

Education as a Basic Element of Improving Professional Important Qualities of Aviation Technical Maintenance Personnel

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Abstract – In this article the importance of professional qualities, competence and their increase, directly dependent on the training of aviation technical maintenance personnel and determination the level of flight safety is covered. This publication analyses necessary training and requirements for aviation technical personnel involved in aircraft maintenance, as well as the requirements for aviation training organizations, defined as per Part-147, for such personnel preparation and training.

Keywords – EU 1321/2014, item response theory, maintenance, modules, Part-66, Part-145, training.

I. INTRODUCTION

Usually it is estimated, that the proportion of the human factor in the statistics of aircraft accidents is accounting 70 % to 80 % of all causes, with three-quarters of them caused by flight crew [1], [2]. In this regard, the greatest study of the influence of human factors on safety is for flight and supervisory personnel, but there is little research on the technical personnel [2],[3].

Meanwhile, the investigation of a large number of accidents and incidents has shown that the probability of the aircraft failure during flight is 4 times larger than the frequency of the flight crew errors. Aircraft failures depend primarily on the level of professional qualities of technical personnel. Such quality for technical personnel can be improved during their education or training process.

Basic standards in the training of aviation personnel are the standards ICAO Annex 1 [4]. However, the European Union, the United States of America, Russia and other countries have developed own, more stringent standards and are constantly improving them by themselves.

Legislative documents establishing requirements for aviation personnel training and training centres for its preparation in the European Union documents are:

- Commission Regulation EU No. 1321/2014 Annex III or also called EASA Part-66 [5] and;
- Commission Regulation EU No. 1321/2014 Annex IV or also called EASA Part-147 [6].

In this article let us consider the requirements for training in Technical Hour aircraft.

II. CATEGORIES OF AVIATION PERSONNEL

International Civil Aviation Organization (ICAO) certification requirements of aviation technical personnel is setting the standard for aviation technical personnel in European Union by EASA Part-66 document, which furthermore sets standards for the base model of technical personnel training and licensing standards and their issuance from the National Administration of a Member.

In accordance with the requirements of EASA Part-66 for the licensing of maintenance personnel, there are 5 categories of certifying staff (see Fig. 1) [5].

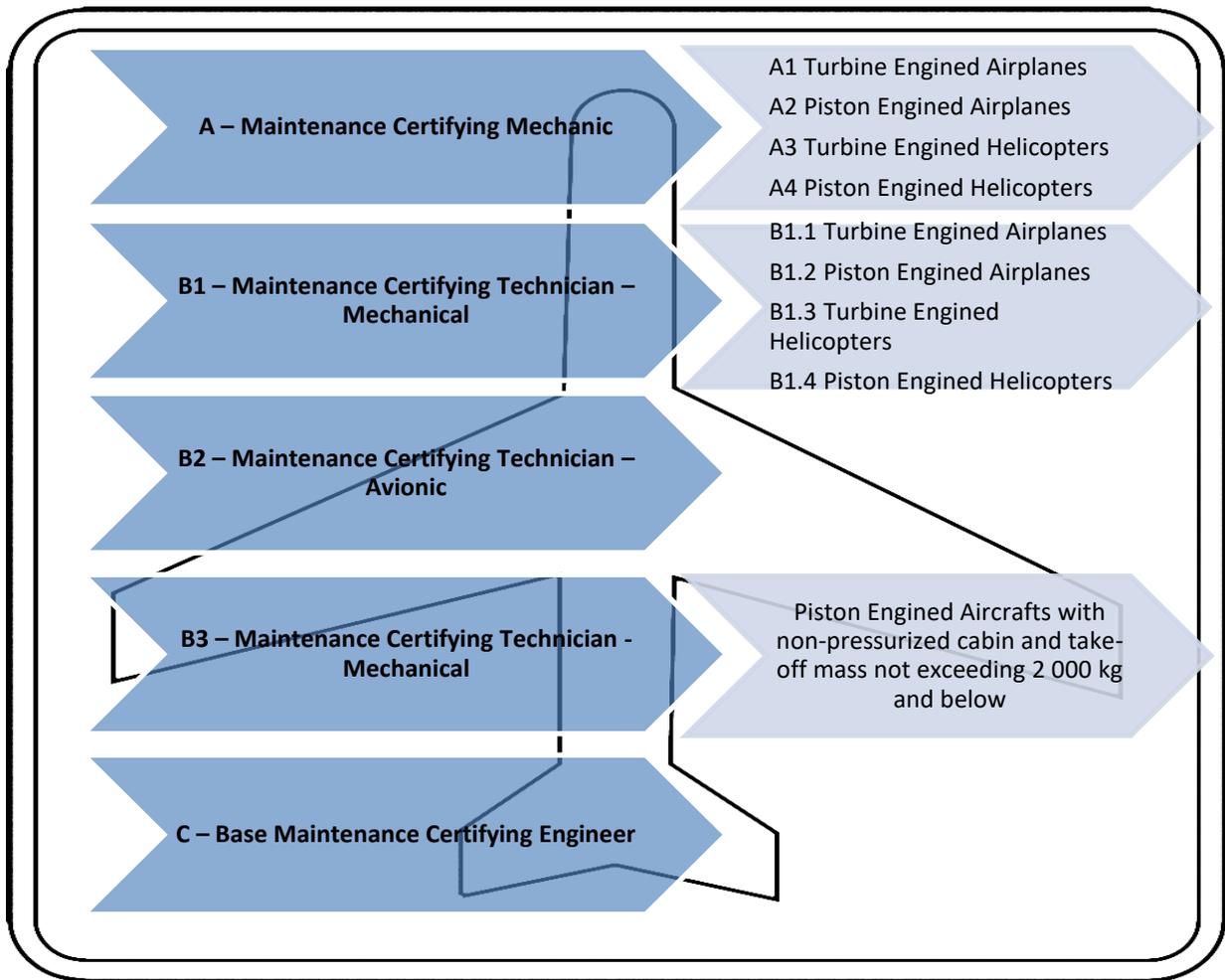


Fig. 1. Licensing categories of Technical maintenance personnel.

As can be seen category A (Maintenance Certifying Mechanic) and category B1 (Maintenance Certifying Technician – Mechanical) is divided into 4 sub-categories depending on the type of aircraft and type of its engines.

Category A is a category of technical personnel, with the minimum certification authority. License of category A allows its holder to perform small size maintenance, troubleshooting and rectify simple technical defects.

Category B2 (Maintenance Certifying Technician – Avionic) has no subcategories. License of category B2 allows its holder to carry out work on Technical Hour in avionics and electrical systems, to carry out work in the electronics and avionics systems in power plants and in mechanical systems, provided that this requires only an ordinary tests (checks) to confirm their suitability for the operation and performance of the technical certificate Hour by issuing admission into operation after the elimination of defects.

III. DEVELOPMENT OF KNOWLEDGE REQUIREMENTS

Since each level of training involves the development of relevant professional competences, monitoring should cover all their components. To organize such control, in addition to the goals and skills mentioned in ICAO Annex 1 [7] and EASA Part-66 [5] regulations it is necessary to develop requirements for knowledge that achieve desired objectives. Tables are used in order to reflect the correspondence between knowledge and skills. In such table rows are specifying the knowledge requirements, but columns are specifying skills. The cell at the intersection of *i*-th row and *j*-th column is written one if for the formation of the *j*-th skill requires knowledge of the *i*-th (see Table I).

TABLE I
CORRESPONDENCE BETWEEN KNOWLEDGE AND SKILLS

Knowledge requirements	Subsidiary objectives				
	1	2	3	4	5
1. Physics of the atmosphere: International Standard Atmosphere (ISA), application to aerodynamics	1				1
2. Terms: camber, chord, mean aerodynamic chord, profile (parasite) drag, induced drag, centre of pressure, angle of attack, wash in and wash out, fineness ratio, wing shape and aspect ratio					1
Knowledge requirements	Subsidiary objectives				
	1	2	3	4	5
3. Generation of lift and drag: angle of attack, lift coefficient, drag coefficient, polar curve, stall		1	1		
4. Relationship between lift, weight, thrust and drag		1	1		
5. Theory of the turn: Influence of load factor: stall, flight envelope and structural limitations	1	1			1
6. Lift augmentation	1			1	
7. Flight stability and dynamics: longitudinal, lateral and directional stability (active and passive)					1

The use of such tables simplifies the transition from the currently existing structure of theoretical training, based on the study of individual disciplines, to the modular structure, when the basis for a training course is created on the recommendations of the aircraft technical operation.

The given competence-based approach to learning and the main provisions for training is suggesting the following criteria for determining the level of training of specialist for aircraft maintenance:

1. The rating given to students mastering strategy.
2. Condition for achieving the status of training, when the measure of training Y exceeds a predetermined threshold Y_{thr} (1):

$$Y(n) \geq Y_{thr}, \tag{1}$$

3. Condition reaching a plateau on the learning curve when changing the measure of training in one learning step does not exceed a predetermined value v_Y (2):

$$(n + 1) - Y(n) \leq v_Y, \tag{2}$$

4. Stability condition for achieving a given learning outcomes when the value of the standard deviation $\sigma(n)$ of training measures do not exceed the threshold σ_{thr} (3):

$$\sigma(n) \leq \sigma_{thr}, \tag{3}$$

Selected criteria for assessing the quality of equipment should be based on an analysis of the parameters determining the accuracy, time and indicators of its operations and character reliability and the likelihood of the task.

Under certain boundary values for the probability of putting an unambiguous assessment of p_0 and p_1 , reduces the problem to the choice of such a value p^* ($p_0 \leq p^* \leq p_1$) and the number of such experiments n , in which the result can be

1. Pass, if $p^* > p_1$ or
2. Fail, if $p^* < p_0$.

The probability of errors of the first and second kind are, respectively, α and β . Expressions for the p^* and n are as follows (4)–(7):

$$n = \frac{[\Psi(1-\alpha)\sqrt{p_0(1-p_0)} - \Psi(\beta)\sqrt{p_1(1-p_1)}]^2}{(p_1-p_0)^2}; \tag{4}$$

$$p_* = p_0 + \Psi(1-\alpha)\sqrt{\frac{p_0(1-p_0)}{n}}; \tag{5}$$

$$\Phi(u) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^u e^{-\frac{\tau^2}{2}} d\tau; \tag{6}$$

$$z = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\Psi(z)} e^{-\frac{\tau^2}{2}} d\tau; \quad z = 1 - \alpha; \beta, \tag{7}$$

where

$\Psi(z)$ the inverse function.

Therefore, the values of p^* and n are defining set points for probabilities p_0 and p_1 and permissible error probabilities of the first and second kind α and β .

The standardized method for the control of knowledge is applied in order to improve the efficiency of the control. Such method allows:

1. Sample form of control tasks from their general population.
3. Assess the distinctiveness of each test task that avoids duplication of tests.
4. Identify the relationships between the individual tasks.
5. Justify the choice of the time allocated to address each of the control tasks.

The accuracy of the test control is achieved by using adaptive testing method based on the theory of modelling and parameterization pedagogical tests from Item Response Theory (IRT). Application of IRT models improves the accuracy of measurement and controls optimization of the procedure by the selection of tests in accordance with the level of preparedness of students [8]. This reduces the testing time, while the measurement accuracy is achieved using conventional test fixed length.

The IRT models are based on the assumption that the probability of correct assignments of the test is a function of the difference between the two latent variables:

θ – variable describing the level of knowledge of the student;

β – variable describing the level of difficulty of the test questions.

The two-parameter model A. Birnbaum has been used for testing, which further development is one-parameter model by G. Rasch (8), (9):

$$P_i\{x_{ij} = 1/\theta_i\} = \frac{e^{Da_i(\theta_i-\beta)}}{1+e^{Da_i(\theta_i-\beta)}}, \tag{8}$$

$$P_j\{x_{ij} = 1/\beta_j\} = \frac{e^{Da_j(\theta-\beta_j)}}{1+e^{Da_j(\theta-\beta_j)}}, \tag{9}$$

where

θ, β independent variables;

D constant 1.7;

θ_i i -th level of knowledge of the student, $i = 1, \dots, N$;

β_j level of difficulty j -th job, $i = 1, \dots, N$;

a_i, a_j quantities characterizing the ability of differentiating tasks.

Variable x_{ij} takes:

- value 1, if the i -th answer of student on the j -th task is correct;
- value 0, if the i -th answer of student on the j -th task is not correct.

The adaptive testing program “Aerodynamics and flight dynamics” (Part-66, Module 8) was developed to control knowledge on the subject with the aim to improve teaching methods. Each test task has been assessed by two-point system:

- 1 – if the correct answer is given;
- 0 – if the wrong answer is given.

Based on the total amount of points, the final assessment is determined by 4 point scale.

The indicators' relationship between the test results for a particular task with a total score for all test (using p – biserial correlation coefficient and the classical Pearson correlation coefficient) was considered as the validity of question for each test question. The calculated data for the first 10 test items is shown in Table II.

In the case of a significant positive Pearson correlation coefficient ($r_{xy} > 0.3$) there is reason to believe that test task is valid, i.e. it features the subjects with a high level of knowledge from poorly prepared students. During first tests it was noticed that task No. 2 and No. 10 can be removed from task list (see Table II) due to fact these two tasks have almost zero discriminative ability ($r_{xy2} = 0.07$; $r_{xy10} = 0.04$), and the validity of the task No. 3 and No. 8 can be questioned.

Afterwards correlation was calculated not only in relation to the total score, but also among themselves. The obtained results of the correlation analysis were summarized in the matrix R (Table III shows the correlation matrix R for the first ten test questions), and then made the final “cleaning” of the test.

Analysis of the correlation matrix show that the task No. 2, No. 3, No. 8 and No. 10 must be removed from the test, since the corresponding rows and columns of the matrix R contain negative values.

TABLE II

THE INDICATORS RELATIONSHIP BETWEEN THE TEST RESULTS FOR A PARTICULAR TASK WITH A TOTAL SCORE FOR ALL TEST

No. of task	1	2	3	4	5	6	7	8	9	10
Number of correct answers on a task	30	13	29	1	3	16	28	27	13	17
No. of task	1	2	3	4	5	6	7	8	9	10
The arithmetic mean of all tests from students who have successfully responded to this task, M_{resp}	20.7	20.7	20.6	30	29	23	21.2	20.7	24.1	20.4
The arithmetic mean of all tests students incorrectly answered this task, M_{inc}	12.5	19.9	16.3	19.9	19.3	17.4	13.5	17.6	17.6	20
p – biserial correlation coefficient, r_{pb}	0.35	0.07	0.22	0.31	0.49	0.49	0.44	0.2	0.56	0.04
Sample variance on the instructions, SS_{xj}	0.06	0.25	0.09	0.03	0.09	0.26	0.11	0.14	0.25	0.26
Sample covariance (correlation time), SP_{xjy}	0.5	0.2	0.38	0.32	0.85	1.44	0.87	0.42	1.62	0.11
Pearson's correlation coefficient, r_{xy}	0.35	0.07	0.22	0.31	0.5	0.49	0.45	0.2	0.57	0.04

TABLE III

THE CORRELATION MATRIX R FOR THE FIRST TEN TEST QUESTIONS

No. of task	1	2	3	4	5	6	7	8	9	10
1	1	0.21	-0.08	0.05	0.08	0	0.68	-0.11	0.21	-0.24
2	0.21	1	-0.17	-0.15	-0.27	0.06	0.12	-0.17	0.09	0.14
3	-0.08	-0.17	1	0.06	0.1	-0.11	-0.12	-0.14	0.05	0.13
4	0.05	-0.15	0.06	1	0.56	0.18	0.07	0.08	0.22	-0.19
5	0.08	-0.27	0.1	0.56	1	0.11	0.12	0.14	0.17	-0.13

No. of task	1	2	3	4	5	6	7	8	9	10
6	0	0.06	-0.11	0.18	0.11	1	0	0.09	0.19	-0.06
7	0.68	0.12	-0.12	0.07	0.12	0	1	-0.16	0.31	-0.17
8	-0.11	-0.17	-0.14	0.08	0.14	0.09	-0.16	1	-0.17	0.11
9	0.21	0.09	0.05	0.22	0.17	0.19	0.31	-0.17	1	0.14
10	-0.24	0.14	0.13	-0.19	-0.13	-0.06	-0.17	0.11	0.14	1

The corresponding plot of the probability of a correct answer to the task No. 6 – the level of knowledge of the test – is shown in Fig. 2.

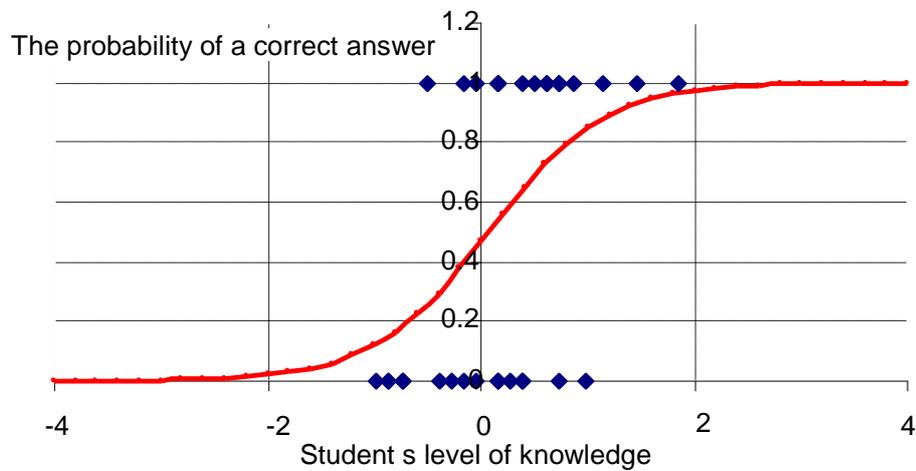


Fig. 2. Dependence of the probability of a correct answer on the level of knowledge.

The numerical values of the parameters a_j and β_j for each test task were calculated using the method of maximum likelihood. Table IV represents the data for the remaining tasks of the top 10 tasks, in increasing order of task difficulty.

TABLE IV

THE DATA FOR THE REMAINING TASKS

No. of task	1	7	6	9	5	4
The resolution of the j -th task, a_j	2.17	2.43	1.87	2.30	91.36	2.31
The difficulty of the j -th task, β_j	-1.40	-0.97	0.07	0.29	1.07	1.77

IV. TRAINING AND REQUIREMENTS FOR PERSONNEL ON AIRCRAFT TECHNICAL MAINTENANCE

It is enough to have secondary special education in order to obtain aircraft technical maintenance category. Such secondary special education can be received in any aviation school, college and/or have training and/or pass all the modules in a specialized school, that is certified according EASA Part-147 [6] requirements and approved by the Competent Authority of Civil Aviation Agency with a license to perform the maintenance of the appropriate category. As a rule, all young professionals before receiving a license initially are working as an aviation technician trainee on the direct maintenance of aircraft.

To remain eligible for support of aircraft the applicant must undergo a course of basic education, where design, maintenance, methods of maintenance and repair of aircraft and their components to be studied. Applicant has also to be able handle competently the technical documentation and know the requirements to be met for personnel.

EASA Part-66 [5] is setting the standard base model for training specialists, curriculum standards, standards for examinations, as well as standards for licensing of maintenance personnel, depending on the category of personnel.

The volume of the basic course of training depends on the category of specialists:

1. Category A1 – 800 hours, of which 30 % to 35 % for practical training;
2. Category A2 – 650 hours, of which 30 % to 35 % for practical training;
3. Category A3 – 800 hours, of which 30 % to 35 % for practical training;
4. Category A3 – 800 hours, of which 30 % to 35 % for practical training;
5. Category B1 – 2400 hours, of which 50 % to 60 % for practical training, of which 30 % directly to the maintenance of a special program practical training;
6. Category B2 – 2400 hours, of which 50 % to 60 % for practical training, of which 30 % directly to the maintenance of a special program practical training;
7. Category B3 – 1000 hours, of which 50 % to 60 % for practical training [5].

Regulation provides the possibility of obtaining a specialist maintenance certifying staff in several categories. For example, the expert category B1.1 (Maintenance Certifying Technician – Mechanical for turbine engine airplane) can undergo retraining on the category B2 (Maintenance Certifying Technician – Avionic), provided additional training of 600 hours (of which 80 % to 85 % – the theoretical training) [9]–[11].

EASA Part-66 includes a total of 17 training modules covering all categories of maintenance technicians. For each issue the module provides levels of training for different categories in 3 levels. As final examination form can be:

1. Test;
2. Essay Question as additional written test, for such modules as Module 9 “Human Factor”, Module 10 “Aviation Legislation” and Module “7 Maintenance Practices”.

It is deemed to be delivered, provided that the correct answers are not less than 75 % of the total number of questions from the examination questions for the module [12]. Made strictly liable for passing grades and examiners. So a student caught in the use of materials other than the examination of tickets, loses a year of law exams. The training system implies the possibility of an independent study program with mandatory exams in modules or in Civil Aviation Agency (CAA), or organizations accredited to the requirements of Part-147 [6], in this case, a deadline passing all modules chosen Professional – 10 years from the date of the first module.

EASA Part-66 guarantees the mutual recognition of professional education in the member countries of the European Union and, therefore, the opportunity for service technician to work in any of these countries [5].

V. REQUIREMENTS FOR TRAINING ORGANIZATION

Requirements for the organization of training standards Part-66 [5] establishes a different document Part-147 [6]. Requirements intercepts all aspects of its operations, including the requirements for logistics training facilities, requirements for personnel training, tools, and training materials and other aspects of the Learning Organization [17].

Thus, groups of theoretical instruction shall not exceed 28 people, and practical – 15 people per teacher/instructor [9]–[11]. Students who pass the exams in basic training modules and exams (same test) for model learning organization approved by Part-147, receive a certificate of training due form recognized in all EU member states. Examination results should be stored in the archives of the teaching indefinitely.

Periodically (once every two years) training organization Part-147 subject to a comprehensive audit of the quality of the National Civil Aviation Agency (CAA) and the European Aviation Safety Agency (EASA).

VI. LICENSE TO PERFORM MAINTENANCE OF AIRCRAFT

For the recognition of the status of the certifying expert challenger, with a background in organization approved by Part-147, an intern at an organization dedicated to the maintenance of aircraft and approved by the requirements of Part-145 [13].

The next step – getting a license, which you need to have a normative experience in aircraft maintenance under the supervision of certifying staff, that is, without the right certification maintenance.

License Part-66, issued by the Administration of the Civil Aviation Authority (CAA) [14] of the country - a member of the European Union, however, after obtaining licenses Part-66, to obtain the right of the aircraft maintenance specialist has to go to the maintenance organization, authorization, which give him the right to the name of the organization, to certify the work performed. Authorization provides quality manager of the maintenance organization, approved under the requirements of Part-145. This authorization gives the right to perform maintenance of aircraft to conduct their inspection, perform the replacement components, carry out not difficult repairs and perform actions on the continuing airworthiness of aircraft for the company [15].

VII. CONCLUSION

1. One of the most significant causes of accidents is still deficiencies in the training of technical personnel. Consequently, improving the training of technical personnel is an effective way to increase the safety of civil aviation.
2. Exit to the operation of aircraft of the new generation with a high degree of automation, changes the nature of the professional activity of the specialist maintenance that sets new requirements for its training.
3. Modern training aviation technical personnel should be systematic and be based on the implementation of the competency campaign, as required by ICAO.
4. For the implementation of the competency approach requires the use of mathematical modelling taking into account features of aviation technical personnel, which allows for the development of all components of the professional competencies.

In the future, engineering education can take up leadership positions in the structure of aviation engineering service

Education, as a basic element, is to increase professional important qualities of aviation technical personnel receiving the professional education and training, to ensure the formation of the competence of aviation professionals throughout their active career, in order to ensure flight safety.

The quality of training of aviation technical personnel on aircraft maintenance is a basic problem for civil aviation [16].

Adopted EU training system shows great potential in this area since it helps to improve professional important qualities of aviation technical staff by getting them professional education and training.

Over the past decade, Latvia in this direction was a difficult path of integration into the European aviation market and has had some positive experience in the training of aviation technical personnel for aircraft maintenance.

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