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ROBUST METHOD TO DEFINE AN OPTIMUM LEVEL OF AN AIR TRAFFIC CONTROLLER SIMULATOR TRAINING

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Abstract

Purpose: to set optimum level of preparation and to structure the process of trainee preparation, as well as to analyze outcomes for ATC instructor. **Methods:** we have chosen to define an optimum level of preparation are Robust, mean square and mean median methods. The most reliable method to protect our data from outliers is Robust method. **Results:** to manage the position of outcomes we forced to structure specific filtering tasks which are mandatory to be done by trainee, in order to guaranty not exceeding predefined level of preparation. To satisfy our goal we have also predefined media tools to apply, such as: Part Task Trainer, Other Training Devises, Radar Trainer, Automated Work Place 'Situation'. **Discussion:** professional preparation of an air traffic controller is a very complicated and time-consuming process with many specialists and instructors been involved. Preparation process roughly divided into the part of theoretical knowledge obtaining and the part where trainees are practicing to convert theoretical material into practical skills with the help of Simulator. For the interim check, common criteria of skill acquisition process is predefined by evaluation of technological operations: Acceptance of duty on the work place, Phraseology adequacy, Coordination with adjacent units, Regularity of flights, Accuracy of aircraft's positions determination, Correspondence of decision making to given situation, Provision of proper separation and general Safety issues, Adequacy of console operations. Instructor evaluates trainee on all his activities, beginning from trainee's readiness of task execution ending by feedback analysis and provision of further recommendations. Completeness, adequacy and quality of mentioned above results depend in direct on quality of instructor.

Keywords: air traffic controller; error statistics; evaluation criteria; individual approach; Median; Robust method; simulator training.

1. Introduction

Professional preparation of an air traffic controller is a very complicated and time-consuming process with many specialists and instructors been involved. Preparation process roughly divided into the part of theoretical knowledge obtaining and the part where trainees are practicing to convert theoretical material into practical skills (SA - skill acquisition process) with the help of Simulator. Practical part is composed by four parts mainly and it is foreseen an assessment of skills conformity only during the finish of appropriate part (Fig. 1).

The final evaluation on task is not flexi enough, thus an individual approach to the trainee is not taken into account. The opportunity to have more

practice is not provided at all. The system of preparation expects readiness of a trainee to each next part of practical preparation [1].

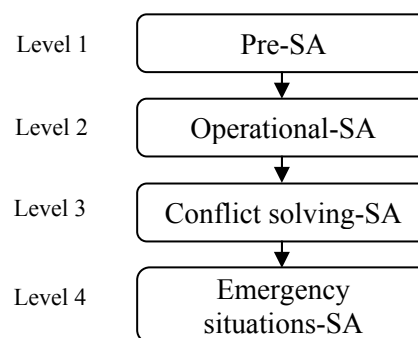


Fig. 1. Levels (parts) of trainee preparation

If the trainee is accumulating gaps of training he might be positioned as unable to comply with the part of preparation. Critical amount of gaps couldn't be defined properly because of many factors, such as: personal tolerance level to gaps, resistance on unexpected situations, an ability to be evaluated properly by instructor, etc.

An instructor is playing the main role in evaluation of practical skills. Depending on a level of instructor's presence through the process of practical preparation we may judge on adequacy and completeness of trainee's skills evaluation. Again, depending on the workload of an instructor we may miss up to 30% of trainee's outcomes during the preparation.

2. Analysis of the latest research and publications

To structure the preparation of an Air Traffic Controller we were relying on regulations and manuals of International Civil Aviation Organization [1]. To protect over statistic of trainee's errors we took Robust method. This method is becoming popular nowadays in statistics analyze. There are some researchers been in progress for robust method, *Peter Meer*, *Doron Mintz*, *Azriel Rosenfeld* from Center for Automation Research, University of Maryland [2] and *Roger Koenker* from Department of Economics, University of Illinois at Urbana-Champaign, U.S.A. is aimed on Quantile regression in statistics [3]. Some other researchers are taken into consideration to apply robust method to our statistics [4, 5, 6, 11].

3. Practical preparation of trainee

As we were already mentioning, trainees are having Theoretical and Practical type of preparation.

For the theoretical part they are to be taught of such subjects as:

- Introduction into the discipline of Air Traffic Control (ATC);
- Aviation Law;
- Operational Procedures;
- Meteorology;
- Navigation;
- Aircraft and Principles of Flight;
- Human Performance;
- Equipment;
- Miscellaneous (depending on area of skills' application).

Educational methods to be applied are:

- Lecture;
- Lesson/demonstration;

- Practical classes;
- Laboratory work;

To assess theoretical knowledge of trainee, Eurocontrol recommends applying predefined levels of taxonomy.

Level 1. Requires a basic knowledge of the subject. It is the ability to remember essential points; trainee is expected to memorise data and to restore it.

Level 2. Requires an understanding of the subject sufficient to enable trainee to discuss intelligently. The individual is able to represent for himself or herself certain objects and events, and to act upon these objects and events.

Level 3. Requires a thorough knowledge of the subject and the ability to apply it with accuracy. Trainee should be able to make use of his/her repertoire of knowledge.

Level 4. The ability to establish a line within a unit of known applications following the correct chronology and the adequate method to resolve a problem situation. This involves the integration of known applications in a familiar situation.

Level 5. The ability to analyse new situations in order to elaborate and apply one or other relevant strategy to solve a complex problem. The defining feature is that the situation is qualitatively different to those previously met, requiring judgement and evaluation of options.

Training techniques to be applied are:

- Lesson/demonstration;
- Case studies;
- Supervised practices;

In many cases the objective of SA is clearly of a practical training nature and therefore likely to be reached in a simulated environment.

The training system we are applying is able to provide SA for tasks of: console operations, part task training (PTT) and real-time hi-fi simulation (SIM).

The simulated environment should be related to the specific expectation of task and to take into account air traffic configuration.

4. Evaluation criteria of skills

Preparation process is successful when the objective is met. As a rule, the objective is to enable the trainee to perform as required in his or her day-to-day work.

If training time not such a critical resource, an instructor could simply wait and observe whether or not the trainee can properly apply on the work place. That would be the perfect measure of success.

However, for reasons of safety, quality assurance, economy, didactics, and legal constraints, this is not possible with training process. We need both interim and final progress checks. This necessity is absolutely undisputed for nearly all-institutional learning processes (table 1).

Table 1

Evaluation of technological operations

№	Technological operations	Evaluation mark		
		excellent	good	satisfied
1	Acceptance of duty on the work place	0 errors	1 error	2 errors
2	Phraseology adequacy	≤1 error	2-3 errors	4 errors
3	Coordination with adjacent units	≤1 error	2-3 errors	4 errors
4	Regularity of flights	0 errors	1 error	2 errors
5	Accuracy of aircraft's positions determination	0 errors	1 error	2 errors
	By distance	±5 kilometres		
	By Azimuth	±4 degrees		
	By direction finder	±2 degrees		
6	Correspondence of decision making to given situation	0 errors	1 error	2 errors
7	Provision of proper separation and general Safety issues	0 errors	1 error	2 errors and more
8	Adequacy of console operations	≤1 error	2-3 errors	4 errors and more

Mentioning error/s (*E*) throughout the table should be understood in the manner of: error itself (slips and lapses), mistakes (knowledge-based errors), mismatches, inadequacy etc. Distribution of *E* among Technological Operations (*Pr_i*) through one given task is represented in (Fig. 2).

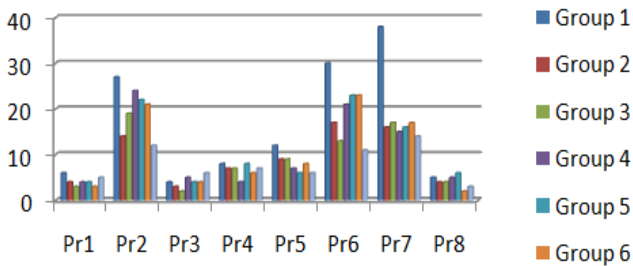


Fig. 2. Distribution of technical operation errors by a task.

It is recognisable in a glance, that phraseology adequacy (*Pr2*), correspondence of decision making to given situation (*Pr6*) and provision of proper separation and general Safety issues (*Pr7*) are the most dramatic in their proportion to other operations (Fig. 3).

Such a proportion is showing us, at least, two very important states to be noted and discussed. At first, it shows the complexity of the task; the larger proportion of these three elements more complex the task is. Secondly, this group of data is a unique indicator of psycho physiological resistance of a trainee during decision making.

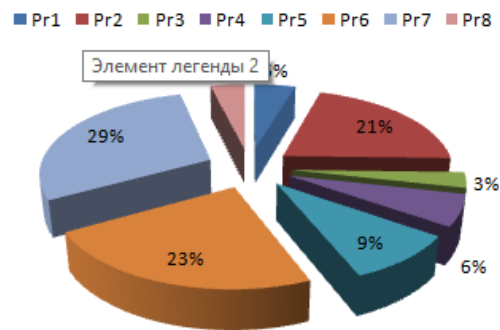


Fig. 3. Proportion of technical operation errors by a task

5. Analysis of instructor's activity

In general, the responsibility of instructor is to organise and to conduct SA by a trainee with the help of simulator.

More in details, instructor starts with determination activity of trainee's theoretical and practical levels. Takes part in planning and conduction of a trainee's preparation, provides supervision and assistance for trainees. Studies, summarizes and distributes advanced forms and methods of training of trainees. Offers suggestions on improving the professional training and organizing methodical work of simulator staff. An instructor conducts reporting and accounting documentation.

In order to make judgments, instructor must possess excellent knowledge of:

- Air Code;
- Flight Rules;
- Regulation on Airspace utilization;
- Air Traffic Control rules, guidance, regulations, directives and instructions;
- Procedures of corresponding Air Traffic Control Units;
- Aircraft technical characteristics;
- Airline Operating Agencies;
- Air Traffic Service and Management;
- Airspace Management;
- Air Traffic Flow and Capacity Management;
- Flight Planning;

- Air Navigation;
- Aviation Meteorology;
- Organization of communication;
- Workload indicators;
- Advanced experience in the field of professional training;
- Labor protection;
- Phraseology of radiotelephony communication in order to conduct imitation of pilot's commands.

Instructor activity on evaluation process

Instructor evaluates trainee on all his activities, beginning from trainee's readiness of task execution ending by feedback analysis and provision of further recommendations. Completeness, adequacy and quality of mentioned above results depend in direct on quality of instructor. Furthermore, personal aspects of an instructor, his ability to manage preparation process, capability to perform SA process forecast, talent to apply individual strategy of SA for trainee, etc.

6. Aims of the work

1. To choose statistical method of process data of trainees' errors in order to set optimum level of preparation.
2. To structure the process of trainee preparation in order to guaranty flexibility of SA management.
3. Analyze outcomes for ATC instructor.

7. Errors analysis

As we were mentioning above, the only one source of all the data of trainee E is outcomes of instructor's activity. So, let us take the most representative E data of technical operation to be analyzed, this will be Pr6 (Fig. 4).

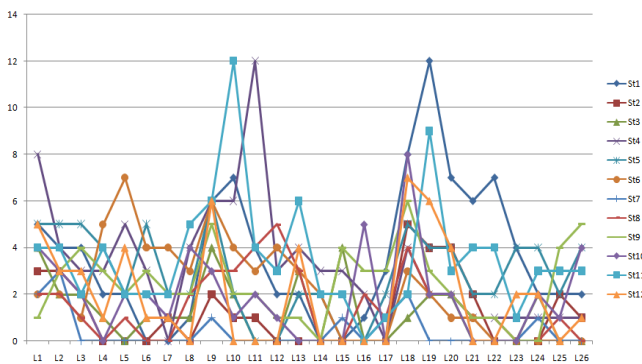


Fig. 4. E data with the duration of 26 lessons (Part 1)

Instructor indicated all decision making induced E for one group of student by performing first part of preparation in full.

From the position of Fig.4 it is absolutely not so clear what portions of tasks are distributed within given part. The sum of all group of trainee E decision making induced, positively illustrates such a dynamic (Fig. 5).

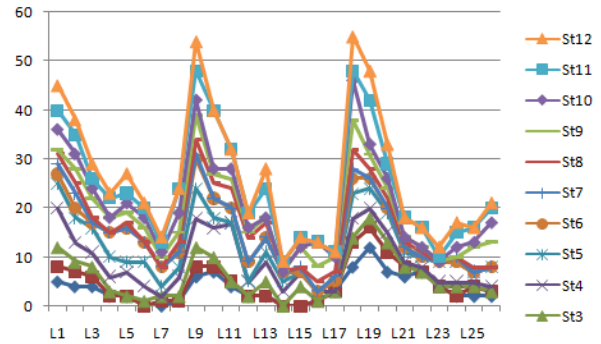


Fig. 5. The sum of trainees E decision making with the duration of 26 lessons (Part 1)

In order to define an optimum level of preparation we are focusing on the most reliable method in order to protect our data from outliers. In other words, we should try to find Robust method to optimize our expectations from the training process.

Mean square error [7]

$$D_i = \frac{1}{n} \sum_i^n (x_i - \bar{x})^2, \text{ or}$$

$$D_i = \frac{1}{n - 1} \sum_i^n (x_i - \bar{x})^2$$

is not robust as far as we are in search of discrete quantity.

Mode (M_o)

$$M_o = x_i + h \frac{f_{m_o} - f_{m_o-1}}{(f_{m_o} - f_{m_o-1}) + (f_{m_o} - f_{m_o+1})},$$

x_i – minimum desired value to be searched;
 h – width of Mode interval;

, also cannot be accepted as well as it is a probability mass function and is affected by outliers.

Median square error [8]

$$E = med_i (x_i - \bar{x})^2, \text{ or}$$

$$E = med_i |x_i - \bar{x}|, \text{ is robust for discrete quantity.}$$

Median variation series

$$m = med \quad X = \begin{cases} x_{(k)} & n = 2k + 1 \\ \frac{x_k + x_{(k+1)}}{2} & n = 2k \end{cases},$$

Is a way of finding the most Robust and discrete value of needed position (Fig. 6).

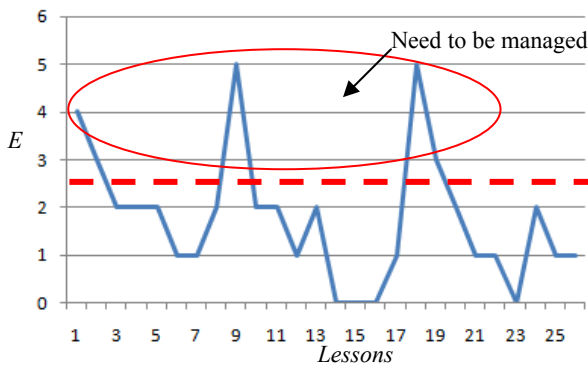


Fig. 6. Median of *E* decision making induced data with the duration of 26 lessons (Part 1)

Consider that the position of Median is our mean level of *E* state, we may already judge on our outcomes. At first, those picks symbolize two known positions; poor theoretical level of trainee at the very start of task execution and reflection of psycho physiological processes of decision maker. Anyway, as far as we are considering acting, against those picks, we are declaring such type of outcome is one to be managed [9,10].

To assist instructor in decision making of whether to initiate management of executed task or not we may also use Sturges' formula and build a bar chart (Fig. 7).

$$k = 1 + 3,32 * \lg n$$

The value of the quantum:

$$\Delta X = \frac{(X \max - X \min)}{K};$$

Determination of the mean of the sample:

$$X_m = \frac{(X \max + X \min)}{K};$$

Measuring frequency of N_m indications,

$$X_m \leq N_m \leq X_m + \Delta X$$

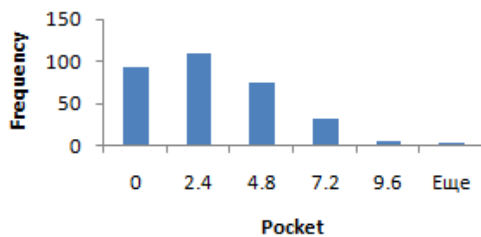


Fig. 7. Bar chart of *E* frequency using Sturges

8. General aspects of preparedness level control

To manage the position of outcomes we forced to structure specific filtering tasks which are mandatory to be done by trainee, in order to

guaranty not exceeding predefined level of preparation. In other words, we are ensuring correspondence of trainee SA level with requirements of certain technical operation predefined criteria.

Media tools that we may apply to satisfy our goal, are next:

- Part Task Trainer (PTT);
- Other Training Devises (OTD);
- Radar Trainer (RAD);
- Automated Work Place 'Situation' (AWP SIT).

The process of SA by trainee from the point of view of technological operations could be divided into 5 categories (table 2).

Table 2

Category of SA by technological operations and correspondence to types of task

<i>N_б</i>	Category of SA by technological operations	Brief description	Type of task
1	Short-term memory practice	Training of our short-term memory for required amount of data.	AWP SIT
2	'Eye' practice	Positioning of aircraft training.	OTD/RAD
3	Procedures and phraseology	Typical procedural algorithm training. React on pilots' requests.	OTD/PTT
4	Conflict resolution	Situation analysis. Conflict detection. Separation provision.	PTT/AWP SIT
5	Decision making	Situation analysis. Strategy application. issues on regulation and efficiency of traffic.	PTT

In order to meet requirements of individual approach for trainee we have to arrange the process of preparation by 'Learning Rate':

- Self-paced learning;
- Time-restricted learning;
- Real-time;

With an eye to establish flexibility of preparedness level control it is better to split the management into three levels based on time; Strategic level (new tasks planning phase), Pre-tactical level (planning phase based on previous results of *E*) and Tactical phase (management of recommendations in a day of training).

9. Conclusions

An instructor is playing the main role in evaluation of practical skills. Depending on a level of instructor's presence through the process of practical preparation we may judge on adequacy and completeness of trainee's skills evaluation. From the other point of view, to provide the best adequacy of ATCO skills assessment by instructor, we must initially create correspondent environment of training area.

The simulated environment should be related to the specific expectation of task and to take into account air traffic configuration.

Results that might be achieved, by already well known method of mean square error, are very vulnerable and unstable. To make a judgment or elaborate some strategy, basing on such results, is a way into the next instability. Therefore, median square method as bright example of robust way of data evaluation is a guaranty for future clear steps of action.

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Робастний метод визначення оптимального рівня підготовки на диспетчерському тренажері

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Цілями роботи є встановлення оптимального рівня підготовки, структуризація процесу тренажерної підготовки та аналіз результатів підготовки інструктором. **Методи**, які було обрано для визначення оптимального рівня підготовки: робастний метод, метод середніх квадратів та метод середньої медіани. Найнадійнішим методом для захисту вихідних даних обрано робастний метод. **Результати:** для управління позицією результатів виконується структурування специфічних завдань з фільтрації, які обов'язково повинні виконувати стажисти, з тим щоб гарантувати не перевищення заздалегідь визначеного рівня підготовки. Для задоволення поставленої мети, визначено набір медіа засобів для застосування: тренування з часткових завдань, інші тренувальні пристрої, тренер-радар, автоматизоване робоче місце "Ситуація". **Обговорення:** професійна підготовка авіадиспетчера – дуже складний і трудомісткий процес, в якому беруть участь багато фахівців та інструкторів. Процес підготовки грубо поділяється на частину з отримання теоретичних знань та частину з практичної підготовки, щоб перетворити теоретичний матеріал на практичні навички за допомогою диспетчерського тренажеру. Для тимчасової перевірки існують загальні критерії оцінювання навичок за такими технологічними операціями: прийняття чергування на робочому місці, адекватність

фразеології, координація з суміжними підрозділами, регулярність польотів, точність встановлення місцеположення повітряних суден, відповідність прийняття рішень для даної ситуації, забезпечення належного ешелонування та загальні аспекти забезпечення безпеки польотів, адекватності пультових операцій. Інструктор оцінює стажиста за всіма його діями, починаючи від готовності виконувати завдання, закінчивши аналізом зворотного зв'язку та наданням подальших рекомендацій. Повнота, адекватність та якість зазначених вище результатів залежать безпосередньо від якості інструктора. Крім того, особистісні аспекти інструктора, його здатність керувати процесом підготовки стажиста індивідуально, вміння виконувати прогноз процесу отримання навичок, вміння застосувати індивідуальну стратегію набуття навичок для стажиста тощо.

Ключові слова: авіадиспетчер; індивідуальний підхід; критерії оцінювання; медіана; робастний метод; статистика помилок; тренажерна підготовка.

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Робастний метод определения оптимального уровня подготовки на диспетчерском тренажере

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Целями работы является установление оптимального уровня подготовки, структурирование процесса тренажерной подготовки и анализ результатов подготовки инструктором. **Методы** для определения оптимального уровня подготовки юбилы выбраны следующие: это Робастный метод, метод средних квадратов и метод средней медианы. Наиболее надежным методом для защиты выходных данных избран Робастный метод. **Результаты:** Для управления позицией результатов выполняется структурирование специфических задач по фильтрации, которые обязательно должны выполнять стажеры, с тем чтобы гарантировать не превышение заранее определенного уровня подготовки. Для удовлетворения поставленной цели, определен набор медиа средств для применения: тренировки с частных задач, другие тренировочные устройства, тренер-радар, автоматизированное рабочее место "Ситуация". **Обсуждение:** Профессиональная подготовка авиадиспетчера - это очень сложный и трудоемкий процесс, в котором участвуют многие специалисты и инструкторы. Процесс подготовки грубо делится на часть по получению теоретических знаний и часть практической подготовки, чтобы преобразить теоретический материал в практические навыки с помощью диспетчерского тренажера. Для временной проверки существуют общие критерии оценивания навыков по следующим технологическим операциям: принятие дежурства на рабочем месте, адекватность фразеологии, координация со смежными подразделениями, регулярность полетов, точность установки местоположения воздушных судов, соответствие принятия решений для данной ситуации, обеспечение надлежащего эшелонирования и общие аспекты обеспечения безопасности полетов, адекватности пультовых операций. Инструктор оценивает стажера по всем его действиям, начиная от готовности выполнять задание, заканчивая анализом обратной связи и предоставлением дальнейших рекомендаций. Полнота, адекватность и качество указанных выше результатов зависят непосредственно от качества инструктора. Кроме того, личностные аспекты инструктора, его способность управлять процессом подготовки стажера индивідуально, умение выполнять прогноз процесса получения навыков, умение применить индивидуальную стратегию приобретения навыков для стажера и тому подобное.

Ключевые слова: авиадиспетчер; индивидуальный подход; критерии оценивания; Медиана; Робастный метод; статистика ошибок; тренажерная подготовка.

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