Möjligheter och farhågor med automation

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Content

English summary

In order for efficient air traffic services to be provided in the future with respect to the increasing demands and challenges in the domain, more and more automation solutions are being implemented to support the human operator. The automation must thus be designed and implemented as a reliable team member that the air traffic controller wants to work with. If the air traffic controller does not accept the introduced technology, the benefits of automation may be lost and mistakes and even incidents may occur (Svensson, 2020). Therefore, there is a need to understand the work of the air traffic controller and what they think about automation and what type of automation they want to work with. Simply adding more automation is not enough to make the air traffic management industry more efficient. It is about enabling human-automation collaboration, and this must be done through careful study of the needs of air traffic controllers.

Increased use of automation depends on user acceptance of automation. Previous research has shown that automation may be viewed with some resistance by controllers and therefore the automation must be designed as a trusted team member with whom the controller can collaborate.

In 2019, a survey study was conducted through a collaboration between LFV/COOPANS and Linköping University in order to investigate controllers' perceptions of automation that exists today and their expectations for future automation. The survey was distributed to air traffic controllers in six different countries. However, only 67 Swedish air traffic controllers (less than 10% of the Swedish air traffic controller population) responded to the survey. This was due to the lack of time of the controllers. Therefore, a follow-up study containing a survey and focus groups is planned. In order to design and implement automation that is safe, usable but also accepted by controllers, it is important to investigate as precisely as possible how controllers perceive the existing and future situation with regard to automation, what controllers think is important in a future collaboration with automation, and what characteristics they think an automation should have.

In total, 113 operational controllers completed an online questionnaire and 35 operational controllers participated in focus groups. The results show clear indications that controllers consider their future work situation to be uncertain due to the likely increased use of higher levels of automation, while controller situational awareness will decrease, leading to an overall deterioration in safety. These results are in line with a previous study (Svensson et al., 2021) where operational controllers feared that they themselves would become a backup system for automation in the future.

This study fills a knowledge gap about air traffic controllers' views on working with future automation and the study has contributed:

- one of the first ever national coverage of human-automation teamwork in ATC in Sweden using a mixed quantitative and qualitative methodology,
- an updated and in-depth description of controllers' expectations of teamwork and task sharing when working with automation, and
- knowledge of teamwork between humans and automation in ATC.

Svensk sammanfattning

För att effektiva flygtrafikledningstjänster ska tillhandahållas i framtiden med avseende på de ökande krav och utmaningar inom domänen implementeras fler och fler automationslösningar för att stödja den mänskliga operatören. Automationen måste därmed utformas och implementeras som en pålitlig teammedlem som flygtrafikledaren vill arbeta med. Om flygledaren inte accepterar den introducerade tekniken kan fördelarna med automationen gå förlorade och misstag och även incidenter kan uppstå (Svensson, 2020). Därför finns det ett behov av att förstå flygtrafikledarens arbete och vad de anser om automation och vilken typ av automation de vill arbeta med. Det räcker inte att bara lägga till mer automation för att göra flygtrafikledningsindustrin mer effektiv. Det handlar om att möjliggöra människa-automations-samarbete, och detta måste göras genom noggrann undersökning av flygledarnas behov.

Ökad användning av automation är beroende av användarens acceptans av automationen. Tidigare forskning har visat att automation kan komma att betraktas med visst motstånd från flygledare och därför måste automationen utformas som en betrodd teammedlem som flygledaren kan samarbeta med.

2019 genomfördes en enkätstudie genom ett samarbete mellan LFV/COOPANS och Linköpings universitet i syfte att undersöka flygledares upplevelser av automation som finns idag och deras förväntningar på framtida automation. Enkäten delades ut till flygledare i sex olika länder. Emellertid svarade endast 67 flygledare från Sverige (mindre än 10% av den svenska flygtrafikledningspopulationen) på enkäten. Detta berodde på flygledarnas stora brist på tid. Därför planeras en uppföljande studie innehållande en enkät och fokusgrupper. För att kunna utforma och implementera automation som är säker, användbar men också accepterad av flygledare är det viktigt att undersöka så exakt som möjligt hur flygledare uppfattar den befintliga och framtida situationen med avseende på automation, vad flygledare tycker är viktigt i ett kommande samarbete med automationen, och vilka egenskaper de anser att en automation borde ha.

Sammantaget svarade 113 operativa flygledare ett frågeformulär online och 35 operativa flygledare deltog i fokusgrupper. Resultaten visar tydliga indikationer på att flygledare anser att deras framtida arbetssituation är osäker på grund av en troligt ökad användning av högre automatiseringsnivåer, samtidigt som flygledarens situationsmedvetenhet kommer att minska, vilket leder till en allmän säkerhetsförsämring. Dessa resultat ligger i linje med en tidigare studie (Svensson et al., 2021) där operativa flygledare befarade att de själva skulle bli ett reservsystem för automatiseringen i framtiden.

Denna studie fyller en kunskapslucka om flygledares syn på att arbeta med framtida automatisering och studien har bidragit med:

- en av de första nationella täckningarna någonsin av ett teamarbete mellan människa och automatisering inom ATC i Sverige med en blandad kvantitativ och kvalitativ metod,
- en uppdaterad och djupgående beskrivning av flygledares förväntningar på teamarbete och uppgiftsfördelning vid arbete med automatisering, samt
- kunskap om teamarbete mellan människa och automatisering inom ATC.

1. Introduction

The use of automation, such as new tools and functions, is dependent on user acceptance of the automation (Bekier, 2013; Hilburn & Flynn, 2001). Within the Air Traffic Management (ATM) industry, automation can be met with resistance and scepticism from the ATCOs (Borst, Westin, & Hilburn, 2012; Hilburn & Flynn, 2001; Svensson, Lundberg, Forsell, & Rönnberg, 2021). Trust, domain experience, age, information requirements the user has regarding the automation, cultural aspects, familiarity with computer usage, experiences with previous automation, job satisfaction, and usefulness of automation (Bekier, 2013; Eurocontrol, 2000, 2004; Lee & See, 2004; Mirchi et al., 2015; Nijhuis et al., 1999; Parasuraman, Duley, & Smoker, 1998; Thompson & Bailey, 2000) are some factors that affect whether automation is accepted and used. Regarding user acceptance and human-automation interaction in ATM, a recent study explored ATCOs' experience of current ATM systems and focused on teamwork between humans and automation (Svensson et al., 2021). However, few studies have addressed the ATCOs' need when it comes to development and implementation of automation. Therefore, more research is needed to better understand how automation can be developed and implemented to support the work of the ATCO.

In 2019, a questionnaire study was conducted as a collaboration between LFV / COOPANS and Linköping University with the aim of investigating ATCOs' experience of automation today and their expectations of automation for the future (Svensson et al., 2021). A total of 249 operational ATCOs from six different countries, i.e. Sweden, Denmark, Ireland, Portugal, Croatia, and Austria, responded to the questionnaire. Note that in Sweden, the questionnaire was sent to all Swedish ATCOs, but responses were received from less than 10% of the ATCO population. This was mainly because of the ATCOs' lack of time. The result showed that operational ATCOs believed that automation in the future will increase, in relation with today, while their situation awareness will decrease with increasing automation. Safety was considered to be at great risk in the future if the automation did not behave as expected or for some reason failed.

This project was planned as a follow-up questionnaire and focus group study based on the results of the 2019 questionnaire. A new questionnaire has been developed, based on the questions from the 2019 questionnaire. For this project, ATM has been the focus due to its exceptional safety record and on-going digitalization and implementations of automation. However, the results can as well be useful in other control domains that faces similar opportunities and challenges as the ATM industry. The topics of automation, safety, situation awareness, and workload were explored through a questionnaire and focus groups with operational ATCOs in Sweden. This study provides unique results about the operators' experiences and expectations. The results can be used for the design, development, and implementation of automation and new tools and functions within ATM.

As Covid-19 has largely restricted air traffic, ATCOs are available within LFV. This entails an opportunity to use ATCOs in the research to a greater extent, for example through survey studies (online) which could simply be done anywhere and anytime.

Despite the effects of Covid-19, automation is expected to increase within ATM. Utilizing the opportunities to collect valuable data on how ATCOs perceive today's and future automation can contribute to increased knowledge and understanding of what the ATM operations

believe will happen in the future, in order to adapt the operational environment to the automation development that prevails today. Conducting studies during a crisis (such as during Covid-19) can lead to innovative thinking, detailed planning, and results that can be quickly used, developed, and implemented when society again reopens.

In summary, to design and implement automation as a trusted team member that the human operator wants to work with, there is a need to understand the nature of ATCOs' work and what they experience about automation and what kind of automation they want to work with. It is not sufficient to only add more automation for the ATM industry to become more efficient. It is about enabling teamwork, and this must be done through careful exploration of the needs of the human end user. The end user's work will change when implementing automation, hence, so might the service provided by the human-automation team. Therefore, it is of great importance to explore how automation might be designed to assist and support the end user, and to what extend the end user wants to work with some kind of automation.

1.1.Aim

The overall aim of the study was to explore ATCOs' experiences with automation and their beliefs about future use of automation to understand how automation can be designed for efficient human-automation teamwork in ATM to maintain safety and enhance performance with the increasing amount of automation being implemented. The aim can be divided into two objectives:

1) Through an online questionnaire, containing questions and statements about ATCOs' experiences and expectations regarding automation, teamwork, and safety, explore how automation is perceived in ATM and what kind of automation ATCOs want to work with. This to be able to design and implement automation in ATM that the users (ATCOs) accept and can work with as a team.

2) Through focus groups with domain experts and designers explore the results from the questionnaire to extract design guidelines to be used when designing and implementing automation in ATM.

1.2.Goals

During the preparation work of this project, goals were specified in accordance to the method SMART goals that stands for Specifikt, Mätbart, Accepterat, Realistiskt, Tidsbundet. Five SMART goals were developed:
S: Approx. 250 responses from operational ATCOs working in Sweden is expected together with 8-10 focus groups with 4-6 participants (domain experts and designers) within each group.
M: The analysis and results made possible with this type of approach (online questionnaire) will be assessed with domain experts in practical focus groups.
A: The active involvement of operational expertise during the focus groups (hence, analysis of the questionnaire results) improves the trust in the process and the acceptance of the method and results.

R: The experience of the involved parties (project owner, project manager, respondents, and focus groups participants) in the project make the goals realistic.
T: Given the expertise of the project owner and project manager and the existing questionnaire from the study in 2019, the proposed goal can effectively be produced in the given time frame.

Considering the covid-19 situation and the fact that the project manager has been on parental leave for two periods of this project, the SMART goals have been achieved with minor changes. This report will outline and explain the method used, the results, and the conclusions that can be drawn from this project.

1.3.Distribution of activities over time

Due to regulations from Trafikverket, budget is moved from 2021 to 2022, which means that the project is extended by 1 year from the original plan. The project has been executed as following:

Q2-Q3 2020:

The project starts and the initial planning kicks off together with the development of the questionnaire.

Q3-Q4 2020:

The online distribution of the questionnaire and the collection of responses takes place. This part of the project ran over time as the project manager was on parental leave. In addition, too few responses were received during the planned data collection period. Hence, it was decided to extend the questionnaire distribution by a couple of months so that more air traffic controllers could answer the questionnaire.

Q1 2021:

Continuation of collection of questionnaire responses.

Q1-Q2 2021:

The analysis of questionnaire responses starts while also planning and preparing the focus groups.

Q2-Q3 2021:

The analysis of questionnaire responses continues.

The focus groups are held with operational air traffic controllers. The idea was to conduct focus groups also with design experts but during the course of the project was decided to focus only on operational staff within the timeframe of this project. Due to the data collection through the online questionnaire ran over time, it was decided to focus on the main target group (air traffic controllers) and instead add more participants to the focus groups with operational staff.

Q3-Q4 2021:

Analysis of questionnaire responses continues.

Analysis of focus groups starts.

Preparation of potential publication for certain parts of the data.

Q1 2022:

Collaboration with the consultancy Combitech is established and a consultant with human factors background is brought into the project. The reason for this was to broaden the project with possibly an additional but smaller data collection towards more air traffic controller as a substitute to the focus groups with design experts. The main task for the consultant is to perform further analysis of the collected responses and focus group results, discussions, and publication writing together with the project lead.

A student from Uppsala University is also linked to the project and part of the data will be used for a thesis project during spring 2022. However, the student chose to drop out of the project as it approached final reporting at the end of Q2 2022. The project was minimally impacted with small amount of data not analysed and reported.

During this stage of the project, an article and a poster are prepared for the Applied Human Factors and Ergonomics conference. The paper will be accepted for presentation and publication. The poster is accepted for publication.

It is planned to conduct a two-day showing at two air traffic control sites in Sweden (ATCC Stockholm and ATCC Malmö), focusing at research projects conducted at the research and innovation department at LFV. The reason is to increase communication and transparency of this ongoing project and other similar Trafikverket projects (COLA I and II, ETRA etc.) amongst air traffic controllers.

Q2 2022:

A human factors workshop is organised with the consultant from Combitech to broaden the internal expertise on human factors. The workshop is part of this ongoing project *Möjligheter och Farhågor med Automation* since the background of the project (how ATCOs may be resistant to change) and results from the questionnaire are discussed at the workshop. The workshop was successful and two further sessions are planned for.

The consultant from Combitech is leaving the project at the end of Q2 2022 due to relocation.

An article for the International Council of Aeronautic Science conference is being planned and prepared.

The research and innovations days at ATCC Stockholm and ATCC Malmö are conducted with good results.

Q3 2022:

Participation in the two accepted conferences Applied Human Factors and Ergonomics and Congress of the International Council of Aeronautic Science.

The project leader is on holiday and parental leave for parts of Q2-Q3 2022.

Compilation of the Trafikverket report.

Q4 2022:

Compilation of the Trafikverket report and completion of the project.

2. Background

The air traffic management/control (ATM/ATC) industry (along with similar control domains such as railway and maritime) is facing challenges such as the demand for higher efficiency, more complex traffic situations, and demand for lower costs while at the same time maintaining high safety levels. To meet such challenges, higher levels of automation (Endsley, 2018; Kaber, 2018; Sheridan, Verplank, & Brooks, 1978) is seen as one solution for ATM (SESAR, 2006, 2017).

Various forms of advanced automation are being developed to reduce operator workload and task load, support performance, and increase safety (SESAR, 2017). However, automation might also introduce risks for decreased safety, even though safety is a fundamental basis in ATM (SESAR, 2006). Higher levels of automation can negatively affect the operator's performance since the operator is being removed from the control loop (Baxter, Rooksby, Wang, & Khajeh-Hosseini, 2012; Endsley & Kaber, 1999; Endsley & Kiris, 1995), which might result in loss of situation awareness (Endsley & Kaber, 1999) and out-of-the-loop problems (Kaber & Endsley, 1997). Hence, introducing automation can result in decreased safety, which is one of the reasons for introducing automation in the first place.

Introducing automation that intrudes on the core tasks of maintaining situation awareness (Endsley, 1995; Stanton, Salmon, Walker, Salas, & Hancock, 2017) and decision-making for the controllers in air traffic control (Eurocontrol, 1996), changes the ATCOs' role fundamentally. For many ATCOs, it can be difficult to accept new automation concepts, and even more if the ATCOs cannot see the possible benefits of the new tool or function being implemented (Eurocontrol, 2004). ATCOs can be skeptical about automation, and experience has taught operators to be cautious (Hopkin & Wise, 1996). In addition, operators can be reluctant to resign responsibility for decision-making or control to the automation (Hilburn, 2000) since experience has taught them that automation might not always be as safe as imagined. In a study by Hilburn (2000), the ATCOs seemed to accept advisory automation as long as they remained in the position of making the decisions. Bekier, Molesworth, and Williamson (2011) found through a questionnaire study that few respondents approved of a tool that meant that the authority to make decisions shifted away from the operator to some kind of automation. The same results were found in a study by Svensson et al. (2021) where the ATCOs wanted to remain in the position of control. However, ATCOs approved of an automated tool that assisted them in organizing materials for decision-making (Bekier et al., 2011) and supported them with simple tasks and decisions (Svensson et al., 2021). Studies have shown that ATCOs also feared that future automation within ATM would include more monitoring tasks (Svensson et al., 2021) and, thereby, greater risks of mistakes when taking control if the automation fails (Hilburn, 2000). Thus, the willingness to accept automation appears to be task-dependent, dependent on the purpose of the automation (Bekier et al., 2011) and whether the ATCO remains in control or not. Finally, in ATM contexts, teamwork factors for human-human teamwork have been identified as central to successful work. For instance, satisfying teamwork between team members can enhance performance (Svensson, 2020; Svensson et al., 2021; Svensson, Ohlander, & Lundberg, 2019).

In a questionnaire study by Svensson et al. (2021), ATCOs believed that automation will increase in the future, that situation awareness and safety will decrease, and that workload will stay at the same level in the future compared with today. The respondents thought that automation would be beneficial only as long as the automation supports the ATCO. It was seen as a benefit to have the automation as a safety net to the ATCO, but having the ATCO as a safety net for imperfect automation was seen as a safety threat. The ATCOs expressed in the questionnaire that safety will increase along with automation, but only as long as nothing unexpected happens.

The present project *Möjligheter och farhågor med automation* continues the exploration regarding what kind of automation ATCOs believe there is in today's ATC systems, what they think will happen in the future regarding automation, safety, situation awareness, and workload, and how they would like to work with automation, and the development and implementation of it.

By investigating what the ATCOs want and the beliefs they have regarding automation, automation could be developed to support the need of the automation and implemented in an acceptable and usable way for the ATCOs.

3. Method

This chapter will present the methods used for this project, an online questionnaire, and focus groups.

3.1. Questionnaire

An online questionnaire was distributed through ATM managers to ATCOs in Sweden, including ATC sites such as area control, approach control, and tower control. 113 licensed ATCOs (68 male and 41 female, 4 choose not to disclose gender) responded to the online questionnaire. The questionnaire was voluntary and could be done during work hours. It consisted of 50 questions and statements split into four sections, see table 1. For full questionnaire, see Appendix 1.

Table 1. The questionnaire consisted of four sections.

Section	Description
Current ATM system	10 questions about the current ATM system the respondents work in.
Teamwork	16 questions about teamwork and how the respondents would like to work with a future automation.
Future ATM system	14 questions about how the respondents believe automation will affect their work in the future.
Demography	7 questions about the respondents work related background.

Likert scales (Fink, 2013) ranging from 1 = 'very low' or 'very much disagree' to 5 = 'very high' or 'very much agree' were used. In addition, free-text sections were provided for the respondents to explain their answers or add additional information. Respondents were free to move back and forth between questionnaire sections and change their responses if

needed. The results were analysed using the statistical software SPSS. Free-text answers were analysed with a thematic analysis (Creswell, 2009; Richards, 2014).

3.2.Focus groups

To analyse the results from the questionnaire study even further and to ask the participants follow-up questions from the questionnaire, focus groups with operational ATCOs from Sweden were conducted. Nine focus groups were held with three to five operational ATCOs in each focus group, 35 operational ATCOs participated in the focus groups. The experience of the participated ATCOs in the focus group varied from 1 year up to 25 years of experience. There was a mix of male (16) and female (19) participants. Not all participants in the focus groups had answered the questionnaire for various reasons. This, however, was not considered a hinder for the focus groups. Instead, it opened up for more discussion regarding the questions asked in the questionnaire.

Due to the Covid-19 situation, the focus groups were held online, making the availability of the participants for the focus groups higher than expected.

The results from the focus group were analysed with a thematic analysis (Creswell, 2009; Richards, 2014).

4. Results

This chapter will present how the project has delivered according to the objectives, the SMART goals, and the overall combined results from the questionnaire study and the focus groups.

The overall objectives for the project and if it has been achieved or not.

1) Through an online questionnaire, containing questions and statements about ATCOs' experiences and expectations regarding automation, teamwork, and safety, explore how automation is perceived in ATM and what kind of automation ATCOs want to work with. This to be able to design and implement automation in ATM that the users (ATCOs) accept and can work with as a team.
    a. This has been achieved. More details in the sections below.

2) Through focus groups with domain experts and designers explore the results from the questionnaire to extract design guidelines to be used when designing and implementing automation in ATM.
    a. The project conducted focus groups with domain experts (operational air traffic controllers). The idea was to conduct focus groups also with design experts. However, during the course of the project, it was decided to focus only on operational staff within the timeframe of this project. Due to the data collection through the online questionnaire ran over time, it was decided to focus on the main target group (air traffic controllers) and add more participants to the focus groups with operational staff instead. Hence, no specific design guidelines was extracted from the focus groups. However, the results from the focus groups together with the results from the

questionnaire can, with some extra analysis, be combined into guidelines for further research and development regarding automation and teamwork in air traffic control. Some recommendations for introducing automation in air traffic control is discussed and listed in 5. Discussion and 6. Conclusions.

4.1.SMART goals

During the preparation work of this project, five SMART goals were developed. Not all of these goals could be achieved in detail. However, this is not something that has affected the overall results and the aim of the project. Below is the SMART goals from the preparation work listed, together with the deviation (if any) and how it has affected the project.

S: Approx. 250 responses from operational ATCOs working in Sweden is expected together with 8-10 focus groups with 4-6 participants (domain experts and designers) within each group.

- 113 responses of the questionnaire were collected together with 35 focus group participants. It was shown in the questionnaire answers and during the focus groups that the answers where "saturated answers", i.e. that the respondents answered the same things. Hence, if there had been more participants, the results would still have been the same.

M: The analysis and results made possible with this type of approach (online questionnaire) will be assessed with domain experts in practical focus groups.

- The results from the online questionnaire were investigated further and discussed through focus groups with operational air traffic controllers, i.e. domain experts.

A: The active involvement of operational expertise during the focus groups (hence, analysis of the questionnaire results) improves the trust in the process and the acceptance of the method and results.

- This has been achieved.

R: The experience of the involved parties (project owner, project manager, respondents, and focus groups participants) in the project make the goals realistic.

- This has been achieved.

T: Given the expertise of the project owner and project manager and the existing questionnaire from the study in 2019, the proposed goal can effectively be produced in the given period.

- This has been achieved.

4.2.Publications, reports, and presented work

- Affiliated Human Factors and Ergonomics, 2022, New York, USA
    - Conference proceeding – Svensson, Å., & Peukert, M. (2022). *User experiences and expectations towards automation and safety in air traffic control.* Paper presented at the Applied Human Factors and Ergonomics. (Svensson & Peukert, 2022)
- Affiliated Human Factors and Ergonomics, 2022, New York, USA
    - Poster presentation
- ICAS 33rd Congress of the International Council of the Aeronautical Sciences

- Conference proceeding – Svensson, Å., & Rönnberg, N. (2022). *Expected teamwork attributes between human operator and automation in air traffic control.* Paper presented at the The International Council of Aeronautic Science conference. (Svensson & Rönnberg, 2022)
- Research and innovation days – internal LFV event
  - Poster presentation
- Trafikverket
  - Svensson, Å. (2022). *Möjligheter och Farhågor med Automation.* Trafikverket. This report.

4.3.Overall results from questionnaire and focus groups

The results are presented in a thematic way, using questions from the questionnaire or the focus groups that the participants has answered followed by a summary of the answers together with graphs from the publications. The results illustrate the combined results from the participants.

For further reading about the results and method used, please see Svensson and Peukert (2022) and Svensson and Rönnberg (2022) for more details.

Automation, situation awareness, workload, and safety

- Automation is expected to increase in the future compared with today
- Safety is expected to decrease in the future compared with today
- Situation awareness (SA) is expected to decrease in the future compared with today
- Workload is expected to increase in the future compared with today

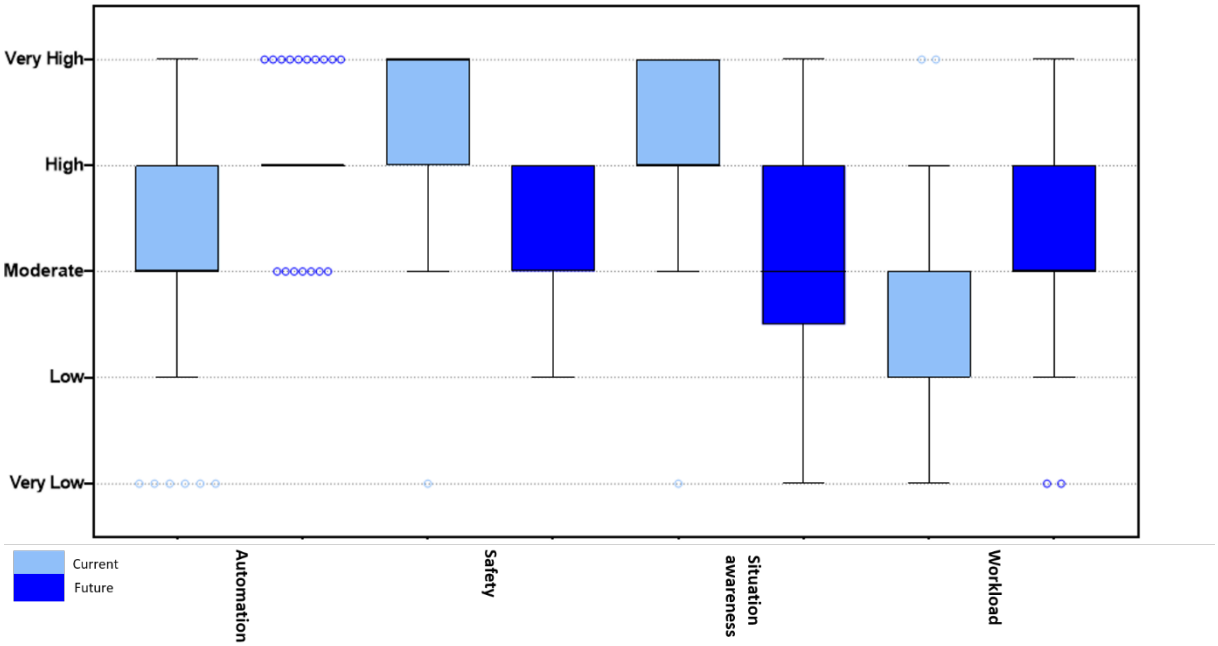

Figure 1. Compared with today, automation is expected to increase in the future, safety is expected to decrease in the future, situation awareness is expected to decrease, and

workload is expected to increase. (Svensson & Peukert, 2022, p. 4). The dots indicates outliers. For future automation, almost all respondents answered "high" and that is why there is a line instead of a bar.

Paired-samples t-test were carried out to investigate the difference between participants' experiences of current ATM system and expectations for future ATM systems. The results show significantly differences between current and future automation amount, ($t(113) = -10.31$, $p < .001$), safety ($t(112) = 11.82$, $p < .001$), situation awareness ($t(112) = -16.31$, $p < .001$), and workload ($t(112) = -4.86$, $p < .001$). See figure 1.

Responses from the questionnaire and focus groups indicated that the ATCOs think there are many positive aspects of automation in ATC. For example, the respondents from both the questionnaire and the focus groups mentioned tools such as medium-term conflict detection and short-term conflict alert as assisting the ATCO in detecting conflicts, contributing to the ATCO saving time for other tasks, and enhancing safety. In addition, existing automation (e.g., conflict detection tools and communication tools) makes the work a little more efficient for the ATCO and, hence, lowers the ATCO's workload. One response from the questionnaire: "*In most parts very positive. Makes the total workload lower compared to less automation but with the same amount of traffic*." According to the responses, automation also removes monotonous tasks such as basic communication tasks, in today's system performed by the technical system instead of the ATCO. The ATCO can also handle a higher capacity and a more comprehensive traffic volume with more automated tools. One response from the questionnaire: "*Today's tools are not too advanced and often simpler automation. This makes it relatively easy to use and does not interfere with the work in position. The tools we have today are supportive of the operator, but you are still the one who makes the final decision*". Many participants saw automation as a safety net, and that the system hinders the ATCO from making errors. One response from the questionnaire: "*Creating more time for the most important things, to control flights and flight safety*". Several participants requested an automated tool to assist them with inbound clearance (for en-route sectors), which takes unnecessary time and capacity from the ATCO and needs to be done for every inbound aircraft. One response from the questionnaire: "*I would like to be able to focus on more complex tasks and letting the system handle routine stuff, like giving inbound clearance*".

Even though the participants believed there are many benefits with automation, they also thought there are (and will be) many issues with it as well. During the focus groups, many participants were sceptical towards more automation and believed that automation often failed them in their current work. One response from the focus groups: "*It seems to work, but in reality, we make it work*", meaning that even though the automation is there to support them, there are many malfunctions the ATCOs need to handle as well. If malfunctions occur today, there are safety procedures to follow, which also will be the case for future automation. One response from the questionnaire: "*When it comes to CPDLC (controller pilot data link communications), it could be more reliable. Sometimes it works, sometimes it does not*." Many participants also believed that today's conflict detection tools are helpful but not always trustable. The participants in the focus groups discussed that false alerts sometimes are so frequent that they "numb" the ATCOs in reacting to the warnings. Another aspect that the participants highlighted is that they could trust the system too much. One response from the questionnaire: "*Easy to get 'blind' and trust the systems too much*."

In addition, the ATCO often double-checks information provided from the system, increasing the workload, which was also a fear for future automated systems. However, the participants found increasing traffic volumes along with complex automation concerning. This is due to today's complexity of closing down sectors and moving traffic, especially if SA is decreased (figure 1) due to automation taking many tasks. Decreased SA was one of the major concerns regarding implementing more automation, seen in both the quantitative and qualitative results. One response from the questionnaire: "*I don't think we are there just yet, but we might lose control and situational awareness with more automation.*" Decreased SA might jeopardize the ATCO's ability to stay in the loop, control the situation, take control from the system if necessary, and, thus, contribute to a decreased safety level.

There was a big concern about what would happen if the automation would, for any reason, fail. Can the ATCO handle a transition after a sudden or unexpected degradation of automation level, or when the automation completely stops working? According to the quantitative results, the participants believed workload would increase in the future compared with today due to increased automation that is imperfect. If automation is introduced and used more frequently, the participants stated that they need to know that it works in all situations. The ATCOs need to understand when and why the automation might degrade in automation level and know that they can handle the situation without the automation. There were many concerns regarding increasing the amount of automation; for example, one response from the questionnaire: "*Balancing the amount of automation so that the controller still remains in the loop*". Keeping the human operator in the loop is essential to maintain safety when the levels of automation increase. According to the participants, this will require more training, education, and information about the automation that will be implemented.

There was a strong correlation found between age and work experience (r (113) = 0.889, p < 0.001) and based on this the respondents were divided in three groups corresponding to their age and work experience: Less experienced (n = 22), Experienced (n = 51), and More experienced (n = 40). There was a significant difference in amount of work experience between these groups (F (2, 110) = 225.757, p < 0.001), and post-hoc tests with Bonferroni correction for multiple comparisons showed a significant difference between all of these groups (all p < 0.001), see Figure 2. The results from the two sets of statements (*I should* and *Automation should* were consequently analyzed for differences in attitudes for each individual statement, to explore if differences in age and experience resulted in differences in attitudes.

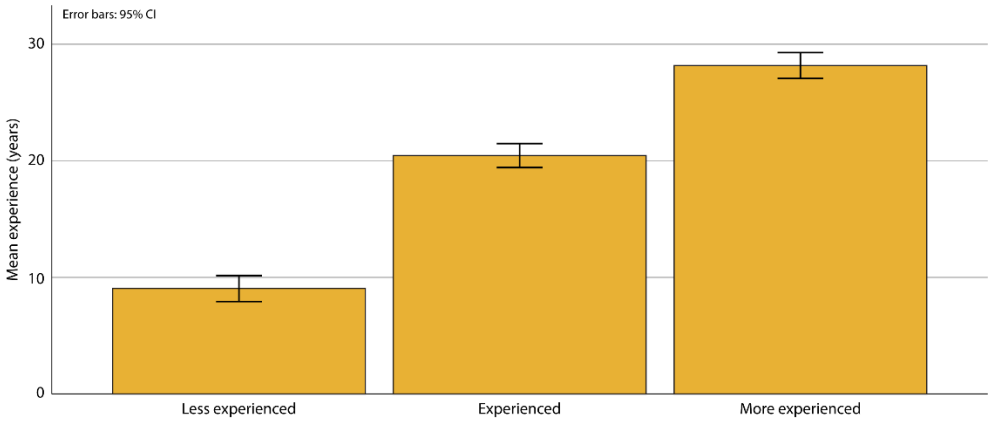

Figure 2. The respondents were divided in three groups (Less experienced, Experienced, and More experienced) based on their age and work experience.

According to a Kruskal-Wallis test, no statistical differences were found for the *I should* statements between the groups, even if the analysis showed a tendency towards statistically significant difference for *I should be able to use verbal communication* (p = 0.055) and to some extent also for *I should be able to trust the automation* (p = 0.097), see Figure 3. Therefore, for completeness of the analysis, both the total of all respondents as well as the individual groups are presented in the figure.

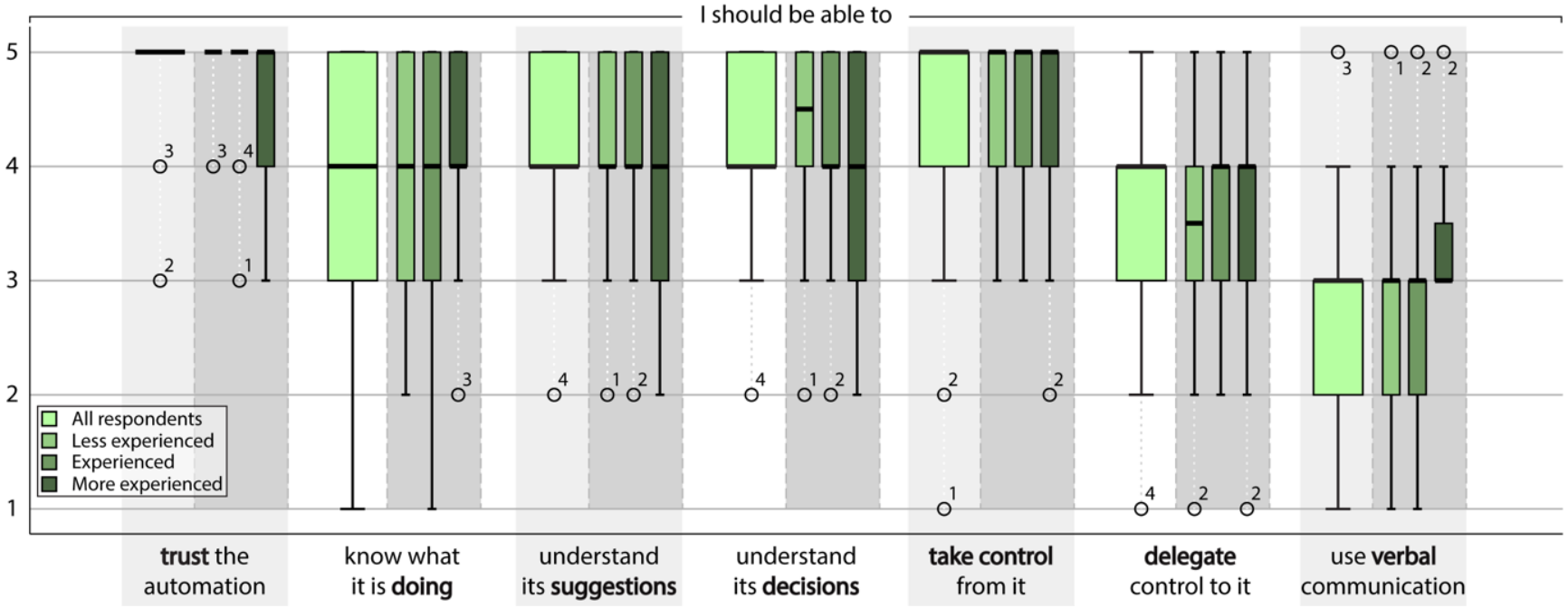

Figure 3. The ratings for the *I should* statements for all respondents (bright green), as well as the three groups. In general, "*I should be able to trust the automation*" was rated as most important, while "*I should be able to use verbal communication*" was rated as least important. In addition, for these two statements, there was a tendency of difference between the groups. The dots indicates outliers.

As shown in Figure 3, the statement *I should be able to use verbal communication* did the respondents agree to the least compared to the other statements, which was also supported by the statistical analysis, see Table 1 for the statistical analysis. The statement *I should be able to trust the automation* was, in general, rated as the most important aspect together with *I should be able to take control from it*.

I should	**verbal**	**delegate**	**take control**	**decisions**	**suggestions**	**doing**
trust	< 0.001	< 0.001	= 1.000	< 0.001	< 0.001	< 0.001
doing	< 0.001	= 1.000	< 0.001	= 1.000	= 1.000	
suggestions	< 0.001	= 0.148	= 0.012	= 1.000		
decisions	< 0.001	= 0.062	= 0.032			
take control	< 0.001	< 0.001				
delegate	< 0.001					

Table 1. The statistical analysis, related-samples Friedman two-way ANOVAs with Bonferroni correction for multiple comparisons, of differences in ranking between all *I should* statements.

For the *Automation should* statements, there were no statistical differences between the groups according to a Kruskal-Wallis test. As shown in Figure 4, there seemed to be one set of statements that, in general, was ranked as more important than the others were. These were the statements that the automation should know the operator's workload, focus (i.e. what the ATCO is looking at), knowledge about what the operator is doing, and provide the operator with suggestions. Consequently, the respondents, in general, agreed less to that the automation knows the operator's stress level, and that the automation can take decisions and take control. This was also supported by the statistical analysis, see Table 2.

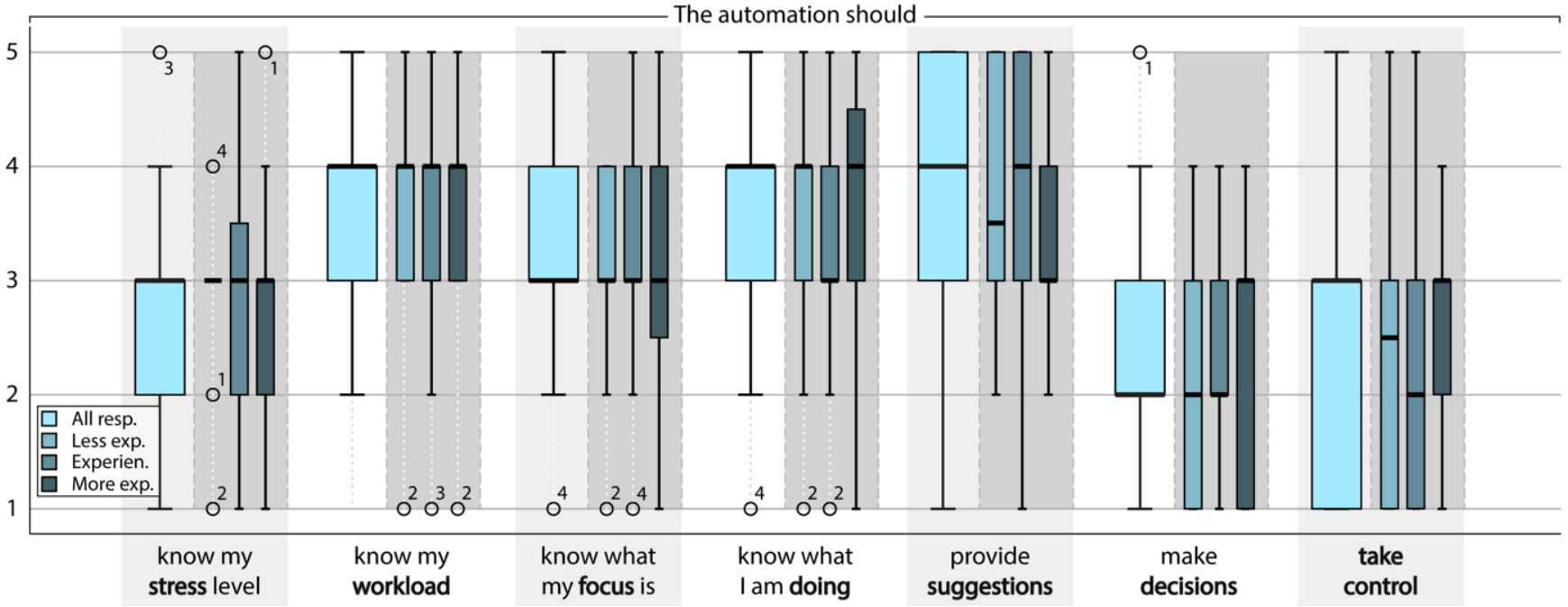

Figure 4. The ratings for the *Automation should* statements for all respondents (bright blue), as well as the three groups. The respondents, in general, agreed less to that the automation knows the operator's stress level, and that the automation can take decisions and take control. The dots indicates outliers.

Automation should	**take control**	**decisions**	**suggestions**	**doing**	**focus**	**workload**
stress	= 1.000	= 1.000	< 0.001	< 0.001	= 0.097	< 0.001
workload	< 0.001	= 1.000	= 1.000	= 1.000	= 0.046	
focus	< 0.001	< 0.001	= 1.000	= 1.000		
doing	< 0.001	< 0.001	= 1.000			
suggestions	< 0.001	< 0.001				
decisions	= 1.000					

Table 2. The statistical analysis, related-samples Friedman two-way ANOVAs with Bonferroni correction for multiple comparisons, of differences in ranking between all *Automation should* statements.

For the open-ended question *What kind of automation would you like to have/work with?,* thematic analysis was applied to the responses. Some respondents gave detailed examples, and some provided more overall functions that can be used within ATC. The results from the analysis are presented in Figure 5. There were no statistical differences between the answers and age or experience.

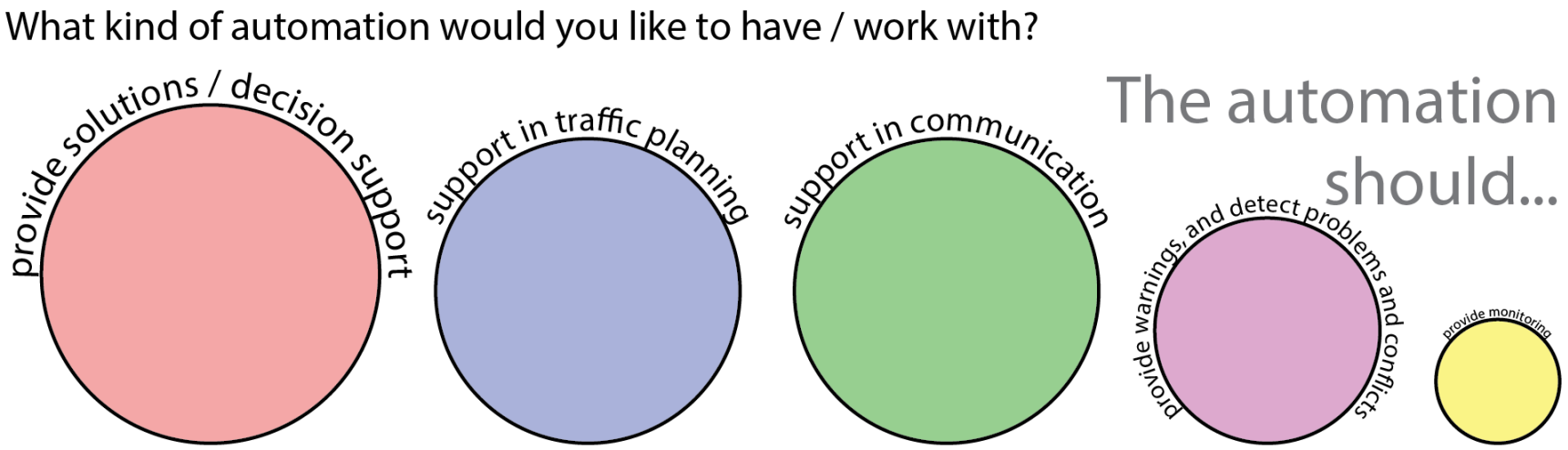

Figure 5. Thematic analysis of the question *What kind of automation would you like to have / work with?* The circles represent the frequency of each identified theme; provide solutions / decision support (red), support in traffic planning (blue), support in communication (green), provide warnings, and detect problems and conflicts (purple), and provide monitoring (yellow).

In general, the respondents wanted automation that assisted them with suggestions/solutions and decision support. They also wanted support in traffic planning, such as sequencing, sector changes, and heading/speed changes. Support in communication with the air traffic control system and the pilot was also often listed as automation they want to have. For example, many respondents gave examples of more advanced Controller Pilot Data Link Communications (CPDLC) and automatic identification of the aircraft messages. The participants also wanted conflict detection tools and tools that could monitor simple tasks for the ATCO.

The respondents seemed to be comfortable with automation that could perform actions, but only if the ATCO accepted the command first. One citation from the questionnaire answers: "*Conflict tool that gives options to solve conflicts (for both air, runway, and taxi). If possible, a future overall "smart" system tool that makes system-wide calculations based on every available piece of information and presents clear options for me*."

The participants also wanted the automation to be customized depending on the environment based on observations of the work of the ATCOs. The participants believed developers and researchers could not develop automation to fit all ATCOs or ATC environments. One respondent wrote: *"The important is not to have as many tools as possible, the important thing is to have the right tools and that they are trustable and easy to use and learn at high workload".*

There was, however, resistance toward automation among some participants. For example, one respondent wrote: "*No, I'm too old to learn major changes in the way to work or think*". Some respondents did not want more automation at all. One respondent wrote: *"Current system support is enough"* while another wrote: *"The less human involvement within a system the less room for human error".* But there was also uncertainty amongst the responses. One respondent wrote: *"Don't know. I do not know what opportunities there are. I like the craftsmanship of being an air traffic controller".*

For the second open-ended question *How would you like to work with an automation?*, the majority of the respondents wanted to work with an automation that provided them with solutions and decision support (see Figure 6). One respondent stated that: "*Automation suggests some decisions to me, if I choose to accept it performs them for me*".

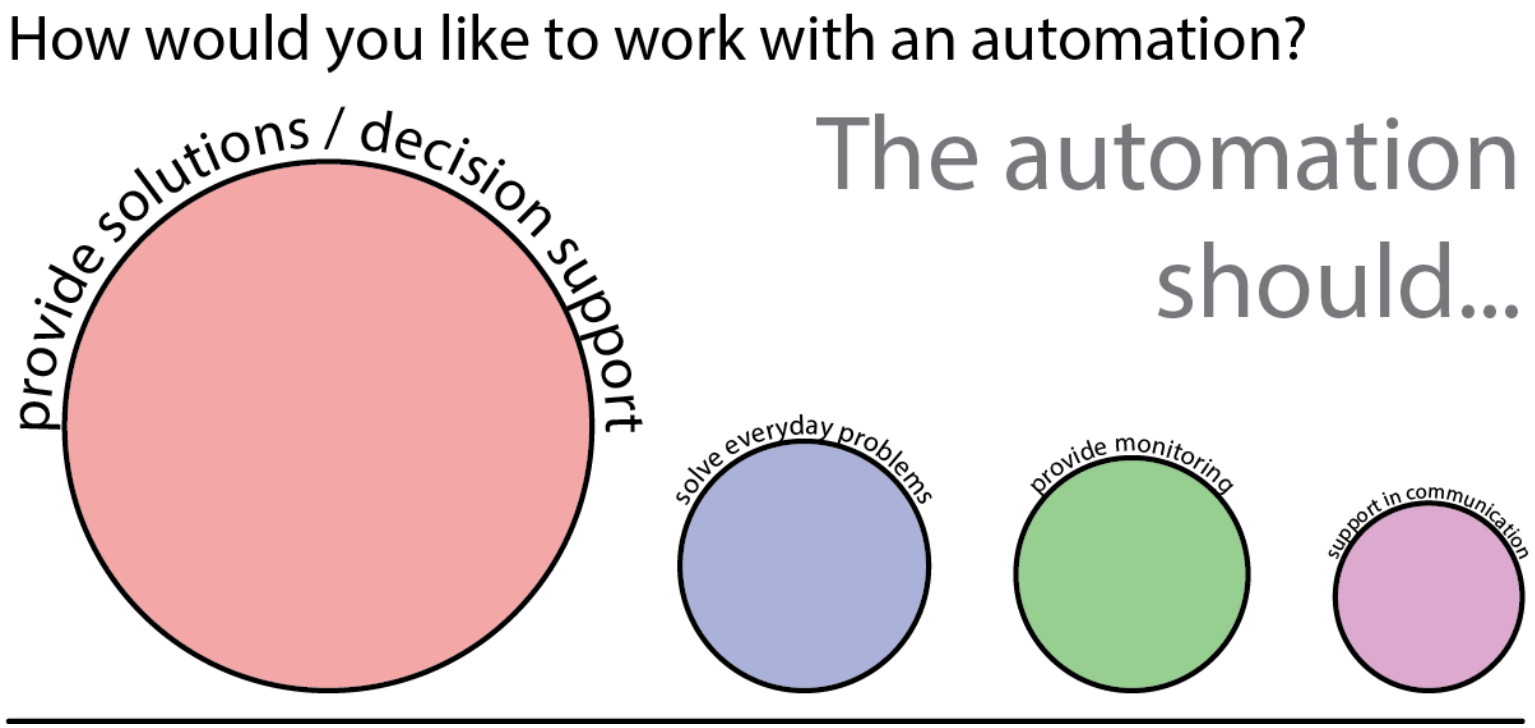

Figure 6. Thematic analysis of the question *How would you like to work with an automation?* The circles represent the frequency of each identified theme; provide solutions / decision support (red), solve everyday problems (blue), provide monitoring (green), and support in communication (purple).

There were clear indications that the respondents wanted automation to be a support system to the ATCO and not the other way around. One citation from the questionnaire answers: "*Working together. As a team all the time. It shouldn't be the person or the computer doing the work but a teamwork."* Several respondents wanted a system that can help them solve everyday problems and perform monitoring tasks. One citation from the questionnaire answers: "*Automation does things and I monitor. I do not want to discuss with the automation. I want to know what functions it do and what I should do*." However, there were also indications that the ATCOs do not want to monitor the automation. One citation from the questionnaire answers: "*I will not become a monitor over the system"* while another wrote:" *Just let me monitor".* Hence, the opinions differ regarding how much of monitoring of the automation there should be for the ATCO.

Through the Human-Machine Interface (HMI), mouse, keyboard, and eye-tracking (with examples of double-blinking for 'click' or voice) were suggestions of ways for interacting with the automation.

In addition to the above results, the following text provides a summary of the answers that emerged from the thematic analysis of the questionnaire answers and the focus groups.

What kind of automation do you believe is considered as automation in current ATM systems?

- Medium Term Conflict Detection (MTCD)
- Short Term Conflict Alert (STCA)
- Online Data Interchange (OLDI)
- Arrival Manager (AMAN)
- Separation Tool (SEP)
- Controller Pilot Data Link Communications (CPDLC)

Do you think that automation in ATM today contributes to anything positive?

- Detect conflicts
- Saves time
- Lower workload
- Removes monotonous work tasks
- Higher capacity
- Safety net
- Higher safety

Do you think that there are any issues concerning automation in ATM today?

- Malfunctions in the software
- The need to double check information
- You cannot trust automation to 100%
- Over trust / you trust it too much
- Difficult to understand
- Decreases situation awareness
- What happens when the automation stops to work?
- Can the human operator handle the situation when the automation stops working?

How can we introduce automation in the future?

- Better communication
- Air traffic controllers need to be involved in the early stages of the development
- Invite air traffic controllers in development work
- Inform about ongoing projects
- Inform about upcoming projects
- Inform about upcoming implementations
- Inform about why something is implemented

What kind of automation would you like to have/work with?

- Automation monitors simple tasks
- Automation gives me suggestions
- Automation might perform actions if I choose to accept them first
- Automation is a support system to me
- Automation works together with me as a team all the time

Do you personally want to have more automation in the future compared with today?

- 34 clear "yes" responses. Citations from the respondents:
  - *"Yes if it is implemented in a way that you can trust it"*
  - *"Yes but I still want to feel that I am doing my tasks in my way"*
  - *"Yes I want even higher safety"*
  - *"Yes, but technology is not always good. It should be easy to use and easy to understand. That is the biggest challenge, I think."*
    "Yes if it can increase capacity"

- 13 clear "no" responses. Citations from the respondents:
  - *"No, I enjoy doing something myself"*
  - *"No, my experience is that it becomes more difficult to work when I have to adapt to the system and not the other way around. In addition, the work becomes more tedious, but that is another matter."*
  - *"No, the systems I have seen have usually been based on the aircraft themselves adapting to a point at a certain time and it works extremely rarely. They may be separated at the point, but on the way there they fly so differently that there can be several undercuts of separation."*
  - *"No. With the levels of traffic that will be in the foreseeable future, it is not needed"*

Air traffic control as a craftsmanship

- The work of an air traffic controller is clearly seen as a craftsmanship
- The craftsmanship is changing over time
- The core in the craftsmanship is to provide a safe and effective air traffic service
- The reason for why air traffic control is seen as a craftsmanship is that much of the reasoning, the decisions, and actions made by the air traffic controllers cannot be done by only technical devices in today's systems according to the focus group participants

5. Discussion

The results from the present study show that trust is the most important aspect of human-automation teamwork. For decades, it has been known that trust in automation is important but also something that can be difficult to achieve (Bekier et al., 2011; Hoffman, Johnson, Bradshaw, & Underbrink, 2013; Janssen, Donker, Brumby, & Kun, 2019). The level of trust for an automation depends on several factors, and some of these could be found in the results from the questionnaire study, which will be discussed further below.

In general, most of the respondents expressed that taking control from the automation was more important than delegating control to it. These results align with previous studies where ATCOs want to remain in the decision-making position and are reluctant to resign responsibility for decision-making or control to the automation (Bekier et al., 2011; Hilburn, 2000; Rieth & Hagemann, 2022; Svensson et al., 2021). This could be a sign of low trust in automation, as the respondents would not want to delegate control to it. However, the level of control was not clarified within the questionnaire. Hence, the respondents could interpret the statement as either all control or some control. However, it can be assumed that it is acceptable for the human operator that automation has some control, as long as the operator can take all of the control whenever the operator wants.

This study shows that ATCOs may accept automation that provides suggestions for the ATCOs to choose from, which is in line with previous results (Bekier et al., 2011; Hilburn, 2000). However, the respondents did not want the automation to take decisions without their involvement. Instead, they wanted to know the reasoning behind its suggestions and decisions. The ATCOs do not wish to be left out of the control loop but rather understand what the automation is doing. Hence, the automation needs to be transparent of its actions toward the human operator and offer teamwork (Rieth & Hagemann, 2022; Svensson et al., 2019). Having transparent automation is relevant for the operator to know what the automation bases its suggestions and decisions on. For example, the operators need to know which source of data the automation uses, not only providing the operator with one source [19] (which can be faulty, even though the automation uses a source with correct data). Transparency is also essential when technical systems are provided from different vendors (Smith & Baumann, 2020).

The results from the present study have also shown that it is not as important for the respondents that the automation knows what the ATCO focuses their attention on. One reason for this could be that for the automation to know what the operator is looking at; the respondents might have assumed that additional equipment, like eye-tracking devices, would be necessary as part of the work environment. Equipment like that can be intrusive for the user, and negatively affect work and performance. In addition, some people might also believe that it can intrude on personal integrity.

The respondents stated, in general, that automation should know what the ATCO is doing. This is already implemented in current ATC systems since the ATCO is typing in commands in the system through the HMI that the system responds to. Still, the system does not have the concept of "mind" in today's ATC environments, and if the system then "knows" what the ATCO is doing is for another paper to discuss. What the ATCO is doing within the different ATC systems is thus known for the organization. However, more research is needed regarding

integrity and ethics within the ATC community and how much "knowledge" the automation should have about the human operator.

The results show that it was also not as crucial for the respondents that the automation would know the ATCO's stress level. The respondents agreed more to that the automation knows the ATCO's workload. However, workload and stress levels are related (Warm, Matthews, & Finomore Jr, 2008), and the stress level might increase if there is a high workload. Thus, knowing the workload and the stress level of the human operator could potentially increase safety if the human operator would be comfortable with that the automation can intervene or acknowledge the management if there is a very high workload of the human operator that the human seems not to be able to handle.

The respondents did not rate verbal communication with the automation as important. Even though the questionnaire did not state what was meant by verbal communication, it can be interpreted as the ATCO can give system inputs by, for example, speech recognition. However, few respondents agreed to verbal communication and only one respondent gave voice as an example for how he/she would like to work with an automation in the future. If the questionnaire had given more examples of what was meant with verbal communication, the responses might have been different.

Several respondents expressed an uncertainty regarding what kind of automation they would like to work with. Many respondents wrote "*Don't know*" for the open-ended questions. The reason for this could be lack of time for answering the questionnaire, or that they thought the Likert-scale answers were sufficient as answers. It can also indicate a lack of knowledge, unfamiliarity, unconcern or even ignorance about technical development within the industry due to lack of information transparency and knowledge dissemination regarding automation research within ATC.

For this study, the questionnaire was distributed amongst ATCOs working with tower control, en-route control, and approach control. However, several ATCOs can operate in either tower control or en-route control and approach control simultaneously. Consequently, no comparison could be done for analysis of different endorsements. Further studies should be conducted to investigate the differences between tower control, en-route control, and approach control regarding automation expectations. The level of development progress at different ATC sites differs within Sweden. Hence, the attitude, expectations, and acceptance of automation may differ between ATCOs working at various ATC sites.

6. Conclusion

Some of the major reasons for introducing higher automation levels in ATC are to increase capacity, cost efficiency, and safety. Automation is introduced as a safety net support to improve safety performance. However, if the automation fails, the ATCO is supposed to take control of the situation (e.g., with a higher and more complex traffic volume than today), making the ATCO a backup system to the automation, something the participants from this study and previous studies (Svensson et al., 2021) fear. The results also indicate a concern regarding the expected increase of workload and automation in the future, while safety and SA are expected to decrease. However, balancing workload and automation is difficult in

today's ATC environments due to automation, e.g., MTCD, giving "false alerts" (due to parameter settings in the system that cannot be changed easily). These results align with previous results (Svensson, 2014, 2015). In addition, according to the results, trust towards automation should be well-calibrated since it can easily be eroded due to automation failures. The ATCOs should be involved in all early stages of automation development, from idea development based on previous research and experience to discussion groups, workshops, development prototypes, etc. This is particularly important when the automation can malfunction, and the ATCO needs to be the backup system. The expectations highlighted from this study must be understood and managed through change management, communication, and dialogues between research, development, and end-users. The ATCO needs to know the benefits of the automation, how it works, why it performs in specific ways, why it malfunctions, and what happens when it does. This calls for better integration of human capabilities and transparency of the system functionalities. Extensive automation training is necessary for the ATCO to keep safety at a high level. In addition, follow-up studies with updated questionnaires are important to capture existing concerns, fears, and anticipations amongst the end-users (in this case ATCOs).

A questionnaire study followed by focus groups was conducted. 113 operational air traffic controllers responded to the online questionnaire and 35 operational air traffic controllers participated in the focus groups. The results show clear indications that the participants believe that their future work situations are uncertain due to a believed increased used of higher levels of automation while the ATCO's situation awareness will decrease, resulting in a general safety decrease. These results are in line with a previous study (Svensson et al., 2021) where operational ATCOs feared being a back-up system to automation in the future. The results from these two studies should be a strong wake-up call to the ATM industry.

The present study fills a knowledge gap regarding ATCOs' view of working with future automation and the study has contributed with:

- one of its first-ever national coverage of a human-automation teamwork in ATC in Sweden with a mixed quantitative and qualitative approach,
- an updated and in-depth description of ATCOs' expectations of teamwork and task allocation when working with automation, and
- knowledge regarding human-automation teamwork in ATC.

6.1. Recommendations and future work

To meet the future demands of higher traffic volumes, increased efficiency, and lower costs while simultaneously maintaining a high safety level, automation can be implemented to support the ATCO. Based on this project, where results from a total of 113 questionnaire respondents and 35 focus groups participants have been collected and analysed, some recommendations have been developed:

- The controllers should be involved in the early stages of the development phase of new tools and functions. Communication of why and how is of importance for acceptance and use.

- The controllers need to know the benefits with the automation, how it works, why it performs in certain ways, and why it malfunctions and what happens when it does, at the early beginnings of development and taught during training.
- Extensive information and training of the new automation is recommended and necessary for the controller to be safe in position when working with it. This is of particular importance when the tool/function can malfunction and the controller needs to intervene or take over that task from the tool/function if necessary.

In addition, continuous updated and in-depth descriptions of ATCO's expectations and practices of teamwork and automation is recommended.

7. Acknowledgement

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Appendix

Section 1. Current ATM system

The following section contains statements about your opinions regarding your current ATM system and controller position. With automation means a device or system that accomplishes (partially or fully) a function, task or event that was previously, or conceivably could be, carried out (partially or fully) by a human operator. Automation is a technical system that can propose decisions, make decisions and/or perform tasks and events with or without human involvement. When answering this section, you are supposed to think about the terms in general.						
Statement	**Answer**					
I consider the amount of automation (tools and functions) in my current ATM system to be	1 = Very low	2 = Low	3 = Moderate	4 = High	5 = Very high	Optional comment
I consider the safety in ATM today to be	1 = Very low	2 = Low	3 = Moderate	4 = High	5 = Very high	Optional comment
I consider my situation awareness when working in position today to be	1 = Very low	2 = Low	3 = Moderate	4 = High	5 = Very high	Optional comment
I consider my general workload when working in position today to be	1 = Very low	2 = Low	3 = Moderate	4 = High	5 = Very high	Optional comment
I consider my confidence in the automation tools that exists today to be	1 = Very low	2 = Low	3 = Moderate	4 = High	5 = Very high	Optional comment
I consider my trust in the automation tools that exists today to be	1 = Very low	2 = Low	3 = Moderate	4 = High	5 = Very high	Optional comment
I consider my control over the automation tools that exists today to be	2 = Very low	3 = Low	4 = Moderate	5 = High	6 = Very high	Optional comment
Question	**Answer**					
Please provide examples of what you believe is considered as automation in current ATM systems	Free text answer					
Do you think that automation in ATM today contributes to anything positive? Why or why not? Please specify.	Free text answer					
Do you think that there are any issues concerning automation in ATM today? Why or why not? Please specify.	Free text answer					
Any other comments?	Free text answer					

Section 2. Teamwork

The following section contains statements about how you would like to work with a future automation tool/fucntion. With the future means a time horizon of 10-15 years where automation could be more advanced decision support tools and where the automation could potentially make decisions and execute actions with or without human involvement. When answering this section, you are supposed to think about automation in general and how you want the future collaboration with automation to look like.						
Statement **When working with an automation....**	**Answer**					
I should be able to trust the automation	1 = Very much disagree	2 = Disagree	3 = Neutral	4 = Agree	5 = Very much agree	Optional comment
I should know what the automation is doing all the time	1 = Very much disagree	2 = Disagree	3 = Neutral	4 = Agree	5 = Very much agree	Optional comment
I should know the reasoning behind the automation's suggestions	1 = Very much disagree	2 = Disagree	3 = Neutral	4 = Agree	5 = Very much agree	Optional comment
I should know the reasoning behind the automation's decisions	1 = Very much disagree	2 = Disagree	3 = Neutral	4 = Agree	5 = Very much agree	Optional comment
the automation should only provide suggestions for me to chose from	1 = Very much disagree	2 = Disagree	3 = Neutral	4 = Agree	5 = Very much agree	Optional comment
the automation should make decisions without my involvement	1 = Very much disagree	2 = Disagree	3 = Neutral	4 = Agree	5 = Very much agree	Optional comment
I should be able to take the control over the situation from the automation whenever I want	1 = Very much disagree	2 = Disagree	3 = Neutral	4 = Agree	5 = Very much agree	Optional comment
I should be able to delegate control to the automation whenever I want	1 = Very much disagree	2 = Disagree	3 = Neutral	4 = Agree	5 = Very much agree	Optional comment
the automation should be able to take control from me if necessary	1 = Very much disagree	2 = Disagree	3 = Neutral	4 = Agree	5 = Very much agree	Optional comment
I should be able to communicate verbally with the automation	1 = Very much disagree	2 = Disagree	3 = Neutral	4 = Agree	5 = Very much agree	Optional comment
the automation should know my stress level	1 = Very much disagree	2 = Disagree	3 = Neutral	4 = Agree	5 = Very much agree	Optional comment
the automation should know my workload	1 = Very much disagree	2 = Disagree	3 = Neutral	4 = Agree	5 = Very much agree	Optional comment
the automation should know what I am looking at	1 = Very much disagree	2 = Disagree	3 = Neutral	4 = Agree	5 = Very much agree	Optional comment
the automation should know what I am doing	1 = Very much disagree	2 = Disagree	3 = Neutral	4 = Agree	5 = Very much agree	Optional comment
Question	**Answer**					
What kind of automation would you like to have/work with?	Free text answer					
How would you like to work with an automation? (For example, when solving an everyday problem, when making a decision, when monitoring a simple task etc.?)	Free text answer					
Any other comments?	Free text answer					

Section 3. Future ATM system

The following section contains statements about your opinions regarding the future ATM system and controller position. With the future means a time horizon of 10-15 years where automation could be more advanced decision support tools and where the automation could potentially make decisions and execute actions with or without human involvement. When answering this section, you are supposed to answer what you think will happened within the field of automation.						
Statement	**Answer**					
In the future, I think the general amount of automation compared with today will	1 = Very much lower	2 = Lower	3 = The same	4 = Higher	5 = Very much higher	Optional comment
In the future, I think my general situation awareness compared with today will be	1 = Very much lower	2 = Lower	3 = The same	4 = Higher	5 = Very much higher	Optional comment
In the future, I think my general workload compared with today will be	1 = Very much lower	2 = Lower	3 = The same	4 = Higher	5 = Very much higher	Optional comment
In the future, compared with today, I think my confidence in the automation tools that will exist will be	1 = Very much lower	2 = Lower	3 = The same	4 = Higher	5 = Very much higher	Optional comment
With increased automation in the future, I think the level of general safety compared with today will be	1 = Very much lower	2 = Lower	3 = The same	4 = Higher	5 = Very much higher	Optional comment
To be able to successfully prevent air incidents/accidents in the future, I think the amount (quantity) of automation compared with today needs to be Please specify why.	1 = Very much lower	2 = Lower	3 = The same	4 = Higher	5 = Very much higher	Optional comment
To be able to successfully prevent air incidents/accidents in the future, I think the quality of the automation compared with today needs to be Please specify why.	1 = Very much lower	2 = Lower	3 = The same	4 = Higher	5 = Very much higher	Optional comment
To be able to utilize airspace more efficient compared with today, I think the amount of automation in ATM needs to be Please specify why.	1 = Very much lower	2 = Lower	3 = The same	4 = Higher	5 = Very much higher	Optional comment
In the future, compared with today, I think the grade of automation to support the air traffic controller's monitoring of traffic flow will be Please specify why.	1 = Very much lower	2 = Lower	3 = The same	4 = Higher	5 = Very much higher	Optional comment
In the future, compared with today, I think the grade of automation to support air traffic controller's active controlling tasks/tactical work will be Please specify why.	1 = Very much lower	2 = Lower	3 = The same	4 = Higher	5 = Very much higher	Optional comment
Question	**Answer**					
Do you think there is a need for more or more advanced automation in the future compared with today? Why or why not? Please specify.	Free text answer					
Do you personally want to have more automation in the future compared with today?	Free text answer					
Do you personally want automation to be more advanced in the future compared with today? Why or why not? Please specify.	Free text answer					
Do you think that there will be any issues concering automation in ATC in the future?	Free text answer					
Any other comments?	Free text answer					

Section 4. Demographic

The following section contains demographic questions about you and your role as an air traffic controller.	
Question	**Answer**
Gender	Male Female Don't want to specify
Age	Not yet turned 20 Turned 20 but not yet 30 Turned 30 but not yet 40 Turned 40 but not yet 50 Turned 50 but not yet 60 Turned 60 but not yet 70 70 or older
Current endorsement/rating? (multi choice)	En-route control Approach control Tower control Air traffic control assistant Flight data operator Other, please specify
Main type of traffic you handle on a daily basis? (multi choice)	Commercial flights General aviation Military flights Other (police, ambulance, search and rescue, etc.)
Total years of experience working operationaly as an air traffic controller?	
Beside working in position/operational, do you regularly work with development/innovation/analysis or planning questions related to automation? If yes, please specify.	Yes / No Free text
If the researchers have any further questions or clarifications, would you like to be contacted by the researchers? Please fill in your email-address. (your respones will still be anonymous)	