

Maintenance Management education in Denmark

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Abstract

This paper describes the development of maintenance management education from the beginning in 1994 with three week oriented courses to a master education system with a master thesis and a content of at least 60 ECTS. All development has been done in very close cooperation with the industries in Denmark.

Keywords:

EFNMS recommendation.

Diploma in maintenance management.

EuroMaint.

Master in maintenance management.

Historical background behind the education.

The Marine Engineer Society in Denmark initiated a project in 1994 for the development of a module-based education system for people who were in a working situation as managers or wanted to become so.

The contents of and requirements for the education were found by asking a representative group of maintenance managers in Danish companies.

The Fredericia Marine Engineer Institute was invited to submit tenders for the developing work as well as for the following education, which was named DAMASK. This name denotes a qualified lift in the competencies of Danish marine engineers.

At the same time as these courses were running there was a similar development work at the EFNMS, (The European Federation of National Maintenance Societies) with a background in the need for a lift in the competence in the maintenance managers of companies all over Europe. The recommendations from this work were implemented in the DAMASK education system and a new element was a certification system, which was a mixture of theoretical tests and practical knowledge as a maintenance manager. Passing the tests and the fulfilling the requirements for practical work led to the designation European Expert in Maintenance Management.

The third step in the development was a new structure, which was initiated from the Bologna process in 1999. This was started by 28 different ministers of education, mostly from European countries. This reorganization meant that the education was organized in a new way and was extended to the current system. After the latest change the name of the degree is Technical Diploma in Maintenance Management.

Technical Diploma in Maintenance Management.

The education system was developed by two Danish institutes, VIA-university and Fredericia Marine Engineering College and it was the first and only Danish diploma course in Maintenance Management. VIA university has considerable experience in the development of such courses and Fredericia Marine Engineering College is home to the major part of the Danish teaching expertise on the subject of maintenance.

The current development within the management of maintenance requires more and better knowledge amongst the individuals engaged in this field, who often are faced with very considerable financial and human responsibilities. The diploma curriculum will provide the participants with the background to handle the tasks that such a manager may be expected to encounter.

The course is at bachelor level, but aimed at practical use, for which reason much use is made of visiting lecturers from both leading industrial and commercial enterprises as well as from industrial and commercial consultants.

Target Group

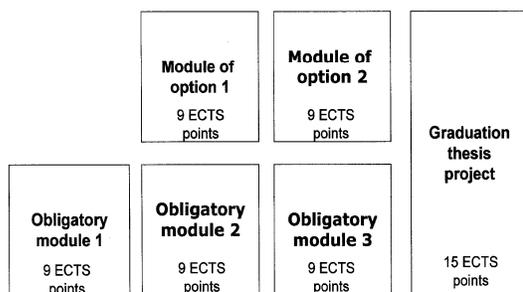
The course is targeted to those, who work with maintenance on a daily basis - it is important that the participants have experience in maintenance management or have been involved in maintenance work over a considerable period of time. The Diploma Course in Maintenance Management is structured in the form of project-work - the acquired knowledge will thus be useful within practically the whole field of maintenance, and the participants will normally find the solutions to many of their daily problems in the projects undertaken during the course. The general aim is to work with maintenance management for practical use, for which reason the course will evolve from the participants' experience as managers.

The structure of the course

The Technical Diploma Course in Maintenance Management is nominated as further education at bachelor level. The course is structured in modules, and can be adapted to individual requirements and wishes and be undertaken jointly with daily employment. The course is problem-oriented and is evolved from problems and cases from the participants' own environment.

The Diploma Course consists of 5 modules - 3 compulsory and 2 optional - and a final project. The choice of optional modules is constantly being developed and adjusted as required.

Diploma in Maintenance the structure



4 semesters of ½ years duration, total 60 ECTS points

One or more modules can be undertaken in each semester. The full course is nominated as a complete year, i.e. a full year's work for the participant. If the recommended sequence is followed, the course can be completed in 2 years. This requires quite a lot of work, but you will in return receive useful working tools and a priceless network, that will make you into a better and more result-oriented maintenance manager.

Description of the modules:

The teaching aspects of the course include maintenance methods and tools to improve the competence of the participants in the establishment, planning, control and carrying out of maintenance management. Emphasis is also placed on the analysis, understanding and strategic control of a maintenance organization. Further, the participants' skills in personal communication and team relationships will be developed through practical tasks and theory. The modules of the Diploma Course in Maintenance Management can be taken individually or together. Some modules require a certain knowledge of specific subjects, for which reason it is best to follow the recommended sequence. The optional modules may also require previous knowledge from other modules. Every module ends with an examination, which often takes the form of an evaluation of a project undertaken at the participant's place of employment. The participant will receive a diploma on the satisfactory completion of the course.

The Obligatory modules:

Title of the module: Reliability, techniques and methods in maintenance

Competences:

An understanding of the factors, which influence on dependability, maintainability, reliability of supply and availability
Be able to use mathematical and statistical graphs to optimize the factors related to maintenance based on failures in equipment and in human errors. Shall also be able to use empiric based methods.

- To understand the factors that influence dependability, maintainability, reliability of supply and availability

Be able to use mathematical and statistical graphs to optimize the factors related to maintenance based on failures in equipment and in human errors. Shall also be able to use empiric based methods.

Learning Outcomes: (Describes the norms / goals to be reached with this course)

- Reach a very good knowledge and understanding for those elements which have influence on availability, maintainability, logistic and the operation.
- Find methods to improve the ability off the plant through influence of the availability.
- Get knowledge in the mathematical and statically formularies we can use for optimizing the maintenance related elements.
- Understand the meaning of the human aspects on good and effective maintenance.
- Understand what influence maintenance has on production and quality.
- Be able to make relevant risk analysis.
- Know the relevant laws and regulations.
- Get a very good knowledge of the pattern of failure and the reasons for failures.
- Learning techniques for doing things better and avoiding that the same failures again.

Topics: (Describe the content of the course in topics)

- Availability.
- Reliability
- Maintainability
- The logistics of maintenance.
- Possibilities for improvement.
- Mathematical and statistical formulas used for specification and verification.
- Production dependability.
- Environmental aspects and risk analysis.
- Failure of equipment, and human error.
- Quality aspects
- Laws rules and guidelines.
- Key performance indicators and benchmarking.
- The theory behind the different patterns for failures.
- The different types of wear and corrosion.
- Techniques for improvement
- Tools for solving problems.
- Techniques for prevention.
- Inspection techniques.
- Measurement techniques for the state of repair
- Methods for extending the lifetime.
- Measurement systems for optimising the maintenance
- Systems of control
- Maintenance related techniques for optimising the output
- Repair technique.

Evaluation: 4-hour written examination.

Title of the module: Management, organization, economy and information in maintenance

Competences:

- To state a company mission and the visions for maintenance.

- To state suitable goals and strategies for the visions of the company for maintenance with associated key numbers as well as to describe the possibility of benchmarking.
- To design a maintenance organisation based on the company organisation, that supports its political goals and strategies.

Learning Outcomes:

- Get a very good knowledge about how one makes the vision and policy of management and maintenance.
- With the background of the policy to be able to make good goals and strategies.
- Be able to make decisions about what activities we shall use for supporting the goals.
- Be able to make an organization for the maintenance which in connection with the companies other organization will support policy, goals and strategies.
- Understand the influence of maintenance on the economy of the company.
- Understand the meaning of using economic models as LCC & LCP.
- Be able to define the demand of maintenance for the future.
- Be able to define the demand to the right CMMS in all aspects for the company.

Topics:

- Business-, production - and maintenance policies.
- Vision's, goals and strategies as well as activities, that shall support the wanted goals.
- Maintenance organisation, that together with the companies other organisations supports policies, goals and strategies.
- Motivation and teamwork in a maintenance organisation.
- Key numbers, benchmarks and Balanced Scorecard.
- Apply economical models, among others also LCC/LCP.
- Future maintenance requirements.
- Demands to the needed maintenance information systems, administrative / economical and technical systems.
- Spare part and purchase control.
- Humane and materials resources when implementing the organisations.
- Change management in connection with maintenance.
- Health, safety and work conditions, internal as well as external.
- Control and feedback of suitable key numbers for follow-up activities.

Evaluation: Project

Title of the module: Management and Coaching in relation to maintenance

Competences:

- The student will have knowledge about theories about the fundamental positions and coaching models of the manager.
- The student understands the importance of

efficient and targeted coaching from the context of the organisation.

- The student will acquire an improved self-understanding and will understand the importance of reflection, self-observations and the ability to distinguish between different positions in the coaching process.
- The students will focus on competence in communication as an active tool in relation to the main goals of coaching. Among others the implication for management and ethical implications.
- To pave the fundament for the students ability to work with the development of his personal competencies in relation to the roll of coaching. Among other the view of other people and motivation.
- A connection between theory and the everyday life of the student is created so that the learned abilities can be implemented in the daily work.

Learning Outcome:

- To understand to communication in all situations.
- Get knowledge of the development of team and project groups and the intern relations, also handling of conflicts.
- Understand the connection between a good cooperation in projects and teams and be able to use the theory about communication and teambuilding.
- Get knowledge about others needs and the factors for motivation and be able to use these in a practical way.
- Make the background for working with the development of your own personal competencies in connection to the managing job.

Topics:

- Coaching from the perspective of management and organisation.
 - Theory and perspectives of learning.
 - Fundamental concepts and basic assumptions.
 - The basic positions of the manager.
 - Ethical game rules.
- Methods and tools.
 - Individual and team coaching.
 - Phases and activities.
 - Methods and models.
 - The supportive approach to coaching.
- Training and reality.
 - Linguistic perspective and pattern breaking.
 - Structured dialog.
 - Motivation coaching.
 - Tales from every day life.

Evaluation:

Individual verbal examination based on a realistic case

Title of the module: Final project and thesis in maintenance management

Competences:

- To be able to deal with all the major jobs that are a natural part of the role of a maintenance manager.

Learning Outcome:

- The student will be introduced in using of the socio-scientific method for defining and formulate the final project and its problems and frame work
- The student has to make an interdisciplinary project who has its background in a real problem and on the background of trained theories, methods and models to develop a suggest for solution for the choose problem.

Topics:

- a. Project part 1. Theme meetings
 1. Start up, introduction to project working method
 2. Initial description of the definition of the problem, the phases of the project
 3. Purpose, limitation, problem formulation, choice of theories and models.
 4. Need for informations, choice of methods and collecting of data.
 5. Project part 2. project work under supervision.

The project work is done in groups of 1 – 3 students in a period of one till two semesters.

In part 1: There will be teaching in the project working method and parallel to this there will be worked out a project description based on an approved project method. The project group will have assigned a supervisor based on the choice of topic.

By the end of part 1. the project description shall be approved by this supervisor.

On part 2: The project work is done under supervision.

There shall be worked out a documentation on 30-40 normal sheets pr. Student, besides project description and annexes.

Evaluation:

The subject shall be evaluated in an oral examination, based on the student's project report. In the report the student shall use relevant theory on a case study from own company or daily work, and through this demonstrate the ability to use relevant methods and tools in practice and give these a perspective in relation to own daily work

The evaluation of the student is based upon:

- The written report – the thesis (50%)
- The oral presentation and the defense of the report (30%), there is a time reservation on ca. 1½ hours for presentation and defense, inclusive 15 minutes for evaluation
- The objection remarks from the student (20%)

The Optional modules - examples:

Title of the optional module: Condition monitoring and techniques for optimizing maintenance

Competences:

- An understanding of the factors that influence the stability of operations, maintainability, supply chain stability and service availability?

- To use mathematical and statistical graphs for optimisation of the maintenance related factors taking equipment as well as human failures into account. The person shall also be able to use methods based on empirical evidence.
- To understand and be able to analyse improvement techniques and preventive activities, among others condition based measurement.

Learning Outcome:

- The purpose of this module is to learn how to choose and use the right tools for condition measurement and analyze this to the best way for maintenance.
- After the module one know how to choose and use tools for the following fields:
 - Dynamic measurement
 - Particle measurement
 - Chemical measurement
 - Physical effect measurement
 - Temperature measurement
 - Electrical measurement
- Besides this, one has learned to use qualified operation and primary parameters for optimizing the decision about maintenance.

Topics:

- Vibration measurement and analysis
 - Orbit and SPM measurements.
 - Spectral photometry.
 - Detection of flaws by penetration and magnetic powder.
 - Detection of flaws with ultrasound and eddy current.
 - Radiography
 - Fiber- and borescope measurement
 - Replica
 - Strain gauge measurement.
 - Thermography
 - Temperature measurements.
 - Linear polarisation measurement
 - Electrical resistance measurement and electrical potential measurement.
 - Meggers and similar voltage generators.
 - Hardness measurement.
 - Operational and primary parameters for the prediction of future maintenance
 - Corrosion and corrosion preventive activities
- Tools and methods are chosen in accordance with recognized standards.

Evaluation: Oral examination based on a project from own company

Title of the optional module: Facilities Management - Planned systematic maintenance of buildings

Competences:

The student shall be able to:

- Understand the difference between the concepts of Facilities Management and Maintenance Management.
- Understand the legal obligations of the contractor, when implementing a maintenance system.
- Understand the contractor's motivation and incitements for the implementation of a maintenance

system.

- Knowledge of methods tools and systematically forms of work, which are normal in connection with planning, call for tenders and carrying out systematically building maintenance.
- Understand common construction failures and their cause.
- Be able to describe typical Danish constructions and construction parts.

Topics:

The history of a facility

- Legal basis.
- The use of literature.
- The environmental protection of a building.
- Recording a buildings (based on drawings and measurements).
- The lifetime and replacement of construction parts.
- Damages to a construction and ways to repair it.
- To price maintenance activities.
- The maintenance program and its use.
- The input of recordings in the program database.
- Conduction of a building check up.
- The planning of maintenance activities.
- Registration by photography.
- The construction journal.
- Offer maintenance activities.
- Control of delivered quality.
- Demands for maintenance data for newly built buildings.
- The policies, goals and strategies of the business.
- Budgets and allowances.
- Danish constructions and construction parts.

Evaluation:

The course is concluded by the evaluation of a theme report of the course, the evaluation is passed/failed.

Title of the optional module: Project Management – methods and tools.

Objectives:

- To familiarize the student with the methods and systematic procedures covering project work and describe the theoretical basis required to make an efficient project manager or project participant.
- To give the student an understanding of the procedures used in project work and the procedures for the management of projects and enable the student to use the planning and management tools related to the time scale, resource utilisation and finances of a project.
- To ensure that the student can use the tools covering analysis, structuring, planning, management and documentation of a project and can put these into perspective for different types of projects and can use them in connection with a problem taken from his/her own organisation.
- To see that the student can handle different kinds of project and can be part of a network of students in a learning process.

Main topics:

- Working on a project – types of assignments and projects in a company.

- The phases of a project – procedures and structures at the start, during progress and at the end of a project.
- Analysing the situation – the commercial, the organisational and the technical basis of a project.
- Organizing a project – how to build an effective organisation for a project.
- Structuring a project – generating ideas, phasing and milestones.
- Requirements and product specifications.
- Planning the investment and evaluating the finances of a project.
- Planning – including network analysis, Gantt charts and planning of resources.
- The economy of a project, calculations, budgets and cost control.
- Project management – following up on results, economy, resource utilisation.
- Quality control during the progress of a project.
- Documenting a project – management documentation, Knowledge management and systematic collection of experience.
- Reporting - where the student applies the theory to projects from his/her own organisation/daily life.

Procedure:

Instruction based on case histories alternating between lectures, discussions and studying case histories.

The course is conducted in 3 two-day sessions, i.e. 6 days in a term. The students are split into study-groups, and will need to study in between the sessions.

Evaluation:

The evaluation of the student on this module is undertaken as an oral examination based on a project report prepared by the student. In this report the student will apply the relevant theory to an actual situation from his/her own organisation and so demonstrate the ability to use the relevant methods and tools in practice and to put these into the perspective of his/her own project assignments.

The evaluation is based on:

- The written report (50%).
- The oral presentation and argument for the report (30%).
- The student's opponency at the report of another student (20%).

The evaluation is undertaken by the student's instructor in conjunction with an external examiner on the basis of the total performance.

Title of the optional module: Personal development of the manager

Objectives:

- To give the student an increased knowledge of self and an insight into own personal strengths and development needs.
- To concentrate the student's attention on the possibilities and choices that can strengthen a further personal development and efficacy as a manager.

- To prepare the student to be able to cope with the managerial challenges that will arise as a result – among other things – of the major changes that both private and public enterprise is subject to currently and in the future.
- To ensure that the student's personal development and his/her career development correspond - so as to increase the synergism of personal gain and company gains.
- To acquaint the student with management methods and tools that can be used in connection with his/her current and future management assignments.

Main topics:

- An introduction to psychological development phases with – amongst others - the use of reflection procedures.
- Strengthening self knowledge and developing personal resources.
- Focusing on the connections between working time and leisure/family time and the handling of stress.
- Coaching with individual feed-back.
- Building up committed teams/networks.
- Firmly establishing personal development in relation to career development.

Procedure:

The module is comprised of the following sections:

- Section 1: Harmonizing expectations, characterizing the opening position with concentration on:
 - Own strengths and development possibilities using – among other things – a DISC Personal Profile.
 - Basic values and the relations between attitudes/values and actions.
 - Management styles, management tools and the management dilemma.
- Section 2: Recognizing own resources and development needs with concentration on:
- Section 3: User-orientated management with concentration on:
 - Personal goals and action plans.
 - Methods for self-management and achievement of goals.
 - **Method of instruction:**

Instruction is based on working in teams with lectures alternating with discussions and the study of case histories in workshops.

At the start of the module the student joins an autonomous working team which alternating with other teams prepares a presentation during the time between lectures on the principle of Learning by Teaching.

Instruction takes place during normal working hours. Parts of the program will be conducted as 2-day residential courses. During the term of the course the student shall collect documentation in the shape of reports, minutes of meetings, notes, photographs, graphics, etc. that can describe the progress of the course. This documentation is kept by the student as a logbook and will be used as

reference material in connection with the final examination.

Evaluation:

Passed / failed.

Title of optional module: Management and Coaching

Objectives

The student will be introduced to the theory and use of individual and team coaching as a management tool.

- The student will become acquainted with the theories covering the basic roles of the manager and the different coaching models.
- The student will be made aware of the importance of effective coaching within the organization.
- The student will achieve a greater degree of self-knowledge and will recognize the importance of reflection, personal awareness and the ability to distinguish between different roles in the coaching process.
- The student will recognize communication ability as an effective tool within the overall objectives of coaching - including the management and ethical implications hereof.
- creating a basis for the student to work on the development of his/her own personal skills - including human nature and motivation.
- A connection is made between theory and the student's daily work so that the skills achieved can be used therein.

The student will use actual situations and experience from his/her own organization.

Curriculum

- coaching from a management and organizational point of view.
 - Aspects of theory and learning.
 - Basic concepts and background.
 - The basic role of the manager.
 - Ethical rules and practical considerations.
- **Methods and tools.**
 - Individual and team coaching.
 - Phasing and sequence.
 - Methods and models.
 - Appreciative approach to coaching.
- **Training and practical work**
 - Angling the language and breaking patterns.
 - Structured dialog.
 - Forming hypotheses, active listening and feedback.
 - Episodes from real life.

B Method of instruction

The module is a combination of short lectures, presentations, exercises and case histories.

Instruction is based on team work in groups of 3 – 4 students. The instructive use of such teams is as follows:

- To provide a framework for exercises and case histories.

- To allow the practical use of the coaching theories.
- To enable the members of the group to serve as sparring partners in respect of actual situations at work and in daily life that reflect the subjects covered by the course (including feedback on the student's progress as a coach).
- To provide the opportunity for the formation of networks that cross the boundaries of companies and professions.

Evaluation:

Oral examination based on a paper (max 5 pages) prepared individually by each student on a given subject that covers a situation taken from the student's real life.
 Rating: Passed / failed.

Entry requirements

To enroll in the Technical Diploma in Maintenance Management it is necessary to have completed advanced studies at no less than bachelor level or a relevant short term course of further education. Individuals who have obtained the level of European Expert in Maintenance Management in accordance with the definitions laid down by the EFNMS may be exempted from the first two modules of the course. Theoretical grounding must have been followed by at least 2 years' relevant industrial experience.

Timing

The Diploma Course in Maintenance Management starts every year in week 4 and week 35. The course is proffered jointly by VIA University, CVU Management Division in Horsens and Fredericia Marine Engineering College.

Recommendation from the EuroMaint project.

To assess the contents of the existing maintenance management educational programs in Europe and to facilitate an internationalization of the programs, Hoogeschool Utrecht, a technical university in the Netherlands, developed a project subsidized by the European development funds.

Hoogeschool Utrecht initiated cooperation with the European Federation of National Maintenance Societies (EFNMS), and to ensure a thorough work partners were invited from all over Europe. Centre of Asset Maintenance Management at Fredericia Marine Engineering College was asked to represent the Danish Maintenance Society, and has been a partner throughout the project period which began October 2006 and ended ultimo September 2008.

The partners were among other things asked to gather information from the industries about needed future requirements of maintenance managers within 10 years. These national requirements were gathered to an European requirements list, which together with the EFNMS defined certification requirements for European Experts in Maintenance Management formed the base of the a fully updated EuroMaint developed Master Program in Maintenance

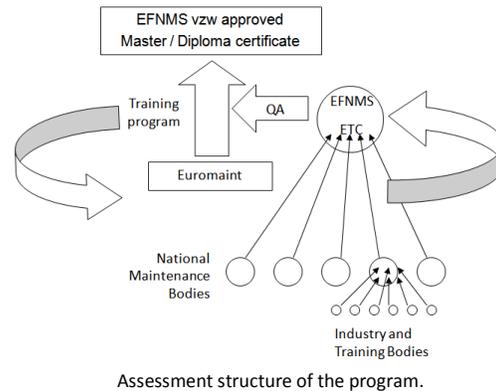
Management, a program which now can be adopted by the universities.

Fredericia Marine Engineering College is not a university, but as long as were not able to provide a Master in Maintenance Management we intend to implement the outcome of the EuroMaint project in the Technical Diploma in Maintenance Management, and the plans have already been prepared.

This is possible because the student workload in a master program and a diploma program are the same, 60 European Credit Transfer System-points. The enrollment requirements are almost the same. Both the Master program in Maintenance Management and the Technical Diploma in Maintenance Management are based on the certification requirements for European Experts in Maintenance Management. The programs only differ in the academic bachelor and master levels.

The implementation will take its start in August 2010, where the first obligatory module in the Technical Diploma in Maintenance Management is converted to the new contents.

In order to assure the relevance of the subjects in the educational programs based on the EuroMaint definition, a structure of assessment of the contents has to be developed.



The training bodies assess their educational programs in accordance with the national demands .

Typically the training bodies have to meet national demands for updated and relevant topics in the programs. This can be ensured by integrating the model shown above in the quality assurance system of the school.

Parallel to the national QA-system, an EFNMS driven QA-system can collect the newest knowledge within the maintenance area. With a certain frequency (e.g. 6 years) EFNMS ask the National Maintenance Societies in Europe to gather the newest knowledge regarding Maintenance Management from the industry and the training bodies. This gathered knowledge goes to the European Training Committee under EFNMS which implement this new knowledge in the existing

Master in Maintenance Management program evolved from the EuroMaint-project.

The training bodies can use the updated educational program voluntarily. If they want an EFNMS acknowledgement, which can be of great marketing value, they have to apply the subjects in their educational programs.

Where do the students come from in Denmark?

The students come from all sectors of Danish Society with around 50% from industry and the rest from public service and the merchant navy. They all have at least a bachelor's degree in engineering and have worked a minimum of two years as engineers. It is of great benefit to the students on the course that they have working experience from real life and the companies that are paying for the course and the students get a major return from the projects and the new competences that the student acquires in the three years that it normally takes to complete the full tuition. Of especial benefit in this respect is the final project and thesis in maintenance management – with an extent of at least 15 ECTS - which is based on a problem from the student's own company. More and more Danish companies ask their maintenance managers to take the Technical Diploma in Maintenance Management.

Who are the authors?

Palle Groendal was educated in marine engineering and has worked with maintenance for 8 years in Danish industry and in the merchant navy. Today he is senior lecturer in the Centre of Asset Management which is attached to the Fredericia Marine Engineering Institute. Palle Groendal has passed the examination as European Expert in Maintenance Management and is a holder of the Diploma in Maintenance Management.

Svend Aage West was also educated in marine engineering and has during the last more than 20 years been the leading figure in the development of maintenance education in Denmark. Today he is manager of the Centre of Asset Maintenance. In addition he is chairman of the presidium of the Danish Maintenance Organisation as well as the Danish representative to the EFNMS. Both Palle Groendal and Svend Aage West grew up in Denmark which is one of the five Nordic countries in Europe. Denmark is slightly bigger than Hainan and has a population a little smaller than that of Hainan. Like Hainan, Denmark is nearly surrounded by the sea on all sides, but the climate is much colder than in Hainan.

Literature:

- Homepage showing the European Expert in Maintenance Management requirements: <http://www.efnms.org/efnms/publications/expert.htm>
- Homepage regarding the Euromaint-project: <http://www.euromaint.hu.nl/index.htm>