Upskilling via Maintenance e-Training

When and Where?

Before embarking on sophisticated and expensive upgrades in technological infrastructure to support asset and maintenance management, enterprises need to consider a basic ingredient of success: personnel must have the right knowledge and skills to perform their expected functions. The maintenance function itself often requires a truly multi-disciplinary set of skills that is rarely readily available and thus staff needs to be trained, most often after entering their working life. E-learning offers flexible and efficient means to deliver such training, breaking space and time barriers.

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Modern enterprises are paying increasing attention to making optimal use of their assets, leading them to adopt adequate maintenance strategies and see them through by putting in place the right maintenance policies. Ensuring that the right maintenance policies for human capital management are implemented is a fundamental ingredient of success before even considering advanced and sophisticated technological solutions for engineering asset management. A key aim for any human capital management policy is to ensure that personnel have the right knowledge and skills to perform their intended function.

The above aim requires to: identify the required competences for different maintenance functions, deliver the body of knowledge needed to attain these competences and assess personnel competences in an objective way.

This article looks into how e-learning tools can offer useful and practical means to deliver training and competence assessment services for maintenance engineering and management. First, the case for employing e-learning for maintenance is examined. Then we look at specific examples of delivering e-learning for maintenance training, taken from two European projects, namely Dynamite and iLearn2Main.

Why e-Training in Maintenance?

Enterprises often do not share common criteria for required maintenance competences. This affects their capacity to efficiently implement a chosen maintenance strategy. Any ambiguity competence requirements affects also personnel mobility and employability. The nature of the Maintenance function is such that the required knowledge is drawn from a multitude of disciplines. This is well reflected into the EFNMS Requirements and Rules to achieve a Certificate as a European Expert in Maintenance Management, as well as the Regulations for the EFNMS Certificate as a European Maintenance Specialist (see EFNMS documents at www.efnms.org), (Franlund, 2008). These have been important contributions in the direction of establishing a common qualifications framework. Such a framework would enable employees

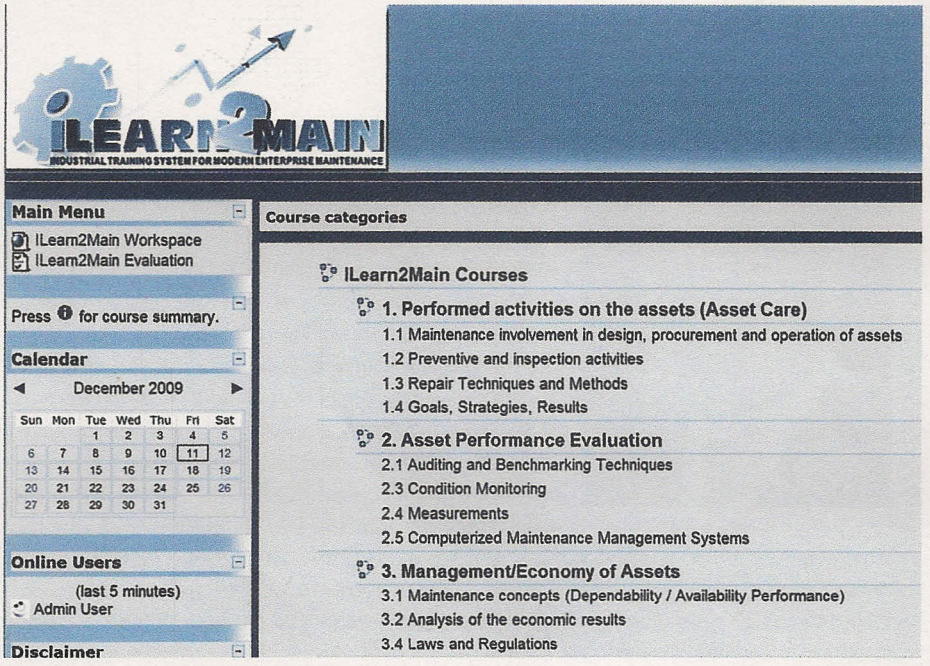


FIGURE 1. *The iLearn2Main e-training showing the Maintenance Management Training Curriculum.*

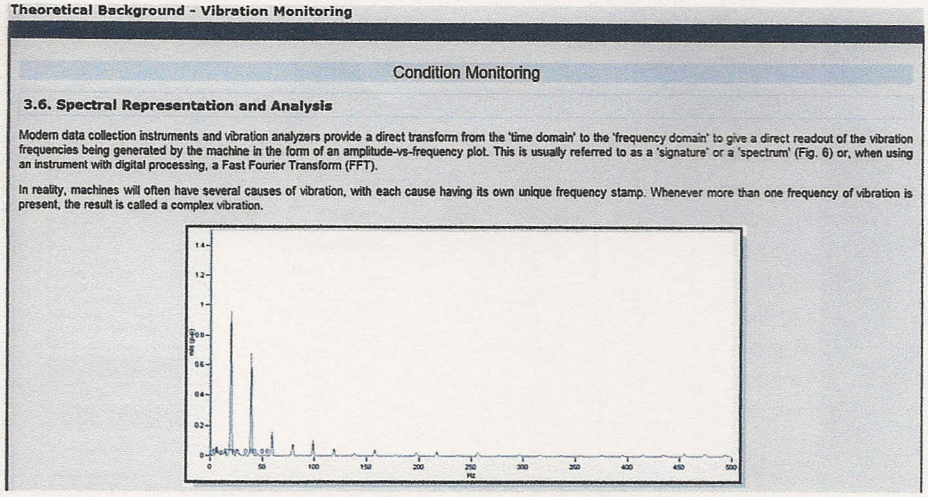


FIGURE 2. *Course with glossary-integrated content.*

to enjoy easier mobility and more transparent recognition of their skills, making them employable in wider markets. At the same time, organisations would become more confident to invest in qualified personnel.

However, the multi-disciplinary nature of the needed skills makes it very difficult to include the required body of knowledge in standard higher education courses and more specialised training is often required (Macchi and Ierache 2009) (Starr and Bevis 2009). Instead, it is mostly included in vocational education and training curricula. Recent surveys have revealed a clear gap between available competences and required skills and have identified areas where a real improvement on maintenance training can be made (Bakouros and Panagiotidou 2008), (Emmanouilidis et al. 2009).

A significant difficulty lies with the fact that trainees are often individuals who have already entered their working life and in most cases cannot take a maintenance training course under pressing time constraints. To mitigate such pressures, while avoiding the high costs of on-the job training, e-training is considered well suited to the specific needs for enhancing maintenance employable skills and competences (Emmanouilidis et al. 2008). Although the cost of developing the e-training solution is higher than that of conventional training, the costs associated with running the training, the flexibility offered to the trainees and the fact that e-learning is by design an interactive and engaging training experience, makes it appropriate for maintenance management training.

Considering the potential impact of e-learning on maintenance-related training, a recent survey of 70 professionals involved in the maintenance function in 5 EU countries (UK, Sweden, Greece, Latvia and Romania) has found that the likely adoption prospects of e-training in maintenance are quite positive (Papathanassiou and Emmanouilidis 2009).

Next we look at two specific examples of maintenance e-training. The first is targeting generic Maintenance Management training and competence assessment. The second is an example of employing e-learning for specialised subjects, e-maintenance in this case.

iLearn2Main: Maintenance e-Training and e-Assessment

The iLearn2Main project has developed a flexible e-learning and e-competence assessment system for Maintenance Management training (www.ilearn2main.eu). Based on the popular open source Learning Management System platform Moodle, the developed e-Learning toolkit offers customised maintenance management training and automated competence assessment. The targeted user group in is personnel involved or aiming at becoming involved in Maintenance Management. An assessment of VET objectives was completed, that has taken into account a user survey of 70 professionals. Taking into account the results of survey, as well as the aforementioned EFNMS requirements, a Maintenance Management Training Curriculum was defined, FIGURE 1.

The iLearn2Main training toolkit offers an integrated environment that supports trainees and trainers to enrol and participate in e–training and e-assessment for Maintenance Management competences. The training modules have been developed and deployed in a Moodle platform that was setup and customised to fit the needs of Maintenance Management training, as specified in the VET objectives.

The iLearn2Main courses content was developed by the University of Portsmouth, UTEK, ATLANTIS Engineering and ATHENA Research & Innovation Centre. Learning objectives have been processed and deployed in a Moodle platform that was setup and customised to fit Maintenance Management training needs and is accessible at www.ilearn2main.eu. When a user first arrives at the project site, they are presented with a list of the offered learning courses, as it is shown in FIGURE 1.

More courses and training content are currently added to this platform. Each course structure consists of an introduction that summarises the main learning objectives and associated courses, the theoretical part of the course, as well as implementation tips and case studies. The course is interwoven with comprehension questions, which assist the learning process and may guide the trainee to different learning paths that better suit individual needs. The course content includes pointers to references so that trainees can seek additional information or resources, should they wish to do so. References can be accessed as a separate web page, which is convenient for direct linking from the courses but also as a collective reference for external material.

Adequate training requires familiarisation with the typical terms relevant to the Maintenance course content. This is supported by the use of an e-glossary. The e-glossary provides links to definitions for the key terms that have been used inside the course. This Glossary is integrated with the training content so as to provide direct and easy access to any of its terms, FIGURE 2. These terms are automatically linked everywhere they exist in the lessons, and comprise a full and analytic reference guide.

E-training has significant advantages compared to conventional training. One key benefit is related to the ability to customise training according to the circumstances and the progress achieved by each learner. In this way it is possible to personalise e-training, on the basis of user roles, performance and recognition of knowledge and competence gaps. Through the use of comprehension and review tests, it is possible to identify knowledge gaps. Furthermore, it is possible to divert the learning sequence to better ad-

dress the identified gaps. In this way different trainees can follow distinct training paths, making the whole training procedure more efficient and tailored to individual needs.

Maintenance Management training involves knowledge and skills which are multidisciplinary by the very nature of the Maintenance Management function. Therefore, the ability to offer this level of customisation by e-training and knowledge assessment tools is particularly.

While knowledge testing constitutes an essential function that is blended with the e-training delivery and facilitates efficient e-training and personalisation of the way this is delivered to each trainee, there is also a clear need for an independent assessment of Maintenance Management competences. In iLearn2Main, this independent assessment is offered by a separate tool.

The underlying design consideration is that a number of tests are created, to cover the breadth of the curriculum courses. These tests are placed in a competence assessment tests pool and the e-Assessment tool randomly picks a subset of those each time to offer a different competence assessment test. Although the choice is random, care is taken so that the chosen tests cover the range of topics and courses that are deemed essential to successfully perform the Maintenance Management function, FIGURE 3.

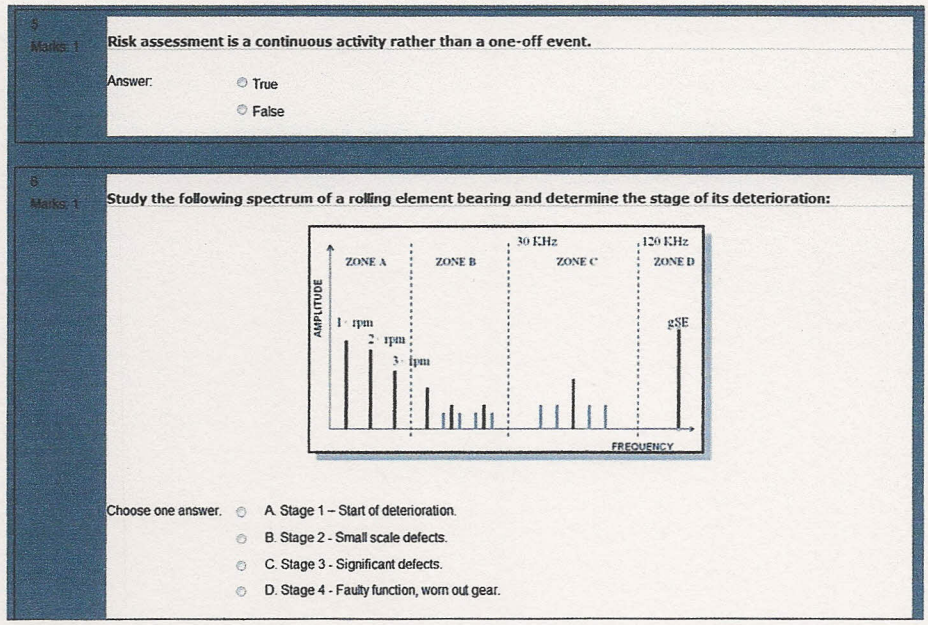
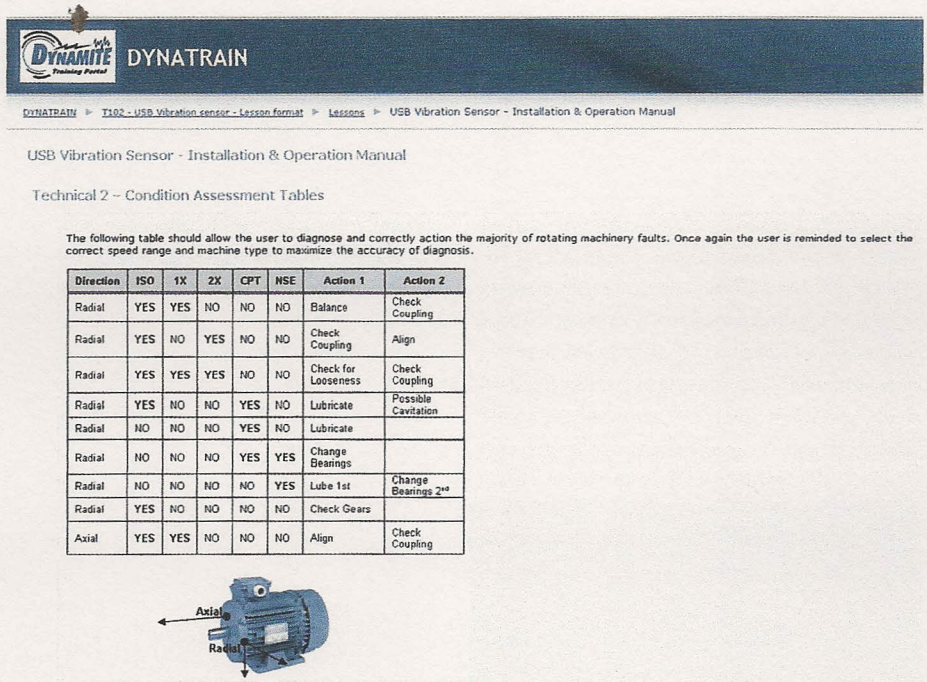


FIGURE 3. *Tests in the e-assessment of Maintenance Competences.*



Direction	ISO	1X	2X	CPT	NSE	Action 1	Action 2
Radial	YES	YES	NO	NO	NO	Balance	Check Coupling
Radial	YES	NO	YES	NO	NO	Check Coupling	Align
Radial	YES	YES	YES	NO	NO	Check for Looseness	Check Coupling
Radial	YES	NO	NO	YES	NO	Lubricate	Possible Cavitation
Radial	NO	NO	NO	YES	NO	Lubricate	
Radial	NO	NO	NO	YES	YES	Change Bearings	
Radial	NO	NO	NO	NO	YES	Lube 1st	Change Bearings 2nd
Radial	YES	NO	NO	NO	NO	Check Gears	
Axial	YES	YES	NO	NO	NO	Align	Check Coupling

FIGURE 4. *Vibration based condition assessment.*

DynaTrain: e-Maintenance training

The second case study is taken from the Dynamite project (Arnaiz et al., 2006). Dynamite advocates the use of innovative ICT technologies to manage and execute a range of maintenance-related actions in an integrated, efficient and seamless manner under an e-maintenance framework. A range of innovative enabling technologies are employed, including (dynamite.vtt.fi):

- smart sensing devices,
- wireless communications,
- portable computing devices and
- web-based e-maintenance services (DynaWeb).

Such technologies are poised to make headways into the maintenance engineering practice. Yet they are not covered by standard maintenance educational programmes. In order to secure acceptance and adoption in industry, e-maintenance technologies need to be incorporated into dedicated maintenance training curricula. Incorporating e-maintenance technologies into maintenance training can benefit much from employing innovative technologies for delivering customised training.

The very nature of the ICT technologies employed in e-maintenance lends itself to the implementation of e-learning technologies to deliver the needed training. The Dynamite project sought to exploit such opportunities by employing the Moodle platform, in order to design, implement and deliver e-maintenance training. The Dynamite e-learning platform, DynaTrain has been designed and implemented to deliver training dedicated to the employed technologies and practice. The training content includes basic knowledge for developing skills to efficiently plan and execute the Dynamite – implemented e-maintenance functions. The training content involves both theoretical background as well as practical examples in the form of "how to" cases to help personnel carry out certain tasks. The training is divided in segments of educational content that can be studied by viewing a single web page, with or without limited scrolling involved.

The course topics were developed by the Dynamite project partners and include vi-

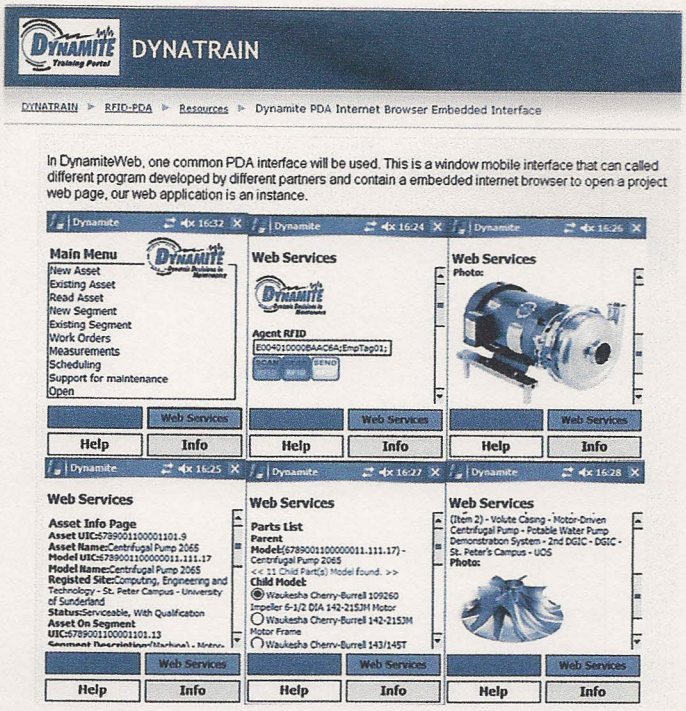


FIGURE 5. *PDA interface for RFID inventory tracking.*

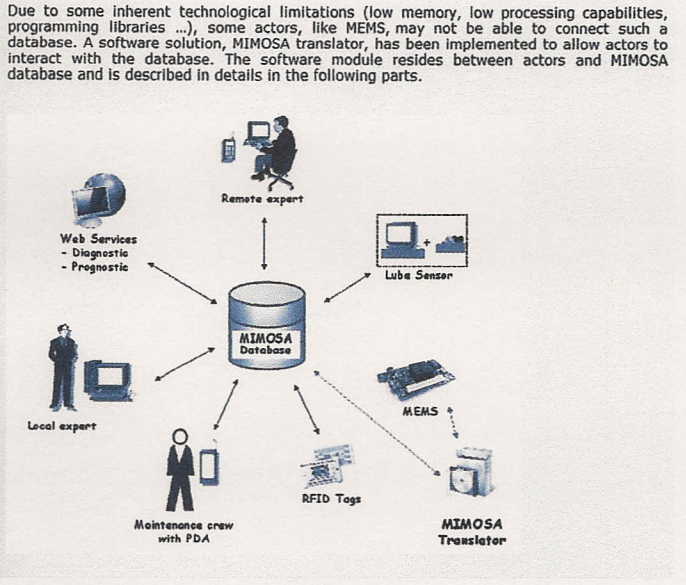


FIGURE 6. *MIMOSA translation for data interoperability.*

bration sensing (Diagnostic Solutions Ltd), data acquisition, (Wyselec Oy), PDA and RFID inventory tracking (University of Sunderland), prognosis web services and MIMOSA translator (University Henri Poincaré). Examples of these specialised courses are shown in FIGURES 4...6.

Conclusion

This article has looked into the usage of e-learning for maintenance training and competence assessment. As Maintenance and Asset Management curricula are in most cases not included in formal education and trainees are often people who have already entered their working life, maintenance training is usually provided within vocational education and training schemes. On-the-job training is acknowledged to be among the most efficient means for delivering professional training. But this, especially in maintenance, involves high costs and inflexible training hours. Trainees often cannot afford the time to enter courses that are inflexible in terms of time and place scheduling. E-training offers a viable alternative that is both flexible and cost-efficient. In addition, competence assessment in the maintenance engineering field can benefit from the introduction of automated e-assessment tools, meeting demands for streamlining and standardising maintenance management and engineering competence assessment.

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