
Predictions and recommendations are based on arrival passenger informations and the processing speed of kMar
Predictions are based on amount of kMar desks open, which is uncertain
Inaccurate data could cause bad recommendations, declining trust of all stakeholders
PC PAX have to enter amount of kMar desks opened, as predictions are based on this information
PC PAX have to enter amount of kMar desks every time they want insight into the predications, this is an additional step in the process, adding an additional interaction between OKP and PC PAX or PCkMar, FLM and PC PAX
Additional time required for using the system by the different stakeholders
The lack of transparency given by kMar about the foresight of the amount of manned desks creates uncertainty for PC PAX, limiting them to make informed decisions.

B.2.1 Insights from workshop used in ideation

- Including all subjective data that is currently being used by PC PAX in the reasoning of ADM, by objectifying it.
- Enable Floor managers to give feedback on the recommendations of ADM based on their expertise, to improve their adherence to ADM.
- Enabling PC PAX to explain decisions made to FLM with help of ADM.
- Also enable OKP to contest and voice their restrictions.
- Convincing kMar of the benefit of ADM and the benefits their involvement would have for their operation as well. Also by showing how Schiphol will account for their data safety concerns.
- Improving trust in relationship between PC PAX and OKP, to finally make sure kMar will share more information with PC PAX.
- Enable PC PAX to evaluate on the decisions they have made themselves, but also together with the stakeholders (FLM and OKP).
- Entering and updating the amount of open kMar desks can not be done everytime.

B.3 Business process map for flow balancing



B.4 Reasoning for guidelines

Insight 7: For security reasons, Marechaussee does not want Schiphol to collect and analyze any data about the division and scheduling of personnel from the Marechaussee, as this could contain sensitive information.

Factor 5: Opaqueness for stakeholders regarding the decision-making process might exacerbate existing tensions.

Tension 4: The lack of transparency provided by flow moderator about the predicted productivity of the flow creates uncertainty for the flow controller, limiting them to make informed decisions.

Barrier 2: Due to a lack of transparency and understanding, flow processors might create resistance towards the usage of the DSS.

Have transparency in decision making
Border control authority and decision executors should be able to know which decisions are made and what the reason for these decisions is, to enable them to pursue their operational goals.

Factor 7: Introducing a DSS in a multi-stakeholder system might cause increased need and pressure on communication between stakeholders.

Barrier 3: The introduction of a DSS might cause a reduction in interactions between decision-makers and flow processors and decision executors, limiting the exchangeof important information that is exchanged during these interactions.

Have formalized interactions with the flow controller
Border control authority and decision executors should have standard interaction moments, that fit within their and the decision makers current workflows and are formally agreed on.

Factor 6: Conflicting goals for the functionalities of a DSS between stakeholders can obstruct its adoption.

Tension 2: Flow controller and flow moderator have different goals for the passenger flow, flow controller wants to minimize waiting and walking times of passengers and flow moderator wants to protect the border security by performing thorough passport checks. These goals can be conflicting.

Tension 1: In some situations flow guiders have a direct need for flow balancing in their own filters, which is not awarded by the flow controllers as this has an overall negative effect for all the others filters.

Opportunity 1: Flow balancing could be more flexible regarding meeting needs of stakeholders.

Barrier 1: The introduction of a DSS may lead to deterioration of the relationship between decision-maker, flow processor and decision executors, if their operational goals are not incorporated in the decisions made.

Negotiate with the flow controller
Decision makers should discuss different decision options with border control authority and decision executors to reach a consensus about a decision that has integral benefits.

Factor 5: Involvement of stakeholders in the design of DSS.

Opportunity 9: A DSS could facilitate mutual understanding and more involvement of stakeholders in the decision making process through stakeholder access and involvement.

Insight 3: Interactions that PC PAX have with stakeholders are not only for the benefit of exchanging information, but also adds to f.e. alignment and other social aspect adhering to the decision-making process.

Tension 3: Due to the lack of formal agreements between flow controller and flow moderator, there is a large dependency on informal relationships, causing a lack of uniformity and uncertainties how decision are taken and whether decisions can be contested.

Engage in the decision making process
Border control authority and decision executors should have the opportunity to give input supporting their goals during the decision making process, at an early stage where the initial plan…

Factor 3: DSS should be appropriate and adaptive to the context specific situation.

Insight 1: During the decision-making process PC PAX is using other information sources in addition to information from Wilbur such as their own expertise, information from stakeholders and camera footage.

Opportunity 8: DSS should be appropriate for the user and their needs, this can be done through enabling users to adjust the output and continuous support such as a warning system.

Barrier 5: Because certain subjective information, valued by the decision-makers, is missing in the algorithm of the DSS, as well as the opportunity for verification, decision-makers may perceive its recommendations as inadequate or not trustworthy.

Barrier 4: Junior decision-makers may over-rely on the DSS and its recommendations without contextual understanding. In case of high uncertainty in the data input, it might be difficult for them to judge whether or not to trust the recommendations.

Gather subjective insights alongside predictions
The DSS should stimulate decision makers to gather subjective insights, either from their own experience or from stakeholders, helping them to maintain their contextual awareness and validate recommendations.

Give feedback on recommendations
The DSS should enable decision makers to give feedback on the recommendations generated by ADM after peak moment has passed, which are used to improve the algorithm.

Factor 2: Adjustment of DSS to knowledge, workflow and practices of workers.

Opportunity 2: DSS should provide explanations with recommendations, to gain understanding and trust from users.

Opportunity 3: PC PAX could gain the ability to argue their decisions in a better and more uniform way towards stakeholders.

Receive explanation of recommendations
DSS should provide explanations to decision makers that explain why decisions are taken, based on the effect these decisions on the situation.

Factor 2: Adjustment of DSS to knowledge, workflow and practices of workers.

Insight 2: PC PAX do make a plan upfront but wait until the last moment with finalizing their decision-making, as important information can change up until the last moment.

Plan decisions ahead
The DSS should enable decision makers to make an initial decision plan and record this in the DSS before the critical moments, that can be adjusted in case of large changes in predictions.

Factor 4: Role of DSS is supportive, decision-making happens in collaboration between DSS and worker.

Opportunity 8: DSS should be appropriate for the user and their needs, this can be done through enabling users to adjust the output and continuous support such as a warning system.

Opportunity 4: ADM might make it easier for PC PAX to monitor changes and also to filter whether changes would have a significant impact.

Receive alert in case of change
DSS should filter changes in information according to relevance on previously made plan and only alert decision maker in case it might require reconsideration of the plan.

Factor 1: Consideration of needs, expectations and concerns of workers and other stakeholders in the design of a DSS.

Insight 5: The effectiveness of flow balance actions is negatively impacted by the variability of the quality of the work executed by PA's.

Barrier 6: If important data input is not accurate,it may cause large uncertainties shown in the DSS predictions. This mightcause decision-makers to not see the addedvalue of the DSS for their job.

Opportunity 7: The bandwidth allows PC PAX to calibrate their trust in the predictions generated by ADM.

Know the confidence of predictions
The DSS should show the quality of the predictions made based on the quality and certainty of the data input used that should enable decision makers to determine whether they can trust the recommendations made.

Factor 1: Consideration of needs, expectations and concerns of workers and other stakeholders in the design of a DSS.

Opportunity 6: ADM might give PC PAX the opportunity to evaluate and learn about the effects of flow balancing decisions on the passenger flow.

Decide based on consequences of actions
The DSS should provide decision makers with the option to simulate the consequences of flow balancing decisions through simulation of the effects and therefore select the most effective option.