Air Traffic Controllers' Practical Part of Basic Training on Computer Based Simulation Device

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Abstract - Air traffic controllers are responsible for guiding aircraft through the airspace and for ensuring timely, safe and e peditious flow of air traffic. Throughout the whole education and later wor , air traffic controllers undergo e tensive training that is divided into three phases – initial training basic and rating training , unit training transitional, pre-on-the- ob and on-the- ob training and continuation training conversion and refresher training . n all three phases of the training, the focus is placed on practical training e ercises performed on computer based simulation devices. This paper focuses on basic part of the initial training and gives an overview of practical training e ercises performed on a particular computer based simulation device. t also provides an insight into challenges the candidates are faced with while mastering the techniques of performance based training

I. INTRODUCTION

Air traffic controllers are responsible for safe and expeditious flow of air traffic. Their main task is to provide separation between aircraft. They perform a complex task of guiding aircraft through the airspace safely and efficiently. The goal of Air Traffic Control (ATC) is to minimize the risk of aircraft collisions while maximizing the number of aircraft that can fly safely in an airspace at the same time. To be able to perform all the mentioned duties, air traffic controller candidates have to undergo extensive training and skill acquisition process. During the training, air traffic controller candidates acquire knowledge on procedures, learn about characteristics of a certain airspace, master how to detect and solve potential conflicts between aircraft, learn how to use equipment on their working positions, etc. This paper focuses on basic part of the initial training and gives an overview of practical training exercises performed on computer based simulation devices. It is divided into five sections: 1. Introduction, 2. Air Traffic Controller's Training, 3. Air Traffic Controller's Basic Training, 4. The Simulator - BEST Simulation System, and 5. Conclusion.

II. AIR TRAFFIC CONTROLLER'S TRAINING

Since air traffic control is a highly regulated sector, air traffic controller's (ATCO) training is defined by thorough regulations that prescribe minimum training requirements. In the EU ATCO training has to comply with and meet the requirements laid down in the Commission Regulation (EU) 2015/340 that enables overall standardization of training.

Standardization of training and required competences should also reduce fragmentation and differences in licensing process and enable mutual recognition of licenses among different countries [1].

The training is divided into three phases – initial training, unit training and continuation training that are shown on Figure 1.

Figure 1. Progression of ATCO training [2].

Initial training consists of basic training 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].

Basic Training provides theoretical knowledge and practical skills to enable an ab initio candidate to progress to more specialized Rating Training. The Rating Training provides knowledge and skills related to a job category and appropriate to the discipline to be pursued in the ATS environment [2]. It consists of theoretical subjects and practical exercises. After successful completion of initial training candidates are awarded Student ATCO License. This license is a prerequisite for starting the following phase of training.

The Unit Training leads to the issue of an Air Traffic Controller License that enables ATCOs to work with live traffic. It is subdivided into three parts: Transitional Training, Pre-On-the-Job Training and On-the-Job Training.

Transitional Training is designed primarily to impart knowledge and understanding of site-specific operational procedures and task-specific aspects. It ensures the

development of skills through the use of site-specific simulations and training [3].

Pre-On-the-Job Training (Pre-OJT) is locally based training during which extensive use of simulation using site-specific facilities will enhance the development of previously acquired routines and abilities to an exceptionally high level of achievement [2].

On-the-Job Training - OJT is the final phase of unit training during which previously acquired job-related routines and skills are integrated in practice under the supervision of a qualified on-the-job training instructor in a live traffic situation. [2].

Continuation Training is training for ATCOs with valid license that enables an upgrade or improvement of existing knowledge and skills and includes refresher and conversion training.

Refresher training is designed to review, reinforce or enhance the existing knowledge and skills of air traffic controllers to provide a safe, orderly and expeditious flow of air traffic. Conversion Training is designed to provide knowledge and skills appropriate to a change in the operational environment [2].

All the phases of training consist of theoretical and practical training. Practical training is performed on computer based simulation device, so called synthetic training device (STD). There are two different types of STDs - simulators and part-task trainers. Simulators are computer based devices that simulate important functions of the real situation of ATCO working positions, airspace, procedures, flight trajectories etc. Part-task trainers are computer based devices that enable simulation of partial ATCO functions. Both STDs are used to train candidates in gaining practical skills. Candidates take part in different practical exercises created for each segment of the training according to prescribed requirements. Each certified ATCO training organization defines the number of practical exercises to be performed for different phases of ATCO training in accordance with international standards.

III. AIR TRAFFIC CONTROLLER'S BASIC TRAINING

As previously mentioned, Basic Training is a part of Initial Training. Basic training can be provided as separate course or integrated with rating training. Basic Training is designed in a way that candidates (ab initios) acquire fundamental knowledge and practical skills related to basic operational procedures. The goal of the course is to teach candidates basic theory needed for future work and for rating training. Basic Training is developed and provided by licensed ATCO training organizations and approved by the competent authority.

In Croatia there is only one training organization approved for provision of ATCO basic training and that is Croatian Air Traffic Control Training Centre (HUSK).

HUSK is a unit established at the Faculty of Transport and Traffic Sciences of the University of Zagreb that is certified to provide basic training. HUSK provides two different basic training plans and programs: integrated program of training provided through undergraduate study of aeronautics, air traffic control module, and a separate basic training course [4].

The training program integrated in the undergraduate study of Aeronautics lasts 6 semesters. After the completion of the program, candidates are awarded bachelor's degree (bacc.ing.aeronaut.) and a Certificate on successful completion of Basic Air Traffic Controller Training [5]. The other training program is organized as a separate course lasting from 16 to 24 weeks depending on tender requirements. After the completion of the course, candidates are also awarded Certificate on successful completion of Basic Air Traffic Controller Training [6].

Both HUSK programs are compliant and harmonized with requirements of the EU REG 2015/340 and of EUROCONTROL's Specifications on the ATCO Common Core Content Initial Training.

During the basic training candidates are obliged to take lessons and successfully fulfil courses' requirements. Theoretical trainings are comprised of the following subjects as prescribed by EU REG 2015/340: Introduction to the Course, Aviation Law, Air Traffic Management, Meteorology, Navigation, Aircraft, Human Factors, Equipment and Systems and Professional Environment,

According to the EU REG 2015/340 practical training is provided within Air Traffic Management subject. During the provision of practical training on simulator, candidates develop skills of maintaining aircraft separation, monitoring aircraft movement through airspace and communicating with pilots. Candidates have to incorporate acquired theoretical knowledge into practical training skills for all three types of air traffic control (aerodrome, approach and area control).

IV. THE SIMULATOR - BEST SIMULATION SYSTEM

There are a few companies in the world involved in the development and production of ATC simulators that provide a realistic simulation of aircraft flight and human-in-the-loop real time simulation of air traffic controller's work. All simulation systems used by ATCO training organizations should be certified and approved by competent authorities for the usage in practical training. A simulation system that is very often used by ATCO training organizations in Europe is called BEST (Beginning to End for Simulation and Training) Simulator produced by Micro Nav Ltd. According to HUSK internal survey and according to the research Comparison of Radar Simulator for Air Traffic Control [7], BEST simulator is rated as the best solution to be used in ATCO training.

BEST simulator covers all levels and types of training:

- basic (ab initio)
- rating
- validation
- on-job-training support
- conversion
- refresher
- competency checks

- handling emergencies and unusual situations
- approach control – radar and non-radar
- tower control
- ground and ramp control
- tower data assistant working
- civil and military [8].

BEST is constructed in such a way that it gives a very realistic simulation of the real traffic situations. The following section describes the system functionality and the minimum hardware requirements, software information and additional system and support information.

A. ardware e uirements

BEST runs on commercial standard PCs, networking and peripherals. The minimum hardware specifications are Pentium 4 dual core processor 2.8GHz or equivalent, 2GB RAM, 40GB hard disk drive (workstation position) or 80GB hard disk drive (system manager position), CD-ROM drive (required at the system manager position only), 100Mbps/1Gbps network capability and operating system Windows 7 Professional(workstation position or stand-alone system) and Windows 2003 Server (networked System Manager) [8].

B. B T oftware Development latform

The BEST software is written in C++ using the Borland C++ Builder development environment and it uses Windows operating systems and networking. BEST simulation system comprises of the following ATC radar simulation and training facilities:

- ATC radar controller/student facilities
- Supervisor facilities
- Pilot facilities
- Simulation facilities for driving real radar workstations
- System manager facilities
- Data preparation facilities
- Self-teach facilities
- Voice recognition & output facilities
- Simulated audio communications facilities
- Scripting facilities
- Networking facilities
- Data management facilities [8].

C. B T simulaton system at the aculty of Transport and Traffic ciences

As it was mentioned earlier, HUSK is an approved ATCO training organization that is certified for provision of basic training and is a part of the Faculty of Transport and Traffic Sciences. From 2013the Faculty owns BEST Radar Simulator that is situated in The Laboratory for Control of Air Navigation at the Department of Aeronautics and used by HUSK. It has two ATCO working stations, one pseudo-pilot working station and one supervisor working station which is also used as a pseudo-pilot working station. The user interface is similar to the real ATC workstations. As it can be seen on Figure 2, the ATCO working station consists of a radar screen, an auxiliary screen, a voice communication interface screen, a keyboard, a mouse, two sets of headphones and some communication switches.

Standard operating system has recording and playback system, which allows a recorded exercise to be played back. A replay may be paused at any time and candidates may be faced with their performance.

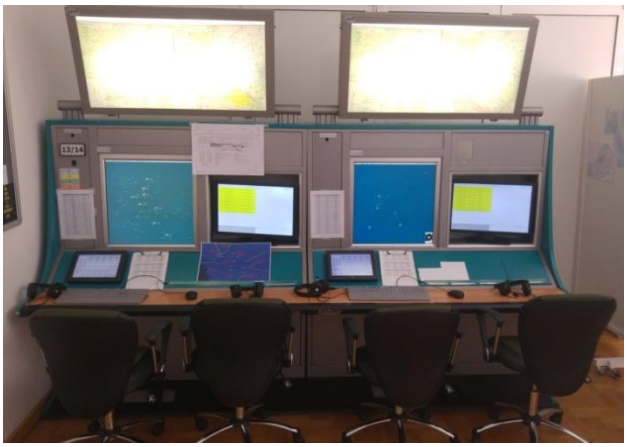

Figure 2.The ATCO working stations of the BEST Radar Simulator at the Faculty of Transport and Traffic Sciences

Process of training and roles of all persons involved as well as their interactions can be seen on Figure 3.

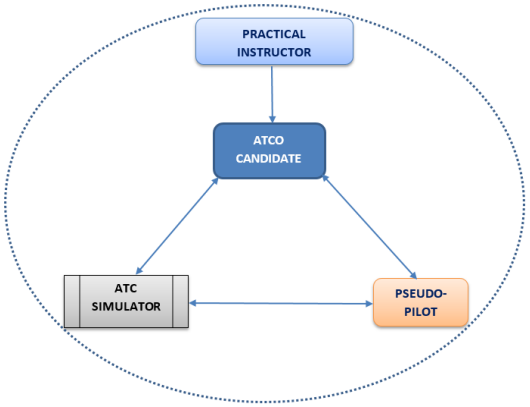

Figure 3. Simulation process during ATCO practical training.

As it can be seen, there are constant MMI (Man–Machine Interface) interactions in three processes: ATC Simulator-ATCO candidate, ATC Simulator -pseudo-pilot and ATCO candidates and pseudo-pilots when using radio communication. Practical instructor supervises the work of ATCO candidate. Roles and functions of all participants are explained in further text.

D. The ATC wor ing station

The ATCO working station enables the ATCO candidate to monitor the air traffic situation on the radar screen and to pass instructions through a set of headphones to a pseudo-pilot. The candidate has to perform a complex task of monitoring all the aircraft through the delegated airspace.

At the same time the candidate has to take into consideration the simulated traffic situation, decide what instruction to issue to the pilot, inform the pilot through a

voice channel on the actions to be taken, observe if the pilot follows the instructions, record all the changes in the system, make an update of the current traffic situation and be familiar with the all equipment. The candidate continuously observes the simulated traffic situation on the radar screen that shows the current traffic situation. The standard radar screen display is shown on Figure4. The position of an aircraft is marked with an * sign and accompanied with the label that mandatory contains aircraft's call sign some additional information regarding aircraft type, speed and altitude.

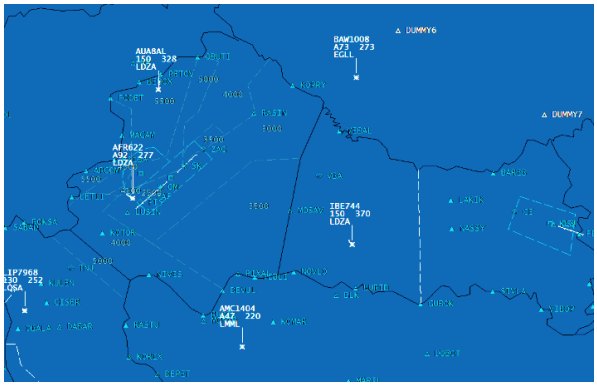

Figure4. The standard radar screen display.

The display controls are located on the toolbar at the top of the display. Different characteristics of the radar display can be altered by selection of an appropriate tool such as:

• display manipulation tools (zoom facility, recentre, drag facility, map layer selection, display range, range rings, compass rose, and text size)

• target display options (history trail, predict vector, track label position, target filters route and trail length)

• information display (exercise time and status (active/frozen), QNH and ATIS identifier

• target symbols: primary cover only, secondary cover only, combined cover, forced onto display, filtered by height or SSR code), etc. [8].

. *seudo pilot wor ing stations*

The BEST pseudo-pilot working station facilities are user-friendly. The pseudo-pilot working station consists of a radar screen, an auxiliary screen, a voice communication interface screen, a keyboard, a mouse, a set of headphones and communication switches. The pseudo-pilot facilities allow the pilot to make changes in flight's behavior as instructed by the controller or instructor. This is achieved via Pilot MMI that is shown on Figure 5.

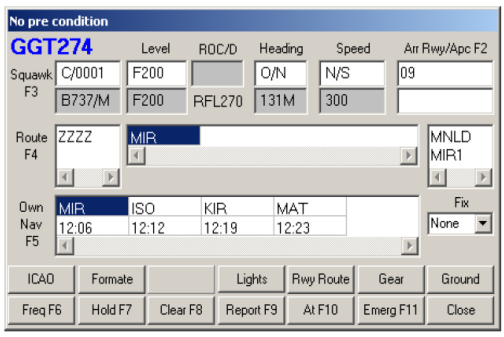

Figure 5. The Pilot Man–Machine Interface [8].

The BEST pilot interface uses standard Windows input methods working with a keyboard or a mouse, or with a combination of both. This allows complex, chained commands to be entered easily. All the inputs are optimized for fast keyboard entry [8].

All aircraft under pilot's control are listed in the *Call sign ist*. The target aircraft can be selected with the keyboard or with the mouse by selecting from the radar display or the *Call sign ist.*

Using Pilot MMI, the pseudo-pilot can enter a command for the currently selected aircraft or can select another aircraft and make necessary changes. When the keyboard is used to select an aircraft, pressing the letter key displayed in the first column of the *Call sign ist* will display the *ilot* for the associated aircraft [8].

. *ractical nstructor role in simulation process*

Practical instructor is instructor authorized to train candidates during practical exercises. Practical instructor sits next to the ATCO candidate. He/she instructs the candidate, provides advice and tuition, observes how a candidate interacts with the equipment, pays attention to candidate's behavior and attitude, monitors if a candidate takes appropriate actions and issues correct clearances. After each exercise, the instructor fills in Daily performance lists for each of the candidates giving his/her opinion on the candidate's performance.

Practical instructor can communicate with the ATCO candidate and with the pseudo-pilot (without the controller's knowledge) via voice communication facilities. The voice communication facilities support simulated radio transmissions between the candidate and pseudo-pilot, communication between the instructor and the candidate and pseudo-pilot for teaching purposes, simulated intercom communications between positions and simulated telephone communications.

. *upervisor wor ing stations*

Supervisor working station is the central part of the complete simulation system. A supervisor has the access to the pseudo-pilot working station facilities and to the majority of functions of student-controller facilities. The supervisor is in charge of managing an exercise – he/she starts the exercise, restarts the paused exercise, changes the traffic situation adding additional flights, removes flights, saves a text file of all script commands run during the course of the exercise and edits the script files associated with the airspace, exercise and/or weather set etc. When the simulator is ready to run, the *upervisor Controls* dialog is presented on the screen at the supervisor position.

. *rovision of Basic Training at U*

As it was said earlier HUSK uses BEST Radar Simulator for the provision of practical exercises during basic training. When the program integrated through undergraduate study of aeronautics is used, candidates do seven exercises of Aerodrome Control, seven of Approach Control and seven of Area Control. Each candidate does altogether 21 exercises (seven for each type of control) and

spends 21 hours training on BEST radar simulator individually.

Exercises of each type of control differ in traffic, number of aircraft involved, number of conflicts, different traffic flows and in performance objectives that candidates need to fulfil. Before the beginning of practical training for each type of control, the candidates are introduced to the simulator equipment and its functionalities. Provision of every exercise is conducted in accordance to the activities given in Figure 6.

Every practical exercise on the simulator starts with group briefing. It is an introduction to the exercise where candidates are introduced with the performance objectives, particular characteristics of the exercise, separation methods and radio-telephony communication. It is provided in the classroom. Group briefing is followed by individual briefing when instructor leads candidate through an exercise, explains the goals of the exercise and emphasizes the important segments, shows flight plans. Individual briefing is as done one-on-one and provided at the BEST simulator.

The candidate does the exercise run on his/her own.

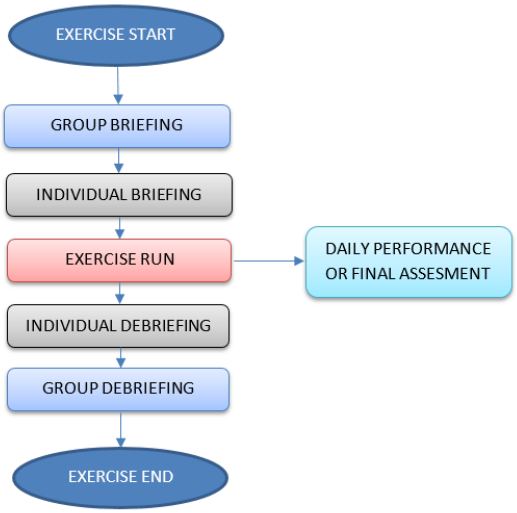

Figure 6. Activities in practical exercise provision

Exercise run lasts approximately 45 min. During the exercise run, instructors train and monitor candidate's work on BEST radar simulator. The instructor observes candidate's performance and provides guidance, if necessary. They use Daily performance lists to track and evaluate candidate's progress or do the final assessment of the candidate's performance using Simulator Assessment List in the case of the last exercise.

After the completion of the exercise run, the instructor does the individual debriefing and evaluates the candidate's work according to the set objectives of the exercise, points out candidate's strengths and weaknesses and gives the recommendations for the subsequent exercises. Individual debriefing is provided while the candidate is still at the simulator.

As it is said, the instructor uses Simulator Assessment List to make final assessment and evaluation of the candidate's knowledge, performance and attitude. A candidate needs to achieve at least 75% on the final assessment to pass.

For each of the exercises, each candidate is awarded the following performance indicators:

Excellent (90-100%) - the candidate has reached the highest passable standard; the performance was excellent but with a few minor errors.

Very good (85-89%) - the candidate has reached higher passable standard; the performance was very good but with more minor errors.

Good (80-84%) - the candidate has reached passable standard; the performance was good but with errors.

Sufficient (75-79%) - the candidate has reached the lowest passable standard; the performance was acceptable but with major errors.

Insufficient (74 % and bellow) - the candidate has failed to reach a passable standard; the performance was less than acceptable and/or erratic [9].

The last segment of each exercise is group debriefing. When all candidates finish the same exercise, a group debriefing is held. It is review of the exercise run and discussion of the outcome of the exercise and candidates' achievements and gives the recommendations for the subsequent exercises.

The instructors repeat the objectives of the exercise, summarize the key points, emphasize well-performed elements, discuss the most frequent mistakes and provide advice for the future.

After completion of the Basic Training simulation exercises on BEST radar simulator the candidate can perform the following performance objectives [3]:

- checking and using the working position equipment
- developing and maintaining situational awareness by
- monitoring traffic and identifying aircraft when
- applicable
- monitoring and updating flight data display(s)
- maintaining a continuous listening watch on the
- appropriate frequency
- issuing appropriate clearances, instructions and
- information to traffic
- using approved phraseology
- communicating effectively
- applying separation
- applying coordination as necessary
- applying the prescribed procedures for the simulated
- airspace
- detecting potential conflicts between aircraft
- appreciating priority of actions
- choosing appropriate separation methods.

. *ample of area control e ercises at U training organisation*

To achieve smooth and performance based training process at HUSK, all candidates undergo through the set of exercises specifically designed for basic training. All exercises are designed with the assistance of certified

practical instructors and are carefully constructed to achieve candidate's continuous progression in skills and are in accordance with performance objectives. As it was said earlier candidates attend three types of simulator exercises, aerodrome, area and approach control exercises and are trained and supervised a by certified practical instructors

To show progress and differences in the exercises during basic training at HUSK, exercises for area control will be explained in more detail in the terms of ATCO workload, number of aircraft and traffic complexity.

Exercise number one is the first exercise for area control. Before the beginning of this exercise, instructors introduce and demonstrate the functionalities of the computer based training device – BEST simulator. All its segments needed for performance of area control exercises are explained in detail and shown to candidates. The objectives of exercise number one are familiarization with the equipment, introduction of generic airspace and basic scenario with low complexity traffic and low ATCO workload requiring heading change. The number of aircraft in the first exercise is four.

In the second exercise, candidates work in the same generic airspace, but are faced with slightly higher workload and traffic complexity in basic scenario. The number of aircraft is increased to ten.

Croatian upper control area is simulated in exercise number three. Candidates go through scenario with overflying traffic and intermediate complexity and ATCO workload requiring heading, level, speed and frequency changes. There are eight to nine aircraft in this exercise.

The fourth exercise is similar to the third exercise, but with slightly higher workload. The scenario includes converging traffic. The complexity is intermediate requiring again some heading, level, speed and frequency changes. The number of aircraft is nine.

Exercise number five is the same as the fourth exercise. Complexity and ATCO workload are the same as in the fourth exercise, only the number of aircraft is increased to ten. This exercise enables candidate's consolidation in progress. Exercise number six is the last one before the final assessment exercise where candidates deal with the highest traffic load on crossing and opposite tracks resolving conflicts by level change or by vectoring. This is the most complex exercise with the highest ATCO workload The number of aircraft in this exercise is twelve.

Exercise number seven is the last exercise and also the assessment exercise. The final assessment and evaluation are carried out during this exercise according to the criteria said in the part H of this paper. In the course of this exercise, the candidates should show what skills and competence they have gained during the practical training. After the completion of practical exercises a candidate shall reliably and consistently apply standard coordination, approved radiotelephony, vertical, longitudinal and radar separation and control techniques [10].

If we compare candidates' behavior and attitude during the performance of exercises, it can be concluded that during the first two exercises candidates have difficulties with the adaptation to the computer based simulation device and familiarization with its functions. With the progression of exercises it is expected that candidates are adopted and familiarized with the system and that they are capable of coping with higher number of aircraft, higher ATCO workload and traffic complexity.

V. CONCLUSION

Air traffic control candidates undergo extensive training. Their training consists of three phases and incorporates theoretical and practical parts. Theoretical training includes all the subjects and topics needed to perform complex ATCO work. Practical training is provided on computer based simulation device where candidates gain practical skills in maintaining aircraft separation and guiding aircraft through airspace. HUSK, as well as every other air traffic control training organization, is obliged to use an adequate computer based simulation device in provision of practical training. BEST radar simulator used by HUSK training organization meets all the objectives and requirements prescribed for the provision of basic ATCO training.

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