Active Supervision in a Remote Tower Center: Rethinking of a New Position in the ATC Domain

Maik Friedrich(✉), Felix Timmermann, and Jörn Jakobi

German Aerospace Center, Lilienthalplatz 7, 38108 Braunschweig, Germany
Maik.Friedrich@dlr.de

Abstract. Air Traffic Control Officers are the most valuable resource in the Air Traffic Control Domain. They devote their full capacities into safe and efficient traffic control. The Remote Tower Center is the next step to use this resource as efficient as possible, optimizing the existing methodologies and procedures. The initial concept for the Remote Tower Center contains a supervisor. Therefore, this paper focusses on the supervisor and how the supervisor workplace is defined as a coordinating and support position for all Multiple Remote Tower Modules in the center. Based on the existing concept of multiple remote tower operations and the supervisor workplace, two research questions were proposed to analyze the supervisor working position in combination with the multiple remote tower workplaces. A real time simulation study was conducted and a total of 15 air traffic control officers from two air navigation service providers participated. Due to the difficulty of comparing two different workplaces, the data analysis is based on descriptive data collected from the questionnaires. The study analyzed the application and handling of use cases as a reference for realistic task descriptions during a multi workplace real time simulation. The results show that the selected use cases represent the task of the supervisor and can help to validate the workplace. This study also shows the different perceptions of task handling within the remote tower center.

Keywords: Multiple remote tower · Supervisor · Real-time simulation · Cooper-Harper scale

1 Introduction

The most valuable resource in the Air Traffic Control (ATC) Domain are the Air Traffic Control Officers (ATCO) that fully devote their capacities into safe and efficient traffic control. To use this resource as efficient as possible, a steady process of developing and optimizing the existing methodologies and procedures is needed. As an alternative for the traditional tower control operations, remote tower has been researched for the last two decades. Remote Tower Operations (RTO) in general are a solution for airports with a low amount of traffic to efficiently distribute their resources. The concept is based on single Remote Tower Operation, which is the control of one airport from a distant location. Weber [1] presents the first German remote tower operation of Saarbrücken

D. Harris and W.-C. Li (Eds.): HCII 2022, LNAI 13307, pp. 265–278, 2022.
https://doi.org/10.1007/978-3-031-06086-1_20

airport from Leipzig center. Saarbrücken is 450 km away from Leipzig, but RTO allows a safe and efficient monitoring of the airport. In the next years, the number of airports remotely controlled from Remote Tower Center Leipzig will increase.

With single remote tower operations proven to be operational, further research focuses on the Multiple Remote Tower Operations (MRTO). MRTO is the provision of ATC for more than two airports at the same time from one workplace. These concepts enable the air navigation service (ANS) providers to rethink their existing workplaces and role assignments and open up new working positions in the ATC domain. Besides an efficient use of ATCOs, MRTO has a positive influence on the hazard of boredom [2, 3]. Even so MRTO have their advantages, Möhlenbrink, Friedrich and Papenfuss [4] claim that one of the major challenges for MRTO is to keep a separate mental picture for each remote-controlled airport and safely switch between those. Generating and keeping a mental picture can be difficult especially in high workload situations [5]. Workload can increase depending on the traffic situation on each individual airport and the resulting traffic mixture.

Following this connection between high workload traffic mixtures and performance [for a summary see 6], methodologies that reduce the occurrence of those situations are needed to ensure a successful transition from single to multiple remote tower. Based on the tower supervisor position, a remote tower center supervisor is considered as a first approach to coordinate the traffic in advance to monitor current and anticipated task load and to balance workload for the individual ATCOs. This paper supports the MRTO concept by analyzing the remote tower center supervisor position.

2 Remote Tower Center with Supervisor

The initial concept for the Remote Tower Center (RTC) supervisor (SUP) is still research in progress [7]. For the purpose of this paper, the supervisor is defined as a coordinator and support position for all Multiple Remote Tower Modules (MRTM) in the center. Each MRTM is considered to have one active ATCO and up to three Airports that are controlled remotely at the same time. Figure 1 shows an overview of the RTC and the main interaction of the SUP with MRTM and airports. The main task of the SUP workplace is to gather pre-tactical data from all airports, plan a distribution of airports onto workplaces that reduce the traffic load for each individual MRTM and implement this plan. The implementation is done with split & merge operations, which means the supervision of an airport is split from one MRTM and merged into another one. The method of communication between SUP and MRTM should be directly via voice or telephone. The tactical information from the airport to the SUP workplace should be transferred automatically and can include e.g. weather and amount of traffic.

Secondary tasks of the SUP are to support each individual MRTM with additional coordination, if requested. Therefore, additional ways of communication are required, especially in connection to each airport, e.g. telephone of the approach control. Additional information for each individual airport, like out-of-the-window view or radar are only available on the MRTMs. Derived from both aspects of the task, the SUP workplace should include ATC functionalities, e.g. weather information and traffic distribution for each airport and radio communication to each ATCO.

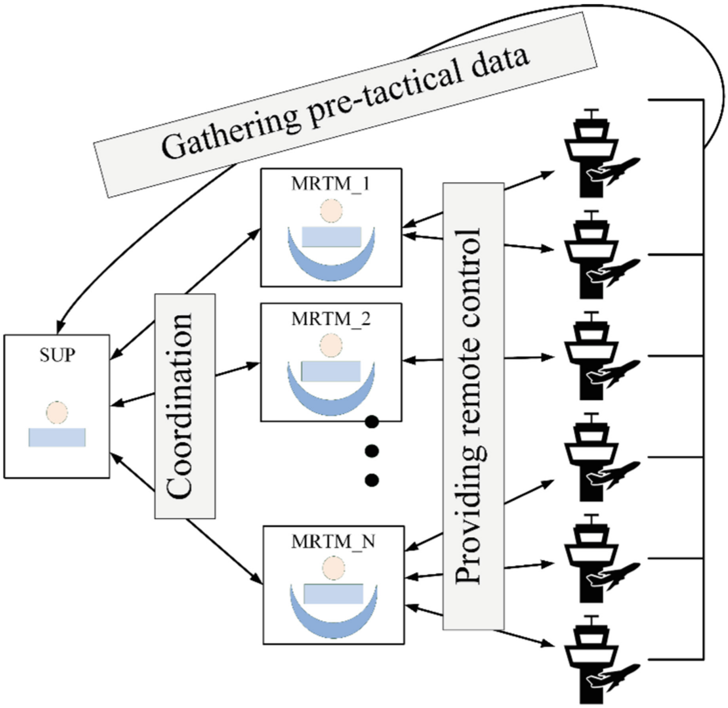

Fig. 1. Set-up for remote tower center supervisor, from [7]

In accordance to the EUROCONTROL/FAA [8] white paper for human performance, the majority of operational procedures can be measured by use cases. Therefore, three design workshops with the focus on general requirements for the remote center supervisor workplace, main use cases and additional use cases were conducted. Friedrich, Timmermann and Jakobi [7] used a user-centered design approach to develop the operational procedures and identified use cases that are relevant for the SUP. Following the MRTO concept, these use cases represent tasks that are expected from the SUP to handle multiple times throughout a shift. For this paper, we focus on the following nine use cases (Table 1), selected from [7]. Each use case requires a mix of information, from the airports and the MRTM directly, that need to be processed by the SUP and transferred into a planning for the near future.

In the context of the use cases (Table 1), two trigger directions for activation were identified. The first is bottom up, which, in this context means, the ATCO of one of the MRTM starts the use case by requesting support. The second is top down, when the SUP initiates the use case by gathering information from airports or asking ATCOs about their availability. Because the SUP is supporting up to 15 MRTM positions, there is a strong connection between his/her workload and the workload of the ATCOs. The general dynamic between the SUP and the ATCOs is an important factor of the concept and needs to be considered for the analysis.

Table 1. Nine use cases that represent the SUP tasks, from [7]

Use Cases	Description
Daily planning	Due to an unexpected event an ATCO is not available for his/her shift that starts in a couple of hours
Handling SUP/ATCO request	Due to unforeseen increased traffic volume on a specific airport, either the ATCO on a MRTM or the SUP requests the split & merge of a specific airport away from the MRTM to another position
Scheduled workload increase	Due to expected increased traffic volume on a specific airport, the SUP requests the split & merge of a specific airport away from the MRTM to another position
Scheduled airport closing	The scheduled closing of an airport begins and the airport needs to be closed
Scheduled airport opening	The scheduled opening of an airport needs to be handled
Unplanned airport closing	Due to severe weather events in the near future (e.g. low visibility) a specific airport has to be closed
Unplanned airport opening	An aircraft requests landing for an airport that is closed
Unplanned runway closing	Due to a technical failure an aircraft blocks the runway on a specific airport
Unscheduled ATCO replacement	Due to unexpected circumstances, an ATCO has to be relieved and replaced for some time by another ATCO (Ex. health issues) from his/her MRTM

3 Research Questions

Based on the existing concept of multiple remote tower operations and the introduction literature to the workplace SUP [7], the following research questions (RQ) are proposed. RQ1: How realistic is this SUP workplace in terms of operational feasibility for MRTO? Due to the current level of the concept this RQ is important to understand if further investigation into the topic is sensible. RQ2: How does the handling differ between a traditional supervisor role and a SUP in an RTC?

With regard to RQ1 we hypothesize that, due to the close relation to an existing supervisor position workplace in a traditional tower, the ATCOs have no difficulties in understanding the purpose and the necessity of the SUP working position. We also hypothesize (RQ2) that workload for the SUP as well as the ATCOs at the MRTM will always be well-balanced, without under- and overload situations and without situations with impaired safety. As an extension to RQ2, it is important to consider that SUP and MRTM are exposed to the same use cases but from a different perspective.

4 Method

A real time simulation study was conducted to create an environment that allows to simulate the selected use cases and analyze the SUP's behavior in a realistic environment.

The selected 9 use cases and the implication for a validation from Friedrich, Timmermann and Jakobi [7] were the basis for the experimental set-up and design of the study.

4.1 Participants

The sample consists of a total of 15 ATCOs (14 male/1 female) from two ANS providers. Eight were recruited from Oro navigacija (Lithuania) and seven from PANSA (Poland) and participated voluntarily during their working hours. Therefore, all participants were active ATCOs. Table 2 shows an overview of the demographic information and the work experience as tower ATCO and tower supervisor. It has to be noted that not all participants have supervisor experience, but due to their training, they all had knowledge of the supervisor working position. The study was performed in accordance with the General Data Protection Regulation (EU) 2016/679.

Table 2. Democratic overview of age and work experience (in years)

	Age	ATCO experience	Supervisor experience
M	39,20	12,80	3,20
SD	5,36	6,83	4,09
Min	32	4	0
Max	46	22	15

4.2 Design and Material

For this study, the set-up of a Remote Tower Center (RTC) was simulated in a high fidelity setting. One SUP, two real MRTM (Module 1 and 2) and 4 virtual MRTM (Module 3 to 6) were simulated to create a RTC. Authentic traffic patterns and flight information were simulated by the NARSIM [9]. The MRTM had the possibility to provide air traffic service via radio communication. The radio communication between the airports was coupled and each ATCO had a headset. In addition, radar, out-the-window view, weather and flight strips for up to three airports could be activated on each MRTM. A detailed description for the MRTM is available by [10].

A within-subject design was used for the factor working position. In order to minimize the learning effect two almost similar scenarios were used. The difference between scenario 1 and 2 was the order of the emerging use cases and scenario 2 had 4 additional use cases with coordination phone calls. These use cases had a duration of approximately 30 s and only required an additional phone call. The amount of traffic was kept similar. The scenarios represent normal workday situations within a RTC. The planned duration for each scenario was approximately 60 min. The traffic volume on each MRTM had a maximum of 7 movements in parallel independent from the airports. The supervisor position overlooked a total of 15 airports. Even though the focus of the validation was the SUP, data of handling qualities and performance during the use cases was collected from every working position.

Each use case (Table 1) depended on traffic situations. Use cases could be activated either by time (opening of an airport) or by traffic situation, e.g., the amount of parallel movements was expected to exceed 8 at a single MRTM (use case "Scheduled workload increase"). The traffic load for a single airport was derived from its usual amount of traffic. For example, a mid-sized airport had around 12 movements per hour, whereas a small airport had approximately 4 to 6 movements. Important for the scenario and the use cases was the traffic distribution generated by combining different airports on one MRTM. In general, the use cases were planned to happen at least once per scenario. Only "scheduled airport opening" and "scheduled workload" were planed with an average of two, because they are the common use cases for the SUP task.

Figure 2 shows the experimental set-up in the TowerLab [3] at the Institute of Flight Guidance, German Aerospace Center (DLR). For this study it was assumed that one ATCO can only hold 4 endorsements at a time. The ATCO on MRTM 1 always held the endorsements for Aalborg Airport, Aarhus Airport, Billund Airport and Budapest Ferenc Liszt International Airport. The ATCO on MRTM 2 always held the endorsements for Billund Airport, Budapest Ferenc Liszt International Airport, Debrecen International Airport, and Pápa Air Base. This allowed for a possible handover of either Billund or Budapest airport, because these endorsements were available by both ATCOs. The virtual ATCOs were available via telephone.

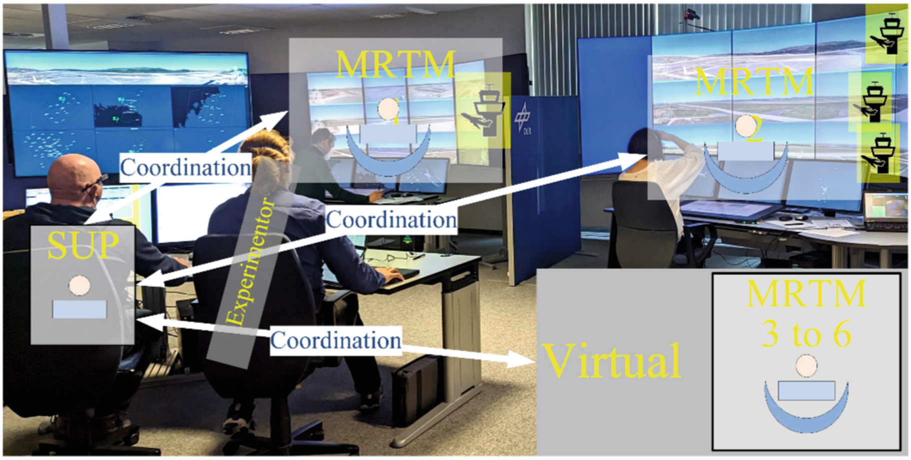

Fig. 2. RTC real-time simulation set-up with one remote tower supervisor position (SUP) and two multiple remote tower module (MRTM_1 and MRTM_2)

Derived from the use cases, system requirements were identified for a tool to support the SUP in his/her tasks. The tool provided the SUP with an overview of the 15 airports and their opening and closing times. Weather, traffic density and technical status were also indicated for each airport. In addition, a pool of 10 available ATCOs was provided, including a list of their individual endorsements. The SUP tool also provided an overview of 6 MRTM, that the SUP could use to assign airports and ATCOs and thereby keep track of the current configuration within the RTC. The SUP tool also provided warnings if the expected traffic load for a MRTM was to increase above the number of 8 movements in parallel.

4.3 Procedure

The study was conducted from the 15th of November to the 1st of December in 2021. The 15 participants were assigned to 5 groups of three participants. Each group was scheduled for two days. Each group received a briefing describing the MRTO concept, the SUP and MRTM workplaces, and the MRTO procedure. Written consent for the recording of personal data was gathered from each participant. Then, a training session with a duration of approximately 40 min per person started. The participants used this time to familiarize themselves with the two workplaces, and the procedures to handle the traffic. After the training, the participants were randomly assigned to either SUP, MRTM 1 or MRTM 2. The positions were changed after each run.

A total of 6 runs (2 scenarios, twice per participant) were performed, three on day one and three on day two. The duration of each run varied between 55 and 60 min, depending on the decisions each SUP made during the run. The participants on either MRTM controlled up to three aerodromes in parallel. During each run, only the SUP answered questions after finishing a use case. After each run all participants completed a standard and a tailor-made questionnaire for the workplace they previously worked at. Each group of participants was debriefed together.

4.4 Data Analysis

Due to the comparability of the two workplaces, the data analysis is based on descriptive data collected from the questionnaires. Dependent on the SUP or the MRTM the participants have to act and react differently in each use case. On the one hand this increases the realism of the experimental set-up, and on the other it allows only for comparison of workload and safety level on a subjective level. It also allows for realistic feedback on the general MRTO concept, which is especially important for RQ1.

A tailor-made questionnaire was developed to identify the feasibility of the SUP workplace and its operational practicability within the MRTO. The questionnaire consisted of 6 statements that the participants could agree or disagree on a 5-point scale ("Strongly disagree", "Disagree", "Neither disagree nor agree", "Agree", "Strongly agree"). The participants completed the questionnaire after each run they worked at the SUP workplace (scenario 1 and 2). The 6 statements are available in Fig. 3.

The subjective handling and perceived safety from both workplaces were collected with the cooper-harper scale [11]. To account for the specifics of the work environment the cooper-harper scale was adapted for the SUP and MRTM. The adapted cooper-harper scale had 10 steps that allows to evaluate if the use case was controllable, impairments in situational awareness could be expected, or safety critical situations would arise. The scale value 1 to 3 indicated efficient and smooth workflow. The scale values from 4 to 6 indicated adequate situation awareness. The scale values from 6 to 9 indicated safe controllability of the situation and 10 indicated an unsafe situation.

At the SUP workplace the ATCOs were questioned directly after each completed use case during the scenario. The MRTM were questioned with the post run questionnaire. Therefore, the results from the SUP workplace were summarized for each run. Even so, the influence between the workplaces cannot be distinguished and therefore they have to be evaluated separately. The same applies to our interpretation of the results in the Discussion and Conclusion sections.

5 Results

Following the research questions, the result section is divided into two sub sections. The data collection worked properly without any technical issues. A restriction of the results is, that due to the degree of realism and the structure of the scenarios, not all needed use cases could be simulated during each run.

5.1 SUP Workplace in General

The first analysis concerns the feasibility of the concept for a supervisor workplace with regards to MRTO (RQ1). Figure 3 presents the agreement or disagreement for each statement supporting RQ1. Each statement was presented once per scenario to each participant. The analysis shows that the majority of the participants agreed that the SUP workplace provides an appropriate addition to the RTC. They even agreed by taking the complexity of the task itself or the traffic volume presented in the scenarios into account. The participants also agreed that the provided SUP tool supported them during the split and merging procedures. The answers of the participants suggest that they did in general neither disagree nor agree with the procedures used to split & merge the aerodromes between the MRTM, nor did they feel supported by the SUP tool to prepare for those operations.

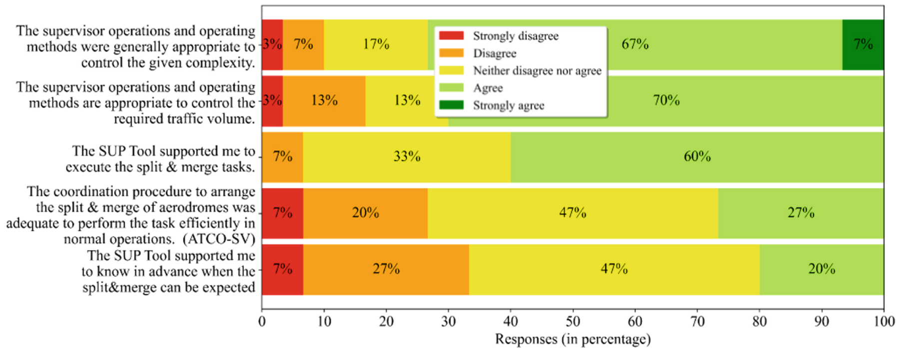

Fig. 3. Agreement or disagreement to the tailor-made questions twice per scenario for each participant

5.2 Handling of SUP and ATCOs

The second analysis concerns the perceived quality of handling for each workplace. This analysis is separated into two steps. First, the amount of answers per use case, scenario and working position is analyzed to identify the comparability of the results. Second, the analysis focuses on the subjective rating to each workplace and the use cases with direct interaction between the workplaces.

Quantity of the Use Cases. All participants at the MRTM completed the tailor-made questionnaire twice but not all experienced the same use cases in their exercises and therefore were not always able to provide answers regarding the requested use cases. This is similar for the SUP workplace if not all use cases could be handled during a run, and the questioning was always done directly after each use case. Therefore, the amount of responses to the use cases varies between the scenarios and the workplaces. another difference is the unbalanced workplace distribution per run. While one participant worked as SUP, two participants worked on the MRTM. This means that every time the adapted cooper-harper scale is completed for a use case by the SUP, it is completed twice from the MRTM perspective after the run.

In preparation for the understanding of the later analysis and to get an overview of the frequency of use cases, the amount of answers collected was evaluated. Table 3 presents the amount of answers collected for both workplaces separated per use case and scenario. The use cases “Daily planning”, “Scheduled airport closing”, “Unplanned airport closing”, “Unplanned airport opening”, “Unplanned runway closing”, “Unplanned airport closing”, and “Unscheduled ATCO replacement” together occurred with an average of 1 per scenario for all SUPs. Only the use cases “Scheduled airport opening” and “Scheduled Workload” occurred 2.45 times per scenario for the SUP. Since the ATCOs on the MRTM were only questioned at the end of each run, their maximum of answers is 30. The ATCOs were instructed to not answer the question if they did not experience the use case during the last run. This leads to an average of 24.6 answers per scenario and MRTM.

Table 3. Amount of answers to each use case per scenario for SUPs and MRTM

Use Cases	Amount of Answers			
	Scenario 1		Scenario 2	
	SUP	MRTM	SUP	MRTM
Daily planning	14		17	
Handling SUP/ATCO request	19	24	23	25
Scheduled airport closing	15	25	17	26
Scheduled airport opening	39	27	40	27
Scheduled Workload increase	38	26	30	27

(*continued*)

Table 3. (*continued*)

Use Cases	Amount of Answers			
	Scenario 1		Scenario 2	
	SUP	MRTM	SUP	MRTM
Unplanned airport closing	17	21	19	25
Unplanned airport opening	14		16	
Unplanned runway closing	13		13	
Unscheduled ATCO replacement	13	21	13	22

Handling Use Cases for Each Workplace. The next analysis focused on the distribution of workload per use case and scenario. Figure 4 presents the answers to the adapted cooper-harper scale per use case and scenario for the SUP. From an overall of 370 answers, the results show that only 1 use case was classified as safely controllable and 328 use cases were classified with 3 or less. Even though scenario 2 had an increased number of use cases in total, no difference was found in the adapted cooper-harper scale for the single use cases.

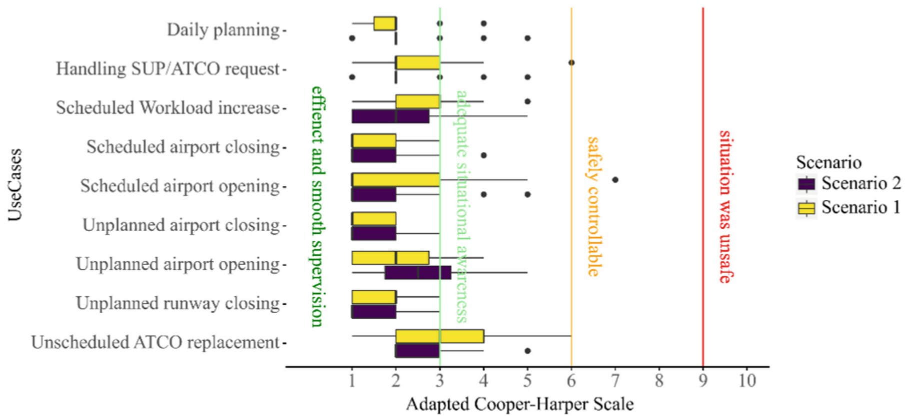

Fig. 4. Answer from the adapted cooper-harper scale per use case for the SUP

Figure 5 presents the answers to the adapted cooper-harper scale per use case and scenario for the ATCO workplace. From a total of 360 possible answers only 296 use case answers were given. The results show that 32 use case were classified as safely controllable and 233 use cases were classified with 3 or less on the adapted cooper-harper scale. As with the SUP, there is no influence or tendency of the factor scenario.

Interaction of Use Cases. The final analysis shows the direct comparison in handling the workplace. For this analysis the data for each scenario was combined, because the

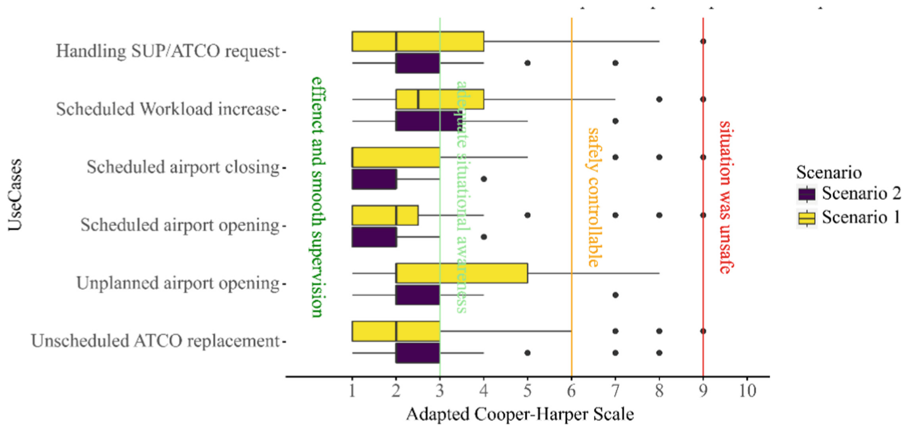

Fig. 5. Answer from the adapted cooper-harper scale per use case for the MRTM

previous analysis showed no influence. Also, the analysis only takes the use cases into account that were experienced at both workplaces. Figure 6 shows the adapted cooper-harper scale results for both workplaces and their interactive use cases. The results show that the average adapted cooper-harper scale was higher for each use case at the MRTM. The use case with the biggest difference is "Scheduled Workload increase".

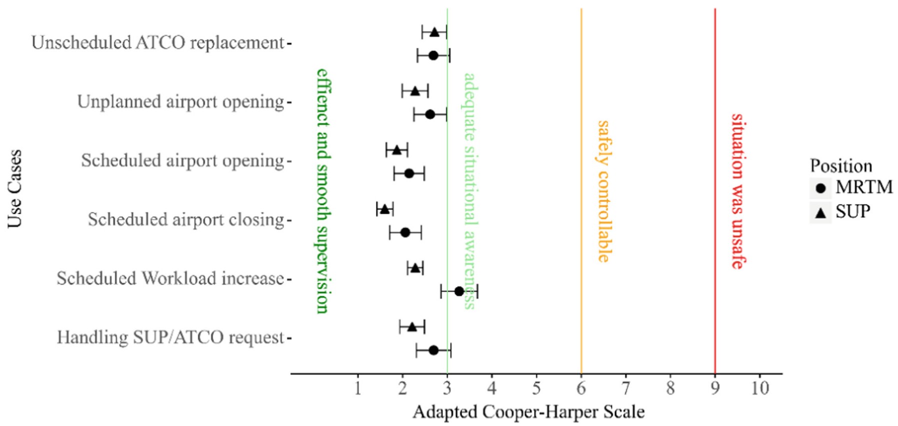

Fig. 6. Average answer with standard error from the adapted cooper-harper scale per use case for both workplaces.

6 Summary for the MRTO Concept

The following chapter summarizes the results individually for each RQ. The sample size of 15 ATCOs is relatively high for an expert sample size in aeronautical research domain, however, still low for inference statistics. The experimental set-up and the approach to compare two different working positions in one environment with unequal number of workplaces (one SUP and two MRTM) could only be covered with an explorative approach that provides a realistic environment to quantify the procedures with use cases. Because the requirements for inferential statistical analysis have not been met, the results are restricted to descriptive analysis. In the context of the development of a new working position and with a focus on RQs, a discussion about the results is essential.

Operational Feasibility of the SUP. As we expected from RQ1, the results for operation feasibility of the SUP shows general approval about the workplace itself. The idea of the workplace is derived from the tower supervisor, which is good for understanding the necessity and the benefits of such a workplace. An influential factor is the SUP tool and its quality to support the task. The SUP tool should provide needed information at the best time. The results suggest that the SUP tool was not as supportive as expected. Another challenge for the SUP is that the procedures were not defined clearly enough. Due to the explorative character of the study the participants were encouraged to explore different approaches for the split & merge procedures. This might have led to a reevaluation process during the split & merge situation and therefore to the results of the questionnaire.

Handling Different Workplaces. RQ 2 investigated how the handling of the different workplaces is perceived during normal operations. Normal operations were implemented as use cases that both workplaces had to complete at the same time. The analysis showed that the planning of the scenarios was successful and that all use cases were handled during the runs. The use cases could be implemented and performed as often as planned and, for some use cases, even more often. This increases the amount of data collected and thereby the quality of the study.

Even though scenario 2 had 4 additional use cases to scenario 1, the workload increase had no influence on the average adapted cooper-harper scale results. This leads to the assumption that either workload does not directly influence the perceived handling of a workplace or that the questioning after each use case, as it was for the SUP, minimized the effect of the general increased workload. Since there is no effect measured for the MRTM by applying the adapted cooper-harper scale after each run, based on this data, the first assumption would be the more plausible. This suggests that the adapted cooper-harper scale is independent from workload, which increases its explanatory power for the RQ2.

The ATCOs on each workplace subjectively identified problems with their own performance during the runs. The results for the interaction on use cases showed that the MRTM handling was more challenging. The results in general support the concept of the SUP workplace as a supporter for the MRTM. Even though the MRTM handling was rated as more intense, the rating on both workplaces expressed efficient and smooth supervision. Only for the use case "scheduled workload increase" the ATCOs on the MRTM stated that smooth and efficient supervision was not possible on average. The increased handling at the MRTM in relation to the SUP raises the idea to redefine the SUP even more as a supporter than a supervisor. Of course, the long-term planning is still only possible at the SUP workplace, but additional tasks could be found, e.g. supporting the split & merge process. Even so, the general handling of both workplaces seemed to be manageable.

7 Conclusion

In summary, this study aimed for the validation of a new workplace within the MRTO concept. Two RQs were postulated to evaluate the influence of the SUP to the RTC. The study analyzed the application and handling of use cases as reference for realistic task description during a multi workplace real time simulation. The results show that the selected use cases represent the task of the supervisor and can help to validate the workplace. RQ 1 is answered and the focus of the further development should be an improvement to the SUP tool and related new operational procedures. The results also show that a rethinking of the workplace is necessary and that the role of a an RTC SUP is more one of a strategical and tactical planner and dispatcher position than a the traditional Tower supervisor or back up ATCO as it is today. This is especially important for further development of the multiple remote center supervisor position.

Acknowledgements. The authors thank SESAR Joint Undertaking for funding this project as well as their project partners PANSA, Oro Navigacija and Frequentis for their collaboration. This project has received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No 874470.

References

1. Weber, E.: Remote Tower Control Centre in Leipzig. https://www.smartinfrastructurehub.com//blog//flexa-0 (2021) 14 Nov 2021
2. Fisherl, C.D.: Boredom at work: a neglected concept. Human Relations **46**(3), 395–417 (1993)
3. Hagl, M., Friedrich, M., Jakobi, J., Schier-Morgenthal, S., Stockdale, C.: Impact of Simultaneous Movements on the Perception of Safety, Workload and Task Difficulty in a Multiple Remote Tower Environment, pp. 1–9
4. Möhlenbrink, C., Friedrich, M., Papenfuss, A.: RemoteCenter: Eine Mikrowelt zur Analyse der mentalen Repräsentation von zwei Flughäfen während einer Lotsentätigkeitsaufgabe [RemoteCenter: A microworld for analysing the mental representation of two airports during the air traffic control task.], pp. 65–72
5. Kontogiannis, T., Malakis, S.: Strategies in controlling, coordinating and adapting performance in air traffic control: modelling 'loss of control'events. Cogn. Technol. Work **15**(2), 153–169 (2013)
6. Young, M.S., Brookhuis, K.A., Wickens, C.D., Hancock, P.A.: State of science: mental workload in ergonomics. Ergonomics **58**(1), 1–17 (2015)
7. Friedrich, M., Timmermann, F., Jakobi, J.: Supervising Multiple Remote Tower Operations: How to develop and test a new workplace in the ATC Domain?, In: HCI International 2021, Washington DC, USA (2021)
8. EUROCONTROL/FAA: Human Performance in Air Traffic Management Safety: A White Paper, Action Plan 15 Safety (2010)

9. Teutsch, J., Postma-Kurlanc, A.: Enhanced Virtual Block Control for Milan Malpensa Airport in Low Visibility, pp. E1–1 – E1–13
10. Friedrich, M., Hamann, A., Jakobi, J.: An eye catcher in the ATC domain: Influence of Multiple Remote Tower Operations on distribution of eye movements
11. Mansikka, H., Virtanen, K., Harris, D.: Comparison of NASA-TLX scale, modified Cooper–Harper scale and mean inter-beat interval as measures of pilot mental workload during simulated flight tasks, Ergonomics, 1–9 (2018)