

THE DEVELOPMENT OF AN INTEGRATED LEARNING ENVIRONMENT FOR THE TRAINING AND CERTIFICATION OF AIRCRAFT MAINTENANCE ENGINEERS: MOVING BEYOND THE CLASSROOM

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Abstract

This paper details the work of the GRABNOWAML project - GRowing Access to Basic kNOWledge for the Aircraft Maintenance Licence (AML) – which is co-funded under the EU Leonardo da Vinci program. Within the next 10 years the estimated demand for certified technicians in the aeronautical field will increase considerably and this project sets out to specify and develop an innovative, flexible training program for the AML through the use of e-learning and blended learning in order to present to EASA (European Aviation Safety Agency) new methods of training. In some EU countries national regulatory authorities permit only classroom training as an acceptable means of compliance with the EASA regulations. In this way the training for the AML in some EU member-states is precluded from embracing and implementing more innovative and cutting-edge training technologies and methods. The aim of the project is to provide evidence of the efficacy of an innovative blended-learning approach to the basic knowledge, skills and abilities (KSA) for the acquisition of the Aircraft Maintenance License so that it can be proposed to the National and EU regulatory entities. The project is focusing on defining and pilot testing an integrated learning environment that can deliver and manage innovative blended-learning paths which impart the basic KSAs required by EASA Part 66 for obtaining the AML. This paper will set out the issues informing the need for e-learning and blended learning approaches in this sector – chief amongst them the shortage of qualified aircraft maintenance personnel in Europe; the approach adopted in the requirements gathering phase; and some initial results from the activities concluded thus far.

Keywords: training, aviation, licensing, integrated learning, regulations

1. INTRODUCTION

The GRABNOWAML project consortium is composed of partners from industry, the third-level education sector and training and education development companies – namely AgustaWestland, a Finmeccanica company (Italy), Trinity College, University of Dublin (Ireland), Nordian (Norway) and Grifo Multimedia (Italy). The project has two main objectives: (i) develop a practical application of an ICT-based learning environment to manage, deliver and monitor a blended learning path (BLP) for the AML, and (ii) define quality and standards criteria to present for future and possible recognition and certification process of blended learning paths for the AML. Currently in Europe most of the training programmes for aircraft maintenance technicians are delivered with traditional methods (classroom sessions) and some national regulatory agencies in the field of civilian aviation safety permit classroom training only. The project intends to develop and demonstrate innovative and flexible training methods using e-learning and other ICT systems to manage and track blended learning as well as to assess skills, while at the same time ensuring that the international requirements and regulations of EASA (European Aviation Safety Association) are adhered to.

EASA has established international requirements for the qualification of aircraft maintenance staff, these are laid out in EASA Part 66. This document defines the knowledge and skills that must be acquired in order to obtain the theoretical part of AML. The GRABNOWAML project is focusing on defining and pilot-testing an integrated learning environment (made up of ICT based systems, learning methodology, e-learning contents and services) that will be in accordance with EASA Part 66. The project partners plan to test, under realistic conditions, the approach and environment by delivering a BLP (including e-learning units, instructor-led classroom sessions, virtual classroom sessions and skill assessment) with samples of real trainees.

A concomitant task in the project's work program is the definition of criteria to evaluate and monitor this type of innovative BLP so that regulatory bodies such as EASA can check it and value the indispensable procedure necessary to recognise and certify it. This will facilitate the mobility of learners and workers in the European aircraft maintenance sector where there is a shortage of qualified personnel. New organisational systems, new technologies (aircraft systems, diagnostic tools and IT systems) and new training concepts (move from apprenticeship to technical training) are transforming the way in which aircraft maintenance operations are carried out.

The GRABNOWAML project intends to propose to EASA the Project results to demonstrate that developing innovative ICT-based services and practices for the AML can assist in developing lifelong learning (a strategic EU objective) and improve worker mobility, employability and competitiveness in the European aerospace industry. In addition, the project will help to identify and share best practises at national level across the EU such that the entire European aviation sector can be at the cutting edge.

The first part of the paper will present the regulations concerning the AML (detailing the experience and knowledge requirements) and will also profile the regulatory process of how courses are approved. The second part of the paper will look at the progress made thus far in the development of the integrated learning environment – specifically in terms of the decision making about what training modalities to be used.

2. EASA REQUIREMENTS FOR THE QUALIFICATION OF AIRCRAFT MAINTENANCE PERSONNEL

2.1 Aircraft Maintenance Training and Licences

The aircraft maintenance licence underpins the whole of aircraft maintenance training. Without the appropriate maintenance licence a technician cannot legally carry out work on an aircraft. EASA sets out regulations governing the issuing of licences. These regulations make specific requirements in relation to the technicians' experience of active maintenance but they also specify the knowledge requirements (and curricula for training) for the various types of licence. EASA Part-66 (previously JAR 66) is the set of regulations governing the issuing of aircraft maintenance licences for certifying staff. There are mainly four categories of aircraft maintenance licence and each one has associated privileges [1]:

1. A category A aircraft maintenance licence permits the holder to issue certificates of release to service following minor scheduled line maintenance and simple defect rectification within the limits of tasks specifically endorsed on the authorisation¹. The certification privileges shall be restricted to work that the licence holder has personally performed in a Part-145 organisation.
2. A category B1 aircraft maintenance licence shall permit the holder to issue certificates of release to service following maintenance, including aircraft structure, power-plant and mechanical and electrical systems. Replacement of avionics replaceable units, requiring simple tests to prove their serviceability, shall also be included in the privileges.
3. A category B2 aircraft maintenance licence shall permit the holder to issue certificates of release to service following maintenance on avionics and electrical systems.
4. A category C aircraft maintenance licence shall permit the holder to issue certificates of release to service following base maintenance on aircraft. The privileges apply to the aircraft in its entirety in a Part-145 organisation.

Experience and Knowledge Requirements

There are two ways in which an individual can obtain an aircraft maintenance licence. The first way is through practical experience (e.g. an apprenticeship scheme); here the applicant is required to pass written and oral exams. Each of the four licences has different experience requirements:

Category A – Requires a minimum of 800 hours of instruction; the technician can perform scheduled line maintenance and simple defect rectification.

¹ The holder of a category A aircraft maintenance license may only exercise certification privileges on a specific aircraft type following the satisfactory completion of the relevant category A aircraft task training carried out by an appropriately approved Part-145 or Part-147 organisation. [1]

Category B1 (Mechanical rating) – Requires a minimum of 2,400 hours instruction; the technician can perform maintenance on aircraft structure, power-plant and mechanical and electrical systems, as well as change out line-replaceable avionics units.

Category B2 (Avionics rating) – Requires a minimum of 2,400 hours instruction; the technician can perform maintenance on avionics and electrical systems.

Category C (combines B1 and B2) – Requires a minimum of 3,000 hours of instruction;

The second way is by completing an approved training programme in a Part-147 approved training organisation, together with the year's practical experience required and the possibility to have recognition of credits. This is the training path that is of interest to the GRABNOWAML project. As stated above, all applicants must pass certain knowledge examinations in addition to having experience before they receive their licence. The examinations are structured in modules. Some modules are general and are required by all licence categories; others are more specific and relate only to certain licences. The modules can be taken in any order but must be completed within the five-year period prior to obtaining the licence. Modules cover subjects such as mathematics, physics, human factors, aerodynamics, digital techniques etc.

EASA Part-66 has further specified the 'levels of knowledge' expected of holders of the different types of aircraft maintenance licence. These are indicated by allocating a knowledge level indicator (1, 2 or 3) to each topic or subject in a module (each of the modules listed above contains a number of different topics). These 'knowledge level indicators' are defined as follows [1]:

Level 1 - A familiarisation with the principal elements of the subject

Objectives: *The applicant should be familiar with the basic elements of the subject*

- The applicant should be able to give a simple description of the whole subject, using common words and examples
- The applicant should be able to use typical terms

Level 2 - A general knowledge of the theoretical and practical aspects of the subject

An ability to apply that knowledge

Objectives: *The applicant should be able to:*

- understand the theoretical fundamentals of the subject
- give a general description of the subject using, as appropriate, typical examples
- use mathematical formulae in conjunction with physical laws describing the subject
- read and understand sketches, drawings and schematics describing the subject
- apply his knowledge in a practical manner using detailed procedures

Level 3 - A detailed knowledge of the theoretical and practical aspects of the subject

A capacity to combine and apply the separate elements of knowledge in a logical and comprehensive manner

Objectives: *The applicant should:*

- know the theory of the subject and interrelationships with other subjects
- be able to give a detailed description of the subject using theoretical fundamentals and specific examples
- understand and be able to use mathematical formulae related to the subject.
- be able to read, understand and prepare sketches, simple drawings and schematics describing the subject.
- be able to apply his knowledge in a practical manner using manufacturer's instructions
- be able to interpret results from various sources and measurements and apply corrective action where appropriate

3. REQUIREMENTS GATHERING

In addition to understanding EASA's requirements it was necessary to understand the ways in which e-learning and blended learning paths can be beneficial to the training of AML students and also to

understand how this new type of training would be received and potentially incorporated into the existing regulatory framework context. To this end the first research activity of the GRABNOWAML project involved analysing the training needs of students for the AML. Interviews with trainers and trainees were conducted to elicit information from the key stakeholders and this data was then triangulated with the outputs of observational studies of training performed in normal current circumstances. The key findings from the activities performed in this part of WP1 are presented below as requirements:

- Requirement for flexible training which allows trainees to continue working
- Requirement for tailored training which allows trainees to direct the pace of learning
- Requirement for continuous progress reporting (early warning indications of problems)

4. DESIGN OF THE INTEGRATED LEARNING PATH FOR THE AML

Three modules relevant to the most representative category (B1) of the AML were chosen for development in the GRABNOWAML project:

- ✓ Module 1 cat B1 – Mathematics
 - Contents selected: 1.2 – Algebra.
- ✓ Module 9 cat B1 – Human Factors
 - Contents selected: 9.2 – Human Performance and Limitations, 9.4 - Factors Affecting Performance, 9.7 – Communication.
- ✓ Module 12 cat B1 – Helicopter Aerodynamics, Structures and Systems
 - Contents selected: 12.4 - Transmission and 12.8 - Electrical power (ATA 24).

Knowledge Level Indicators & Training modalities employed in GRABNOWAML

The three knowledge levels from EASA allow us to build a principled method upon which the decision of training modality is made. It is obvious that each level of knowledge has different training requirements – but the content has an equal, if not more important, role to play in informing the training requirements. The training modalities that will be developed in GRABNOWAML are listed as follows:

Web-conference

1. Web-based Tutorials (text, images teaching the student)
2. Traditional 'chalk and talk' over internet
3. Assessment

E-learning

1. Multimedia contents (Animation (incl. audio and text)
Exercises for self assessment (when applicable)

Session Exam

1. On line test
2. Correction via web conference

The blended learning path refers to the combination of these training methods as a means of providing comprehensive training to achieve the AML. From the analysis of the knowledge levels we can make decisions about the appropriate training modality. However, the differences between the nature of contents in the various modules preclude the development of a precise algorithm for allocating a training method to a particular knowledge level indicator. Clearly Level 2 knowledge of human performance cannot be trained in exactly the same way as Level 2 knowledge of communication. For this reason Liston's Competence model [2] was considered and in part used as the means of selecting the training modality for the training contents. Liston [2] developed a model of competence for the aircraft maintenance domain that accounts for all these issues and which will be used as the theoretical basis informing the blended learning approach in GRABNOWAML. This model of professional competence has 6 elements:

1. Understanding of the work

This is the basis of competence. Understanding is gained through the lived experience of work. This prescribes the KSAs necessary to perform the work.

2. Attributes (KSAs)

This element refers to the knowledge, skills, abilities which a worker uses to perform his/her work.

3. Action

This refers to the enactment of the KSAs. This is when knowledge and skill are externalised and expressed in behaviour.

4. Performance

This refers to the enactment of KSAs. This is where the work activities (or actualised KSAs) of one worker interfaces with the work activities of another.

5. Context

This element refers to the community of practice in which the performance takes place.

6. Evaluation

The use of the label 'competent' is negotiated by the members of the community of practice.

Starting from this model and the experience of instructors, the contents development has required the involvement of SMEs (educational, technical and skilled persons) able to search, check, collect and develop the materials to be used and to collaborate with the graphics and the multimedia developers for the choice of the best modality to be used for the multimedia contents development, taking into consideration the reference Legislation requirements and the educational aspects applicable to new technologies use.

The courses will be delivered in Italian and English language.

5. THE BLENDED LEARNING PATHS (BLP) FOR THE THREE MODULES

The BLPs chosen for the various modules to be developed in GRABNOWAML are listed in Tables 1-3 (below). The timings listed for the various elements of the Module are intended to satisfy the requirements of the majority of trainees and are medium/average estimations of the time required to complete the contents. The BLP was especially designed with shift workers in mind – most of the trainees are already in employment and the schedule has to be flexible to fit around their shift-work schedule.

Table 1: BLP For Module 1 (Mathematics)

M 01_schedule	
Content	Modality
M01	E-learning course activation
On-line contents (1.02)	E-learning contents fruition (Use of on-line platform)
Lesson	Web conference (Live)
Test on line + test correction	Web conference (Live)

Table 2: BLP For Module 9 (Human Factors)

M 09_schedule	
Content	Modality
M09	E-learning course activation
On-line contents (9.02/9.04/9.07)	E-learning contents fruition (Use of on-line platform)
Lesson	Web conference (Live)
Test on line + test correction	Web conference (Live)

Table 3: BLP For Module 12 (Helicopter Aerodynamics, Structures and Systems)

M 12_schedule	
Content	Modality
M12	E-learning course activation
On-line contents (12.4/12.7)	E-learning contents fruition (Use of on-line platform)
Lesson	Web conference (Live)
Test on line + test correction	Web conference (Live)

6. SUPPORT SERVICES

The project has specified one source of support that is fundamental to the success of the BLP concept: Personnel. The Learning Management System (LMS) is one of the innovative instruments used.

6.1 PERSONNEL

The persons involved in the Support are:

- Tutor (course planning, trainee continuous assistance via web conference, e-mail and phone, portal check, data processing, continuous contact with instructors for test development and didactic approach, continuous contact with IT Support)
- Instructor (test and lessons preparation, trainees continuous assistance via WEB conference and e-mail, continuous contact with tutor)
- IT Support (help desk, trainees continuous assistance for IT needs continuous contact with tutor)

The tutor / E- tutor

The main responsibilities of this role are:

- Management and continuous support of online learners (in drawing up study plans, learning strategies, time monitoring)
- Mentoring and motivating learners, anticipating trainees needs or course problems
- Use any kind of media (e-mail, text, audio and video conference and web conference, forums, bulletin boards) for communication with and among trainees when requested
- Support for Instructors and cooperation with them
- Check of course advancement, management, monitoring and contribution to development of the various phases of the course
- Management of interaction between Trainees and Instructors
- Identification, analysis and support to solution or solution of the problems found during the course
- Monitoring of learning levels
- Assess learners' performance
- Evaluation and continuous improvement of e-tutoring support
- Support for instructors and managers in courses assessment

The Instructor

The Instructors are the holder of knowledge and contents course. The main responsibilities of this role are:

- Teaching and preparing the lessons and tests in cooperation with the Tutor
- Assisting the trainee from the didactical (educational) point of view for the entire duration of the training course
- Communicating closely with the Tutor about all aspects of the course
- Planning, development, managing, check of the on line material and tests' database
- Supervision of the various phases of the test
- Coordination and deliberation of content and duration of the course in collaboration with the Tutor
- Use of web instruments (chat, e-mail, web conference, etc) for the communication with the trainees

Technical Support

The Technical Support is a team of IT technicians able to assist the trainees for any technical requests, to find solutions to trainees' technical difficulties or problems. The Technical Support team works closely with the Tutor for an efficient, tailored and complete service. The main responsibilities of this role are:

- Provision of IT Support to trainees for the duration of the entire e-learning course (including installation / start up)

6.2 Learning Management System (LMS)

In addition to specifying the blended learning path for the AML modules to be developed in the GRABNOWAML project, it was necessary to specify the system requirements for a Learning Management System (LMS). This is technology that will be used to operationalise the training

modalities listed above and will be used by two primary users (apart from the trainee): the instructor and the tutor. This work has been completed and the main features are as follows:

- User registration by administrator,
- User management through groups, roles or organization tree
- Course and curricula management system
- Standard and customized multilevel reports (status of completion, time delivered, result on, Post assessment and Course final score)
- Administrator management and profiling
- Competence management module and gap analysis
- Post-assessment management
- Internal search engine for content library
- Course catalogue
- Export report in Excel format and others, report scheduling
- Classroom activity management and monitoring
- Virtual classroom (videoconference), slide show sharing, chat

7. NEXT PHASE

Currently the GRABNOWAML project is in the testing phase of activity. This phase involves using trainees to test the functionalities and provide evaluation feedback. Trainees are being drawn from different EU countries to follow the curriculum. The results of their training will provide an important validation of the BLP developed in the project.

CONCLUSIONS

This paper provides an analysis of the issues associated with introducing inclusive learning strategies into the training for aircraft maintenance licences. It is clear that steps are being made in the right direction, but given the growth in the aviation sector and the predicted increase in demand for certified technicians in the aeronautical field in the next 10 years the situation is critical. The paper also presented the results achieved thus far in the project's efforts to (i) develop a principled means of allocating training modalities to training content; (ii) specify a BLP for the AML, (iii) implement a LMS for the aviation maintenance sector; and (iv) ultimately to test and evaluate the outputs of the GRABNOWAML project's collective efforts.

REFERENCES

[1] EASA Part 66 Annex III Rules (EC) 2042/2003 (www.easa.eu.int)

[2] Liston, P.M. (2006). *Human Factors Competence in Aviation Maintenance*. Unpublished Doctoral Thesis, Trinity College, Dublin