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EXPERIMENTAL RESEARCH OF TERMINAL CONTROL AREA OPERATIONS UNDER UNCERTAINTY CONDITIONS

The experimental research of terminal control area operations under uncertainty conditions is considered. The Identification and assessment of threat factors in air traffic controller operation, identification of the point of controllers' extreme operational conditions appearance and recommendations on associated errors capture and mitigation and improvement of airspace structure on the strategic planning phase are considered.

Introduction

The workload of a controller must be accurately assessed to permit optimum efficiency. If it is too high for too long, they may be overstretched. That is why it is necessary to define, when exactly the extreme conditions for controller operations start to appear and to identify possible consequences of this as well as to provide countermeasures to avoid them with the aim of supporting effective safety provision.

Considering specificity and complexity of process of ATCO activity in terminal control area (TMA), identification and analysis of threat and risk factors are extremely important task of Safety Management System with the purpose to maintain correspondent safety level. In this term EUROCONTROL has developed Air Navigation system Safety Assessment Methodology, ANS SAM) that includes threat and risk assessment. Methodology provides implementation of necessary strategies for maintenance of acceptable safety level, constant monitoring, regular assessment of achieved safety level and making continuous improvement to the overall level of safety [1-4].

Identification (assessment) of threat factors in ATCO operation under uncertainty conditions

On the basis of existing risk assessment principles, specific method of assessment concrete identified threats examples was developed that is applicable for operation of ATCO of TMA. The first step of conducted investigation was identification of main threats during operation of controller in terminal area. The next stage was making of creating questionnaires and making survey among group of air traffic controllers of correspondent workplace. Respondents should arrange the values of probability (from 1 to 100%) and severity (from 1 to 10) that treat will occur (Table 1).

The next step of investigation was creation of matrix of threats and risks that were characterized in term of severity and probability and definition of temporary, acceptable and non-acceptable regions. Assessed threats were put into matrix and it was defined regions what definite threat was belong to. For threats that belong to non-acceptable region the specific strategies of control and mitigation are applied. Application of such a strategies transit threats to the temporary area and then specific methods are used to transit them to acceptable region. In case if strategies are not applicable then activity that revoke definite threat should be terminated.

Table 1

Results of questionnaire among ATCO of TMA

№	**Threat**	**Probability (0-100%)**	**Severity (1-10)**
1	Variable flight profile	85	3
2	Insufficient horizontal size of TMA for maneuvering (in case of high intensity)	70	4
3	Adverse meteorological conditions	90	8
4	Go-around aircraft	40	4
5	Aircraft that perform flight in holding area	35	2
6	Errors of adjacent ATCO	20	4
7	Errors of ATCO passing of duty	25	4
8	Technical maintenance of ground equipment	80	5
9	Failures of airborne equipment	35	6
10	Psycho physiological state of ATCO	25	5
11	Psycho physiological state of pilot	25	6
12	Professional training of ATCO	23	7
13	Professional training of pilot	23	7
14	ATC in contested airspace (ATC without co-ordination)	65	8
15	Similar callsigns	35	4
16	Excessive (insufficient) workload of ATCO	60	6

Identification of the point of controllers' extreme operational conditions appearance and recommendations on associated errors capture and mitigation

Defining the factors influencing workload increase

During the 1st step of the research there were firstly analysed literature resources and defined the factors that may contribute significantly to the increase of workload under uncertainty conditions. After that the participants were provided with a list of the most widespread factors that can cause extreme operational conditions during the shift. After analysing the results and calculating all necessary statistical characteristics there was obtained the ranking of the factors contributing to workload increase under uncertainty conditions. The first three of them were: high density of flights, bad meteorological conditions, bad cooperation with other controllers in a shift.

High density of flights was considered the most important and highly influencing factor on the air traffic controller workload by almost all the experts. That is why this factor will be further investigated by us in the second step of the research.

Investigation of the point of extreme operational conditions appearance

During the 2nd step of the research the participants were provided with the information regarding the workload categories as well as the map and some data regarding a special sector for which they had to perform the task. The task was to identify the number of ACFT for this exact sector at which the controller experiences each of the workload categories.

The obtained results were represented on the figure 1, which shows how workload increases and how its category changes according to controllers' opinions with increase of ACFT being simultaneously under control (under uncertainty conditions).

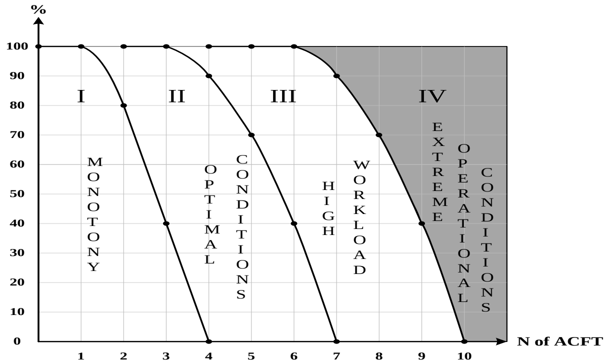

Fig. 1. Experimental correlation of workload from ACFT number under control

Identification of errors that may appear in extreme operational conditions

During this step there were identified errors that are most probable to occur in extreme operational conditions. The participants had to tick off those errors from the list, sorted to the categories, which, on their opinion, could be caused by IV category of workload described in previous step.

There was also found out that the most probable errors to occur in extreme operational conditions are as follows: missed calls, making incorrect inputs to the automated system, rushed handover, wrong clearance, altitude or heading communicated, misinterpretations of requests. These and other errors that have a possibility of occurrence more than 50% were considered in the 4th part of the research and were provided with the countermeasures for their avoidance and mitigating.

Providing recommendations and countermeasures

After providing the investigation there were offer certain countermeasures that can help to avoid and/or neutralize the exact errors that are most probable to occur under extreme operational conditions as this state is the most dangerous and errors mitigating during it has the greatest influence on safety provision. For this purpose there were analyzed known resources and composed a list of countermeasures that can be used to avoid errors mentioned in step 3 of the research. The list included such countermeasures as enhancing the team climate, improving planning and execution procedures, providing necessary reviews and modifications and organizing trainings for the personnel.

Improvement of airspace structure on the strategic planning phase

The newest route structure that is being currently implemented in the major European TMAs is Point Merge System (PMS). To define what advantages PMS brings to the Kyiv TMA the modelling of PMS arrivals was performed with the help of NEST modelling tool provided by EUROCONTROL.

After trajectories simulation was performed it is possible to analyse whether the route structure is efficient using traffic indicators. With the help of functions embedded in NEST the route length, airspace load and workload of current Kyiv TMA route structure and PMS were performed under uncertainty conditions. The results showed the decrease in route length by 3209.6 nm (1.28%). The comparison of workload is shown in Fig. 2. Moreover, capacity evaluation was performed using CAPAN methodology with the help of MatLab.

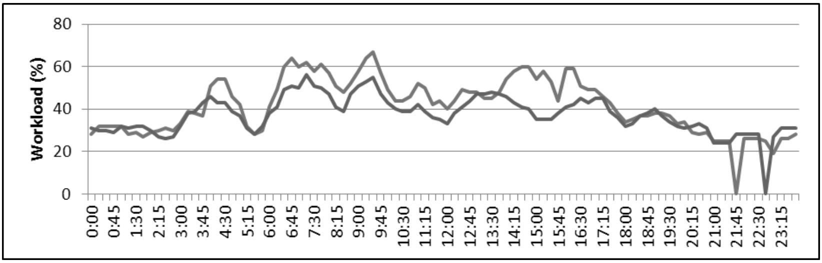

Fig. 2. Comparison of ATCO workload under current arrivals (blue) and PMS (red)

Conclusions

As the conclusion, the results of the experiment can be used in educational purposes and further researches on the topic (TMA operations under uncertainty conditions) as well as to utilize the developed countermeasures on practice for experienced air traffic controllers on the daily bases. This could help to enhance personnel knowledge regarding safety, decrease operational uncertainty and support safety provision by mitigating the errors that may occur, that is to encourage the first and main purpose of the aviation.

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