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Project ATCOSIMA – Air traffic Control Simulations at the Faculty of Transport and Traffic Sciences

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Abstract

Air traffic controller training is a highly regulated sector. It is prescribed by international rules and requirements. The important segment of training is the provision of practical exercises on air traffic control simulators. Although regulations prescribe required performance objectives for initial training, they do not set any assessment criteria on how to assess the candidates, nor do they consider any flight efficiency indicators. In this paper, an overview of the objectives of the ATCOSIMA project is presented. Baseline air traffic simulations performed at the Faculty of Transport and Traffic Sciences of the University of Zagreb were analysed in more detail explaining exercises, assessment criteria description, as well as the achieved candidates' scores.

Keywords: *simulation, air traffic control, air traffic controller, training, assessment, candidate, score*

1. Introduction

Air Traffic Controllers (ATCOs) are highly qualified professionals that provide air traffic control (ATC) service (and maintain safe, orderly and expeditious air traffic within the area of their responsibility. Their primary objective is to separate flights at the safe distance in the air and to separate flights on the manoeuvring area of an aerodrome. While doing that service, they prove different air traffic controller tasks such as: controlling and monitoring aircraft movement, planning, coordination, communicating with pilots using radio or data link, conflict search and detection and, finally, conflict resolution tasks in the airspace of their responsibility.

Since their job directly influences safety of air traffic, they have to be highly trained and skilled to acquire adequate competency for the provision of air traffic control. That is the reason why ATCO training is strictly prescribed by the international rules and regulations. At the global level, International Civil Aviation Organisation (ICAO) defines minimum standards and recommends practices for ATCO training in Annex I – Personnel Licensing [1] while at the European level, ATCO

training is regulated by the EU Regulation 340/2015 [2]. This regulation prescribes ATCO training requirements and conditions for acquiring ATCO license.

According to these regulations, ATCO training is defined with strict and serious requirements. Every candidate has to successfully finish two phases of ATCO training: initial and unit training [2].

Initial training includes basic and rating training. Basic training is defined as theoretical and practical training designed to impart fundamental knowledge and practical skills related to basic operational procedures [2], while Rating Training provides knowledge and skills related to a job category and appropriate to the discipline to be pursued in the ATS environment [2]. After finishing initial training, candidates acquire Student ATCO License which is a prerequisite for starting unit training.

The Unit Training leads to the issue of air traffic controller licence and includes operational procedures, training of specific tasks, abnormal and emergency procedures and human factors issues [2]. After successful completion of unit training, candidates finally acquire an ATCO License that gives them a privilege to provide air

traffic control service within specific airspace and to work with real air traffic.

The high level of ATCO knowledge and competences was a major purpose for development and implementation of a new more detailed uniform European standards of initial training comparing to the previous requirements [3]. This resulted in the development of the common core content for initial training which defines subjects, topics, taxonomy level and training methods [4].

Also, European regulation defines examination and assessment performance objectives for basic training and rating training.

Since ATCO has to be highly competent, skilled and trained to cope with the high traffic demand and possible unusual traffic situations, their training must impart theoretical knowledge and practical skills for all three types of air traffic control: aerodrome, approach and area control. Practical skills are trained and performed on the synthetic training device (STD) such as simulators and part-task trainers. Simulators are real-time human-in-the-loop computer-based devices that simulate important functions of the real situation of ATCO working positions, airspace, procedures, flight trajectories, while part-task trainers only enable simulation of partial ATCO functions. The main functionalities and requirements for acquisition or development of air traffic control simulators are researched in studies [5] and [6].

Despite the uniform standards of initial training, there are still differences in the training process, duration, organisation of courses, number of theoretical lessons, etc. Furthermore, there is neither a requirement for a minimum number of practical exercises on the simulator nor commonly defined assessment criteria for evaluating the candidate's performance during practical exercises.

There are not many previous studies on the training requirements of ATCOs and on how to evaluate the assessment of ATCOs. One of the studies proposed basic principles for evaluation during simulation exercises that assess candidates' performance in relation to safety indicators and workload, such as:air traffic separation, decision making implementation of ATC procedures, equipment usage, communication and coordination [7]. The other study proposed a candidate's performance measurement by counting mistakes and actions. [8].

There is some research on the training requirements under future conditions when the role of the ATCO changes due to technological improvements in the Air Traffic Management (ATM) system, such as increased automation [9]. None of these studies take into account the development of training assessment criteria.

Although ICAO and EU ATCO regulations define types of training, content, performance objectives, they do not define any standard assessment scoring and criteria to be used for ATCO performance and competency evaluation. [5].

On the other hand, Single European Sky (SES) regulations deal with the development of air traffic management in the coming years and take into consideration the continuous growth in air traffic, as well as its influence on the safety, capacity, environment and service costs. SES prescribes high-level targets and measurable indicators regarding flight efficiency and economics [10]. Although the importance of saving flight costs is enormous, these indicators are neither prescribed for ATCO training nor translated into evaluation criteria.

Taking these two arguments into consideration, Project Development of Common ATC Simulation Training Assessment Criteria Based on Future Pan European Single-Sky Targets (ATCOSIMA) is defined. It deals with the development of an innovative method for measuring ATCO candidate's performance during practical exercises in the simulated environment regarding safety and flight efficiency. This paper presents the project overview with the analysis of the simulator facilities and simulations done at the Faculty of Transport and Traffic Science of the University of Zagreb.

2. Project overview

Project ATCOSIMA is funded by the Erasmus+ Program/KA2 Cooperation Innovation and the Exchange of Good Practices/KA203 Strategic Partnership for Higher Education. Three European higher education institutions are participating within the project: Faculty of Aeronautics and Astronautics of Eskisehir Technical University (ESTU) as a coordinating organisation, Faculty of Transport and Traffic Sciences of University of Zagreb (ZFOT) and Institute of Flight Guidance of Technische Universität Braunschweig (TUBS) as partner organisations.

The main goal of ATCOSIMA project is to develop common assessment criteria to evaluate student performance during simulation exercises within ATCO basic training. The new assessment criteria should involve new indicators and metrics based on future Pan-European Single European Sky targets on flight efficiency.

The benefits of the new assessment criteria should be: more objective way to evaluate candidate's performance and skills during simulator exercises, shorter time for adaptation to new operational environment, shorter time and costs of rating and unit training, improved competences for provision of air traffic services in the future Pan-European air traffic management system, harmonization of training process etc.

The overview of the project methodology is given in Fig. 1. The project includes two important parts: first, a baseline simulations and analysis for evaluation of ATCO performance using current assessment criteria and training techniques and, second, development of the new assessment criteria which incorporates flight efficiency indicators based on the Pan-European Single European
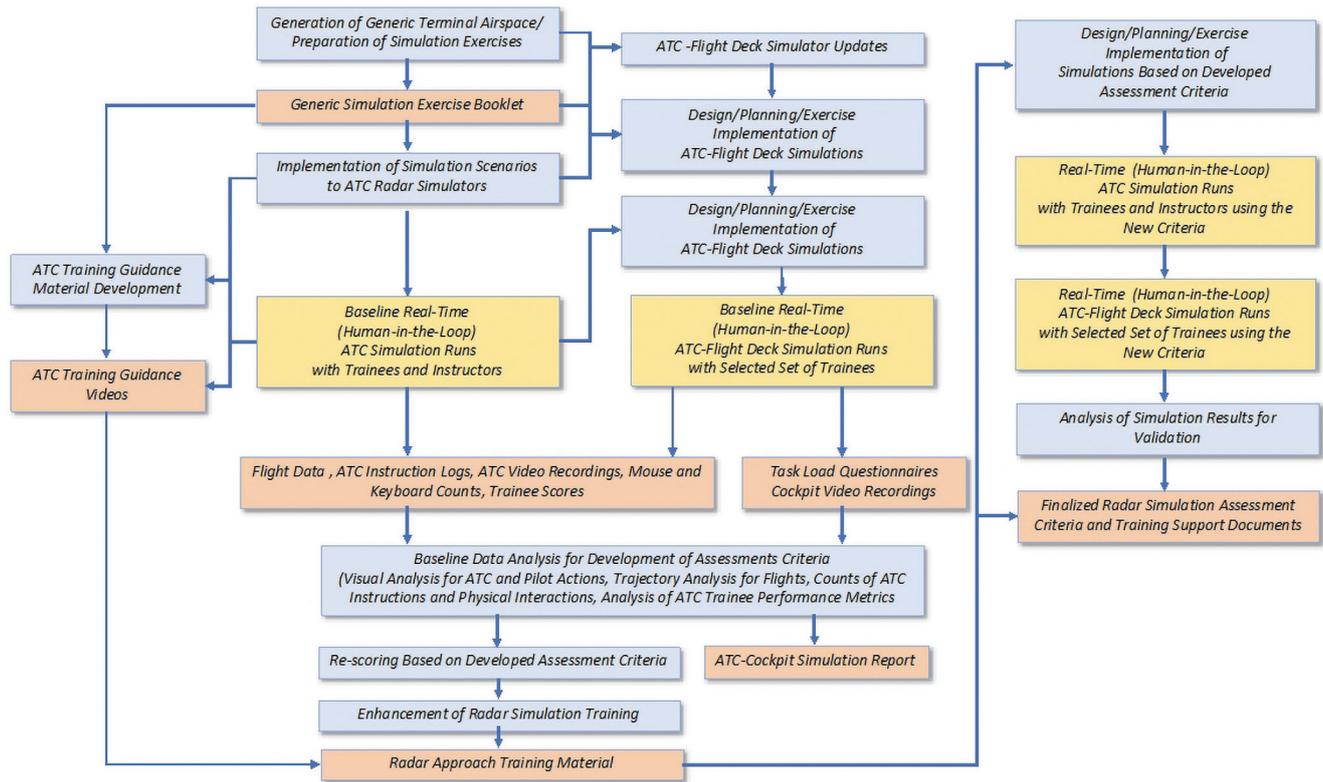
Fig. 1. Overview of the ATCOSIMA project methodology [11]

Sky targets, simulation and evaluation of ATCO performance using these new criteria.

Each project part consists of a set of planning, design, preparation and analysis task (marked by blue blocks), two types of the real time ATC human-in-the loop simulations (marked by yellow blocks) and five outputs that include results of planning and preparation tasks and analysis of collected and post-processed data (marked by red blocks) [11].

As can be seen from the project methodology, the crucial activities are human-in-the-loop simulations. There are two types of simulations to be done: the first one is performed at ATC Radar simulator while the other one is performed at integrated ATC Radar and Flight cockpit simulators. To put it more clearly, the first step simulations will be done at the ATC Radar simulator at the ESTU and ZFOT facilities. Both institutions have the same air traffic control simulator facility and educate future air traffic controllers within undergraduate study of aeronautics. That was a common baseline for the project implementation. The ATC simulator used for this project is Micronav ltd. BEST (Beginning to End for Simulation and Training) Radar Simulator used for air traffic control human-in-the-loop simulations.

The integrated ATC Radar and Flight cockpit simulator within TUBS's facilities enables ATCO human-in-the-loop real-time simulations and human-in-the-loop real time simulations in the A320 flight simulator. There are several output data to be collected from both simulation experiments: flight data logs, video replay files, ATC instructions, ATC voice recordings, mouse and keyboard count and assessment scores. Integrated ATC Radar and Flight cockpit simulations enable additional output data from the pilot's perspective such as: task load questionnaire and cockpit video recordings. [11].

3. Simulator facility at ZFOT

Faculty of Transport and Traffic Sciences owns a permanent license for BEST Radar Simulator from 2013. The simulator is a part of Laboratory for Air Traffic Control at the Department of Aeronautics. It consists of the software and hardware facilities. Hardware is PC based and gathers two ATCO working positions, one pseudo-pilot working position and one system manager working position which can be also used as a pseudo-pilot working position. The user interface is similar to the real ATC working environment. Each ATCO working position has a radar display, an auxiliary display, a voice communication interface display, a keyboard, a mouse, two sets of headphones and several communication switches (Fig. 2).

BEST Radar Simulator software enables simulations of area and approach radar air traffic control service, simulations of flight movement, flight data preparations, airspace design, exercise and scenario development, self-teach facilities etc. Flight movement is simulated according to the Base of aircraft data (BADA) performance model [12]. Simulator system manager enables recording and replay activities of the exercises, so every

Fig. 2. The ATCO working position of the BEST Radar Simulator at the Faculty of Transport and Traffic Sciences

recorded exercise can be played back. A replay of files can be paused at any time so candidates could be briefed about their performances [12].

The training process and the roles of all persons involved in practical simulation training and their interactions are shown in Fig. 3 [13].
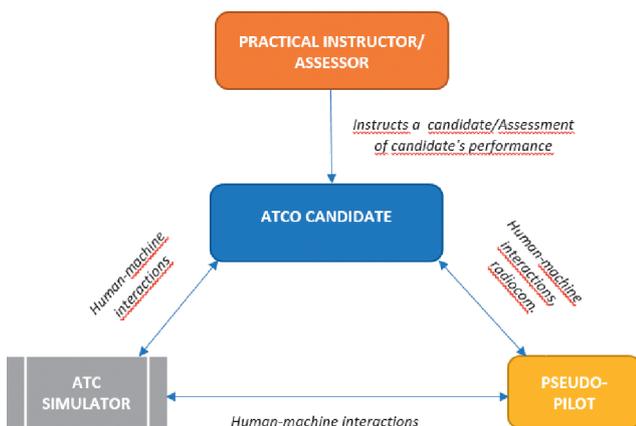

Fig. 3. Persons involved in the process of ATC simulations [13]

There are three persons involved in the simulations: ATCO candidate, pseudo-pilot and practical instructor/assessor. As it can be seen, there are constant HMI (Human-Machine Interface) interactions and relation of ATC Simulator-ATCO candidate, ATC Simulator-pseudo-pilot and ATCO candidates and pseudo-pilots when using radiotelephony communication. ATCO candidate monitors the radar display of ATC simulator, observes and analyses traffic situations according to traffic data and using adequate software tools to find a potential conflict and resolve it in a safe, accurate and expeditious way.

A candidate has to process a range of information and make a quick decision on what instructions to give to an aircraft. This process is a continuous process due to the simulated aircraft movement within the defined airspace.

Depending on traffic situations and traffic interactions, these tasks can vary from low to high complexity and stress, allowing candidates to manage, develop and improve their skills and attitudes.

Every change in a flight plan, every clearance or instruction given to the aircraft, ATCO candidate needs to mark in the flight strip. Flight strip is a specified form that has an important aircraft flight plan data (call-sign, level, entry point, exit point, heading, and speed) with the empty fields to be fulfilled with the ATCO markings. A flight strip can be an interactive electronic strip marked by mouse or keyboard or it can be a paper strip which is placed in the strip holder and marked with a pencil (Fig. 4).

Fig. 4. Paper flight strips used in simulations

Like ATC working position, the pseudo-pilot working position consists of the same hardware facilities. The pseudo-pilot working position is operated by a trained pseudo-pilot. This person knows how to run the simulation system, how to input data and how to communicate using appropriate radiotelephony communication.

Pseudo-pilot guides aircraft through defined airspace using human-machine interface and makes changes in progress of flight's trajectories according to the clearances and instructions given by ATCO or instructor. The pseudo-pilot inputs (using a keyboard or a mouse) different data given by the ATCO candidate regarding the flight trajectory such as: level changes, heading instructions, speed adaptation, flight plan data etc. One pseudo-pilot can run several aircraft per exercise.

Practical instructor is a person certified and authorized to instruct and train ATCO candidates during practical exercises through five phases presented at Fig. 4.

Explanation of the phases:
- group briefing – briefing of the exercise requirements and objectives with the group of candidates that will take the same exercises,
- individual briefing – briefing with one ATCO candidate on the controller working position before exercise starts,
- observation of candidate's work during the exercise run (knowledge, skills, attitude) and giving instruction, advice and tuition if necessary,
- individual de-briefing – briefing with comments and markings on the candidates' performance, weaknesses and strengths, and
- group de-briefing – briefing and pointing out progress and limitation of all candidates within the group [13].

Fig. 5. Simulation activities [13]

The assessor assesses the candidate's performance during the last exercise or the last simulation runs.

The candidate receives an assessment score which is determined according to the defined assessment criteria.

The same person can be an assessor and a practical instructor if he/she fulfils necessary requirements for both roles.

4. Baseline project simulations

For the project needs, the baseline simulations were co-ordinated between ESTU and ZFOT institutions and executed between February and April of 2018 according to the project schedule.

ATCO candidates were selected from students enrolled into the study of aeronautics at both institutions. These students had passed basic radar approach exercises earlier as the main prerequisite.

There were 19 ATCO candidates participating on the simulation runs among which 14 candidates were students from ZFOT, while 5 were from ESTU.

To avoid possible incorrect assessment and bias caused by previously gained knowledge and adaptation to familiar airspace, a generic airspace was developed for this project and designed on the BEST simulators. This generic airspace is based on the real airspace data of the Frankfurt Terminal Area (TMA) (Fig. 6).

Frankfurt TMA is a controlled airspace within which approach control service is provided. It surrounds Frankfurt Airport and is indicated by point FFM VOR (VHF

Fig. 6. Simulated airspace of Frankfurt TMA [11]

Omnidirectional Radio Range) in Fig. 6. Although Frankfurt Airport has four runways, for the purposes of the project all simulations used only runway 07C for both approach operations – arrivals and departures. The shape of the designed airspace (convex airspace) and the size (146 NM and 82 NM of maximum and minimum distances between boundary point) is easy to adopt and suitable for practicing and improvement of candidates' skills in provision of basic radar approach air traffic control service [11].

The general objective of all exercises is that the ATCO candidate maintains separation of arriving and departing aircraft in a safe, orderly and expeditious way by using standard radar separation of 1000 ft vertically and 5 NM horizontally and to assist arriving aircraft in approach to land and to assist departing aircraft in climb to a certain level and point. To be successful in these objectives, the ATCO candidate has to efficiently perform specified ATCO tasks: communication, conflict detection, radar vectoring, speed control, level change, strip marking, approach sequencing, use of HMI tools etc.

In the developed exercises, arriving aircraft gets into the Frankfurt TMA at the entry points (RASVO, COLAS, XINLA, KERAX, OLALI and XINLA) that are on the airspace boundary [13]. ATCO candidate has to direct arriving aircraft for landing at Frankfurt Airport from these points to the instrument landing system (ILS) course before point ASIMA and then to transfer aircraft to the Frankfurt Aerodrome Control Tower using radio-communication on frequency 119.000 MHz.

In the developed exercises, the same entry points are also exit points for departing aircraft. To separate traffic at these points, vertical separation minima must be applied for arriving and departing traffic flows. Departing aircraft from the Frankfurt Airport are transferred to Frankfurt TMA 10 NM from point FFM VOR and have to be directed to planned exit points. The departures have to be transferred to the next air traffic control centre, in this case it can be one of the following Area Control Centres: Langen North (on frequency 120.150 MHz) or Langen South (on frequency 136.125 MHz) and climbed to FL250.

Ten different exercises were developed to provide a human-in-the-loop radar approach control simulation with varying levels of difficulty determined by the number of flights to be controlled and by the complexity metrics, such as: number of conflicts between aircraft, mix of departure and arrival traffic, initial separation between successive departures, initial distances of arriving aircraft from the ILS course. The level of difficulty rises with the progress of exercises – the last exercises have higher difficulty, while during the first few exercises, candidates have to familiarize with the human-machine interface, practice communication skills and adapt to the airspace characteristics (Table 1).

In the last exercises, candidates have to be able to quickly process different information and make adequate de-

cisions, to have advanced skills in communication, conflict detection, radar vectoring, speed control and level change as a measure of conflict resolution and approach sequencing [11].

Table 1. Exercises description [11]

Exercise number	Number of aircraft			Exercise characteristics	
	Arr.	Dep.	Tot.	Duration (min)	Difficulty level
1	5	0	5	24	1
2	6	2	8	26	2
3	6	3	9	25	3
4	6	4	10	26	4
5	7	3	10	27	4
6	7	4	11	28	6
7	8	3	11	28	8
8	8	4	12	30	9
9	9	3	12	31	9
10	9	4	13	30	8

Every student had to run all 10 exercises with the briefing and debriefing procedures done by the instructors. A total of 140 exercises were therefore carried out in the ZFOT during this phase of the project. During and at the end of the exercises, instructors assessed candidate's air traffic control performance at the simulator and marked it in the specified form according to the earlier defined assessment criteria (over-the-shoulder method). After finishing the exercise and error deduction, every candidate was given an assessment score per exercise (Table 2).

The criteria were applied as a percentage deduction from the exercise. Each exercise started with 100% and a certain percentage was deducted for the types of errors such as: collision (30 %), separation loss (30 %), descending aircraft under specified level (30 %), unsafe clearance (10 %), graver mistake in vectoring (5%), greater mistake in communication (3%) etc. By score, the most successful candidate was candidate number 6, while the least successful candidate was candidate number 12.

As it can be noticed, these explained criteria count errors regarding the safety issues. There isn't any indicator dealing with flight efficiency targets.

In all exercises only one aircraft type was used in simulations and that was Airbus A320 as the most frequently used aircraft type with a 16.6% share in the European scheduled flights [15]. The simulated trajectory calculation is based on the Base of Aircraft Data (BADA) [16, 17].

After the simulation provided at ZFOT, a great amount of data was available for collecting and analysis. Simulation circuit with hardware facilities and outputs of air

Table 2. Candidates' scores per exercises [14]

| Ex. num.	Candidate number														Average score per ex.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
1.	85	87	87	86	80	87	92	88	96	85	91	97	92	80	88,1
2.	95	94	97	94	92	93	96	96	100	91	93	94	100	90	94,6
3.	97	91	88	97	92	96	84	87	90	95	90	90	85	95	91,2
4.	92	93	87	98	94	91	95	90	90	82	96	89	90	89	91,1
5.	94	94	87	74	73	93	60	81	79	83	32	65	64	76	75,4
6.	90	92	95	93	94	98	88	93	94	96	75	92	92	89	91,5
7.	97	90	89	94	97	97	96	80	97	95	96	88	87	90	92,4
8.	96	94	95	97	95	95	89	93	97	81	96	93	89	85	92,5
9.	97	92	93	99	100	94	95	96	97	95	97	94	65	88	93
10.	90	80	81	90	82	90	75	81	91	90	75	83	90	84	84,4
Av. score per can.	93,3	90,7	89,9	92,2	89,9	93,4	87	88,5	93,1	89,3	84,1	88,5	85,4	86,6	
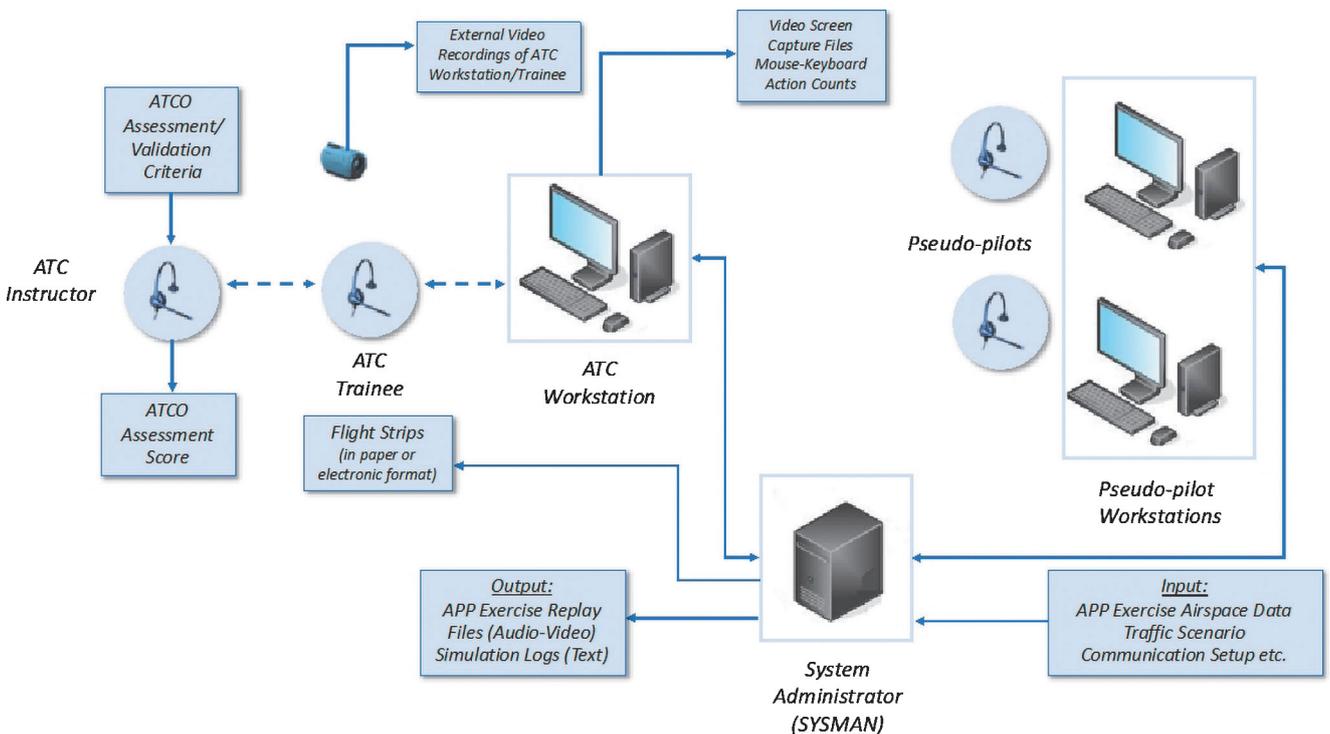
Fig. 7. Simulation data collection [11]

traffic control simulations, as well as data to be collected is presented in Fig. 7.

All simulator facilities are connected to the system manager (sysman) working position in which all airspace flight data and communication are stored as inputs. During the exercises, sysman records exercise replay files and simulation logs which can be later used for assessment evaluation, saving individual data and flight path information [11]. Also, captures of video replay files and candidate's mouse and keyboard interactions are collected to evaluate the candidate's workload.

The second part of the first stage simulations was conducted at TUBS and it incorporated ATC and flight simulation exercises on the A320 simulator. Five out of 14 ZFOT students were selected to run ATC simulations. Assessment scores of the students were taken into consideration for statistical analysis and correlation research of the following metrics: flight efficiency, number of instructions, task count, flight duration, distance flown etc. The results of the first stage simulations are published in the scientific paper 'Project ATCOSIMA: Preliminary Results and Analysis of Real-Time ATC and Flight Cockpit Simulations' [18].

5. Conclusion

Project ATCOSIMA, funded by ERASMUS+, works on the improvement of air traffic controller training and overall competencies of future air traffic controllers. One of three institutions participating in the project is the ZFOT. The project is structured in several stages with the main aim – development of the new assessment criteria to be used in simulation exercises that students complete during the basic training which is integrated into the undergraduate study of aeronautics. In order to achieve its goal, the project has two stages of real-time human-in-the-loop simulations the simulation using

current and two stages of real-time simulation of human-in-the-loop simulations the simulation using newly developed assessment criteria.

In this paper, baseline real time human in the loop simulations with the current criteria assessment at ZFOT are presented with the experiment settings and features.

Acknowledgements

References

[1] ICAO Annex 1 – Personnel Licensing, International Civil Aviation Organisation, Montreal, 2018.

[2] Commission Regulation (EU) 2015/340 of 20 February 2015 laying down technical requirements and administrative procedures relating to air traffic controllers' licences and certificates pursuant to Regulation (EC) No 216/2008 of the European Parliament and of the Council, amending Commission Implementing Regulation (EU) No 923/2012 and repealing Commission Regulation (EU) No 805/2011, Official Journal of European Union, L63, Volume 58, 6 March 2015.

[3] Juričić B, ZIRP 2015.

[4] Specification on Common Core Content for Initial Training, EUROCONTROL, 2018.

[5] Cetek C, Aybek F, Cinar E, Cavcar C., New directions for air traffic control simulators: A discussion to guide the selection and renovation of simulators. The Aeronautical Journal. 2013 Apr; 117 (1190): 415-426.

[6] J. Vagner, E. Pappová, "Comparison of Radar Simulator for Air Traffic Control," "Naše more" 61(1-2)/2014. – Supplement, pp. 31-35.

[7] Wickens CD, Mayor AS, McGee JP, editors. Flight to the Future: Human Factors in Air Traffic Control. Panel on Human Factors in Air Traffic Control Automation. Washington D.C.: National Research Council Press; 1997.

[8] Manning CA, editor. Measuring Air Traffic Controller Performance in a High-Fidelity Simulation. Springfield: FAA; 2000.

[9] Netjasov F. et al. Identification of Safety Critical Hazards to Support Future Air Traffic Controller Training, 23rd ATRSWorld Conference, Amsterdam, The Netherlands, July 2-5, 2019.

[10] COMMISSION IMPLEMENTING REGULATION (EU) No 390/2013 of 3 May 2013 laying down a performance scheme for air navigation services and network functions, Official Journal of the European Union L 128/1, 9.5.2013.

[11] Cetek, C., Juričić, B., Feuerle, T., Radišić, T.: Development of Common ATC Simulation Training Assessment Criteria Based on Future Pan European Single-Sky Targets (ATCOSIMA): *A Project Overview.* // Proceedings of the International Scientific Conference "Science and Traffic Development" (ZIRP 2019) – Topic: Next Generation Transport Industry Innovations / Grgurević, Ivan; Rožić, Tomislav (ur.). Zagreb, 2019. p. 93-104. (https://www.bib.irb.hr/1003772)

[12] BEST radar specification,"Bournemouth: Micro Nav Ltd, 2010.

[13] Pavlinović, M., Juričić, B., Antulov– Fantulin, B.: Air Traffic Controllers' Practical Part of Basic Training on Computer Based Simulation Device// *40. International Conference MIPR0 2017: Computers in Education: Proceedings.* / 2017. p. 1026-1031.

[14] Rogošić T. Examining Relation of Air Traffic Control Student Achievement During Approach Air Traffic Control Exercises with Simulated Aircraft Flight Efficiency Indicators, Diploma Thesis, Faculty of Transport and Traffic Sciences, University of Zagreb, 2019. , https://repozitorij.fpz.unizg.hr/islandora/object/fpz%3A1833/datastream/PDF/view

[15] https://www.eurocontrol.int/sites/default/files/content/documents/official-documents/facts-and-figures/statfor/doc581-market-segments-2015-v1.0.pdf

[16] EUROCONTROL. User Manuel for the Base of Aircraft Data (BADA). Rev. 3.11. Brétigny-sur-Orge Cedex, France: EUROCONTROL; 2013.

[17] EUROCONTROL. Coverage of 2013 European Air Traffic for the Base of Aircraft Data. Brétigny-sur-Orge Cedex, France: EUROCONTROL; 2015.

[18] Aybek Cetek F., Antulov-Fantulin B., Frost P., Donmez K., Kaplan Z., Rogošić T.: ATCOSIMA Project: Preliminary Results and Analysis of Real-Time ATC and Flight Cockpit Simulations, // Proceedings of the International Scientific Conference "Science and Traffic Development" (ZIRP 2019) – Topic: Next Generation Transport Industry Innovations / Grgurević, Ivan ; Rožić, Tomislav (ur.). Zagreb, 2019. p. 11-22, https://www.fpz.unizg.hr/zirp/zirp2019.php