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Master of science in risk management and safety engineering, at Lund University, Sweden

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Abstract

As the risks generated by industry and other organisations in society change, requirements as to how these risks are to be managed must change correspondingly. This means that new methods and techniques of risk analysis and management must be developed. The need for effective research and education in this area is accentuated by the rapid pace of organisational and technological change leading to increasing risks and increased vulnerability in production, transport and infrastructure. To meet the present and future demands of risk management, Lund University is starting a two-year engineering programme leading to a Master of Science in Risk Management and Safety Engineering. This paper presents the main structure of the programme, including goal definition and short descriptions of key courses. The programme will focus on risks associated with safety, health and the environment (SHE), but also provide a general understanding of other major risks concerning companies, e.g. economic, political and organisational risks.

Keywords: Education; Master of science; Risk management; Safety engineering

1. Background

As the risks in society change there is a demand that these risks be managed by industry, authorities, and organisations. It is thus necessary to develop techniques for risk analysis and risk management. Technical development imposes new demands and creates new risks, but also provides better means of avoiding and managing accidents.

Risk analysis and risk management are growing in importance. The reasons for this are the rapid changes in society and social life, economic forces, technological development, and new types of production systems and organisational structures. Information technology ties units together in large complex systems with short time constants, allowing little or no time for the correction of mistakes or for counteracting effects due to unforeseen circumstances. Boundaries between authorities are often vague. This is often the case in company subsystems, and all the way up to the global scale. The concentration of people, dangerous chemicals, energy, information and other values is increasing, which may considerably increase the effects of accidents. There are strong forces driving humanity and nature, as well as organisations and individuals, towards a world of "produced uncertainty and organised irresponsibility". Counter-forces have to be found and used as soon as possible.

Serious accidents receive a great deal of publicity, alerting those responsible for remedying the situation. However, we learn too little and soon become complacent again. This is very worrying because of the increased potential for disasters with ever-increasing consequences, due to the rapid changes mentioned above (Magnusson et al., 1999).

The significance of effective risk management is seriously underestimated in Sweden. The need for more effective risk management is obvious in major accidents which, often unnecessarily, cause the loss of many human lives, create massive environmental damage, and cause enormous material losses. With accelerating technology and increasing size of public areas with greater access by or accumulation of human beings (cities, places of entertainment, etc.) and other values tomorrow's risks will be greater than we are prepared for. Safety must be planned and integrated from the outset. Good risk management should be regarded as absolutely necessary for sustainable development, for good com-

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petitiveness, and thus for a high quality of life in a robust society.

2. Programme objectives

The programme places great emphasis on acquiring knowledge on the different threats and risks present in society, during both normal activities and accidents. The programme should, in particular, offer students the conditions to learn and apply risk analysis as a systematic tool:

- To identify and assess risks.
- To implement measures to reduce risks with the objective of preventing, or at least limiting, injury to humans, and damage to the environment or property.
- Based on the objectives of organisations and the requirements of society, to formulate and work with management systems in the areas of safety, health and the environment so as to establish a low level of risk with regard to finance and conservation of resources.

The main focus, with the emphasis on safety, health and the environment, will be on accidents defined as undesirable incidents having an adverse effect on people, the environment, equipment, property and/or business. These incidents are usually of short duration, are unintentional, and do not form part of the normal function of the system.

Other effects on health and the environment will also be considered, where the exposure is long-term in character and is a result of the normal function of a system, or of a normal lifestyle.

In particular, the risk management and safety engineering education should provide the basis for the application of risk analysis as a systematic process, according to Fig. 1, in the following areas:

- Systematic identification and evaluation of risks and the ability to initiate measures to reduce risks in order to avoid injury to humans and damage to the environment or to property.
- To create processes, products and working environments, taking into consideration the requirements of organisations and society regarding safety, the environment, health, conservation of resources and economy.

The programme should not only increase the depth and breadth of the students engineering knowledge, but also create the capability of communicating and collaborating with many different categories of technical and non-technical individuals. The students must be prepared to work with risk management on the local, regional, national and international scale.

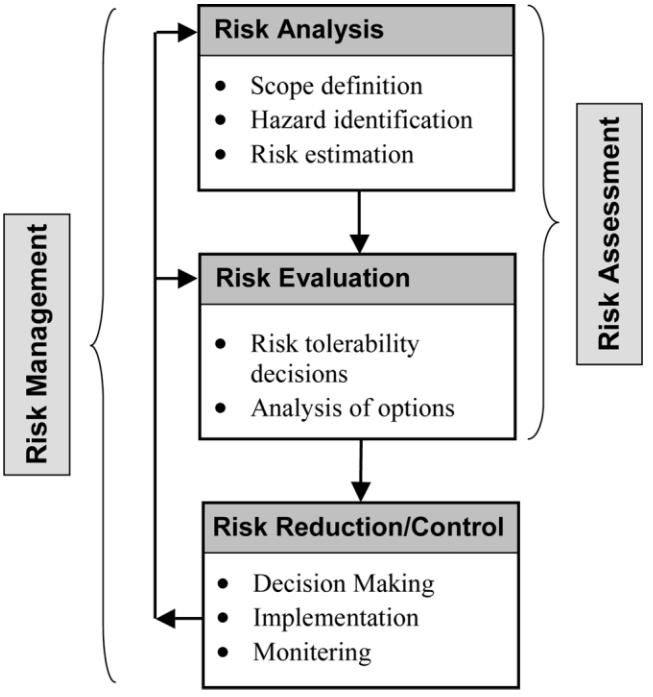

Fig. 1. Flow chart for risk management (International Electrotechnical Commission, 1995).

3. Credits

Sweden has a credit system in which credits (points) are allocated to courses, reflecting the work required by the student to complete the course. Individual courses are assigned credits depending on the estimated total course workload including lectures, tutorials, laboratory work and individual study. The length and intensity of courses is thus expressed as the number of credits awarded. One credit is equivalent to one week of full-time studies (40 h per week), including lectures, independent studies, etc. One academic year (40 weeks) of full-time studies is assigned 40 credits.

One Swedish credit is equivalent to 1.5 ECTS credits. One semester of successful studies gives 20 credits (30 ECTS credits) and one academic year 40 credits (60 ECTS credits). To receive a master's degree in science in Sweden at least 180 credits is necessary. The risk management programme will take the form of a 'concluding' programme of 80 credits, which requires the students to have 100 points before admission.

4. Programme structure and content

The programme consists of compulsory courses, elective courses, and senior thesis (MSc dissertations), see Fig. 2. The compulsory course block covers 40 credits. This block contains basic courses in the area of risk management, which provide the basis for risk analysis, risk assessment and the development of risk-reducing meas-

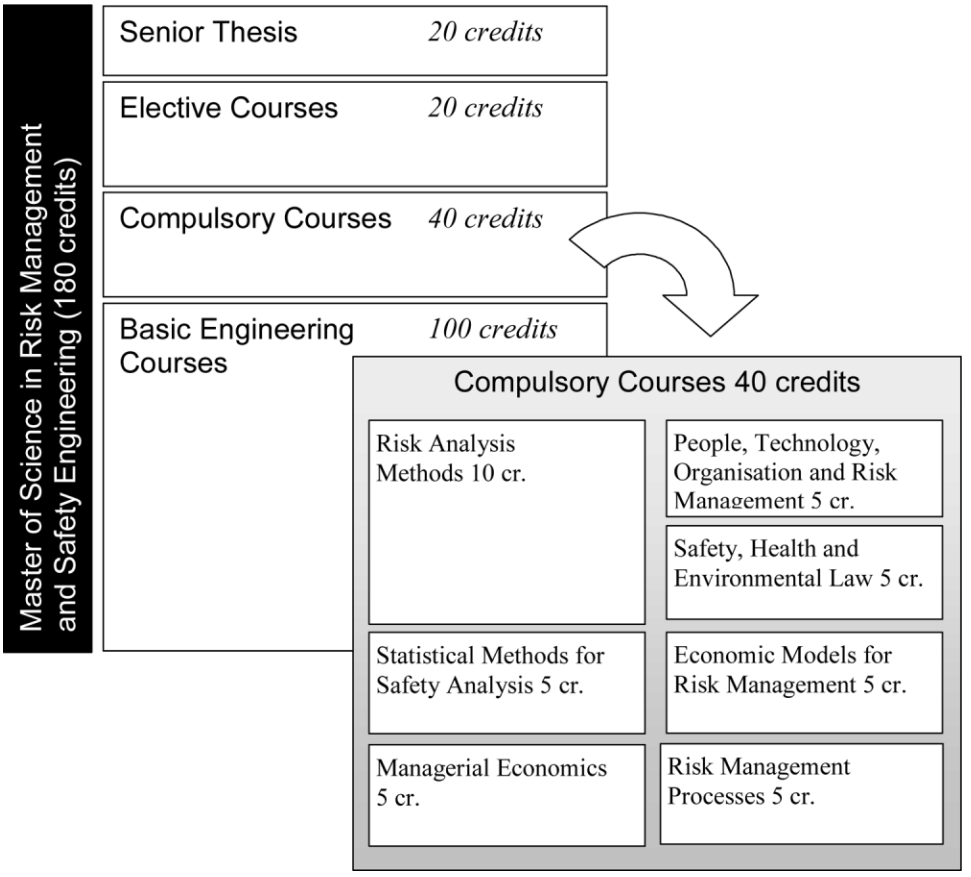

Fig. 2. Content of the Master of Science Programme in Risk Management and Safety Engineering.

ures. The compulsory block starts with courses in basic methods and techniques in both business administration and engineering. The basic knowledge obtained is then employed in the next set of courses, which are more applied. The forms of teaching will be both traditional, with lectures, and project based. Projects will be adapted to the course, subject and specific situation.

In the end of the first year the students can start to extend and specialise their training knowledge through elective courses and a senior thesis, to a large extent according to their own interests. Their choice of elective courses should lead to both a broadening and deepening of their knowledge, such that they are capable of taking responsibility for the development of new techniques.

The programme is largely based on students themselves selecting the elective courses in order to create a personal profile and specialising in one of the areas of safety, health and the environment. This is based on trends in society towards a growing importance of individual responsibility in terms of education, especially regarding flexibility and choice.

It is impossible to cover all aspects of risk management and safety engineering, but the programme should provide the basis from which an overall view of how risks affect organisations can be applied. Facility in assimilating new knowledge is therefore an important quality, as well as being able to communicate this knowledge to others.

4.1. Compulsory courses

The compulsory courses are distributed over the two years according to Fig. 3.

4.2. Course outlines

4.2.1. Risk analysis methods, 10 credits

The objective of the course is to provide an introduction to risk analysis as part of the total risk management process, and also as a basis for continued studies within the area of risk management. Together with other courses, this course is intended to instruct students in the use of decision-making tools in matters involving risk management.

After completing the course, students should be able to act as risk-analysis experts in groups working in risk management within the areas of safety, health and environment. In addition to detailed knowledge of qualitative, semi-quantitative, and quantitative risk-analysis methods in these areas, students should have gained insight into various aspects and perspectives on risks and risk management in society. Methods of quality assur-

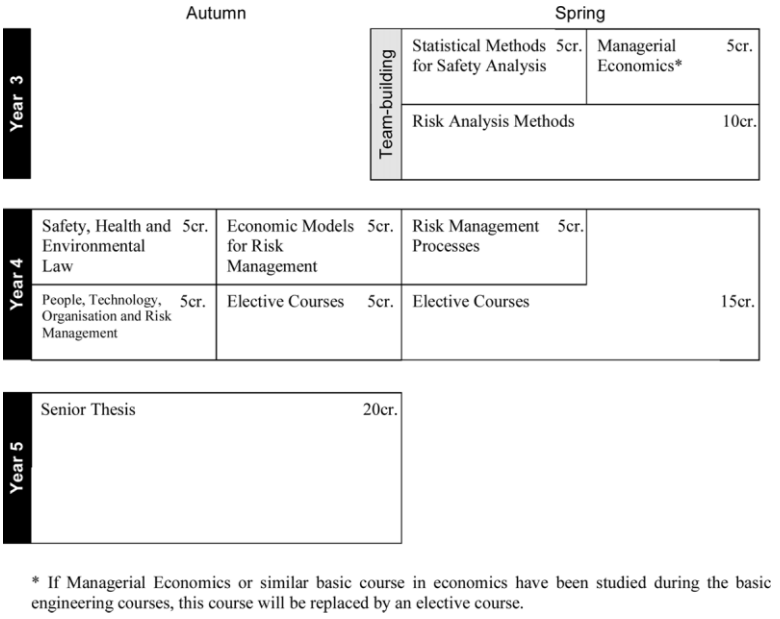

Fig. 3. Syllabus for The Master of Science in Risk Management and Safety Engineering Programme.

ance in risk analysis, where the consideration and treatment of uncertainties plays a central part, form an important part of the course.

4.2.2. People, technology, organisation and risk management, 5 credits

The aim of the course is to impart knowledge regarding the roles and functions of individuals and organisations in human-technology systems in terms of efficiency, quality of working life, and especially safety. After the course, students should know the basis for how to take the human error into account in the design of:

- human-technology systems;
- products;
- organisations.

by considering safety as well as efficiency and quality of working life.

The students should also know the basics of management systems for safety as well as efficiency and quality of working life. In addition, students should know how to carry out various types of risk analysis where attention is paid to human and organisational aspects.

4.2.3. Statistical methods for safety analysis, 5 credits

The course provides knowledge on statistical methods necessary for safety analysis, and integrates these methods into a number of related risk scenarios. The course will extend the statistical skills of the student including, for example: Bayes' Theorem, the Weibull and other extreme-value distributions, event intensities, the Poisson process, models for statistical dependence, Monte-Carlo simulation, Event-tree and fault-tree analysis.

In risk management the knowledge will be useful in various applications, for example: risk updating, risk calculations, supervision and inspection using probabilistic methods, safety index, extrapolation of small risks, analysis and interpretation of experimental and epidemiological data, background variables and risk comparison.

4.2.4. Risk management processes, 5 credits

The overall aim is to impart knowledge of the various methods and techniques used in risk management processes. After the course, students should be well versed in the basics of project management, especially risk management projects. This knowledge will be applied to a project forming part of the course.

The course will bring together *risk analysis*, *risk evaluation* and *risk reduction/control* to *risk management*, i.e. in the project, the student should be trained to take decisions on and to work out measures, based on analysis and evaluation of risks. The purpose is to achieve the knowledge on how to use risk management to reduce losses, damage, and disturbance in an optimal way for an organisation and to convert hazards concerning undesired events to more foreseeable, controllable, and budgetable occurrences. It is important to prepare an organisation for events that are improbable but possible and plan for how to act in such events in order to minimise the damage and loss.

The knowledge acquired during the course should facilitate communication with different parts of a company or an organisation, and great emphasis will be

placed on risk communication, i.e. communication of the results of risk management to the general public.

4.3. Senior thesis (MSc dissertation)

The senior thesis is intended to demonstrate the student's ability to apply knowledge acquired during the course of studies, and his or her ability to carry out a specific task in an independent manner. The work is carried out as a degree project.

The degree project corresponds to twenty weeks of full-time studies (20 credits) and is usually carried out as the final part of the programme.

The degree project may be undertaken at the University, in a company, a local or regional authority, or at a research institute in Sweden or abroad. However, a faculty member from the University must always act as the student's supervisor. The project may be theoretical and/or experimental depending on the student's background and interests. The work is reported in a dissertation and presented at a seminar.

The student is responsible for finding a suitable degree project among those suggested by departments or companies. Before commencing work on the project it must be approved by the student's supervisor. The final courses and the project should together constitute the student's individual profile of skill and proficiency.

5. Research network

Lund University is currently devoting considerable energy to research in risk management. A multidisciplinary risk research centre, LUCRAM (Lund University Centre for Risk Analysis and Management) has been established. Through a network of researchers at several different universities and organisations in the Öresund region, LUCRAM will contribute to the development and dissemination of knowledge regarding research and education in risk analysis and management.

Together with proposals from Räddningsverket (The Swedish Rescue Services Agency), Överstyrelsen för civil beredskap (The National Board of Civil Emergency Preparedness) and Boverket (The National Board of Housing, Building and Planning) for an outline research programme in risk management, LUCRAM will hopefully create a knowledge base in the Öresund region which is a necessary condition for the implementation of the programme.

6. Admission to the programme

Students will be admitted from the fire protection engineering programme at Lund University and from the master of science in engineering programmes in Scandinavia (see Fig. 4). The risk management programme will take the form of a 'concluding' programme of 80 credits. The formal requirement is of 100 credits from any of the programmes mentioned above.

In connection with the establishment of the risk management programme, the intake to the fire protection engineering programme at Lund University will increase from 30 to 50 students per year. Students embarking on the fire protection engineering programme have the option of taking a bachelor's degree in fire protection engineering (140 credits), followed by the choice of studying for one year at the Swedish Rescue Services Agency College at Revinge, or getting a job. Alternatively, after 100 credits they may apply for admission to the concluding master's programme in risk management. Students enrolled on the fire protection engineering programme will have a guaranteed place on the new programme, while those studying on any master's programmes will compete for approximately 40 places.

The formation of the education routes of the new programme may seem controversial in the Swedish educational system, but there are several notable advantages:

- There is strong competition for entry to the fire protection engineering programme, with approximately 16 applicants per place. This group of applicants consists of highly motivated students with good examination results, which creates excellent conditions for successful studies at University.
- Students with different engineering backgrounds are studying together, with the possibility of specialising in a range of different areas, which results in a very interesting and varied range of competences and interests.
- The introduction of the programme means that industry and public organisations will have an increased choice of engineers with both broader and more specialised competences when recruiting.
- The possibility of taking a master's degree after the fire protection engineering programme is not appealing at the moment. The possibility is now being created for fire protection engineering students to change to the master's programme in risk management after 100 credits, or to take a double degree, i.e. a BSc in fire protection engineering (140 credits) and a MSc in risk management (180 credits). There is a good possibility of taking the double degree within 41/2 years study, which is the normal length of combined bachelor's and master's studies.

7. Effect on the fire protection engineering programme — opportunity or threat?

In connection with the introduction of this new programme, the fire protection engineering programme will

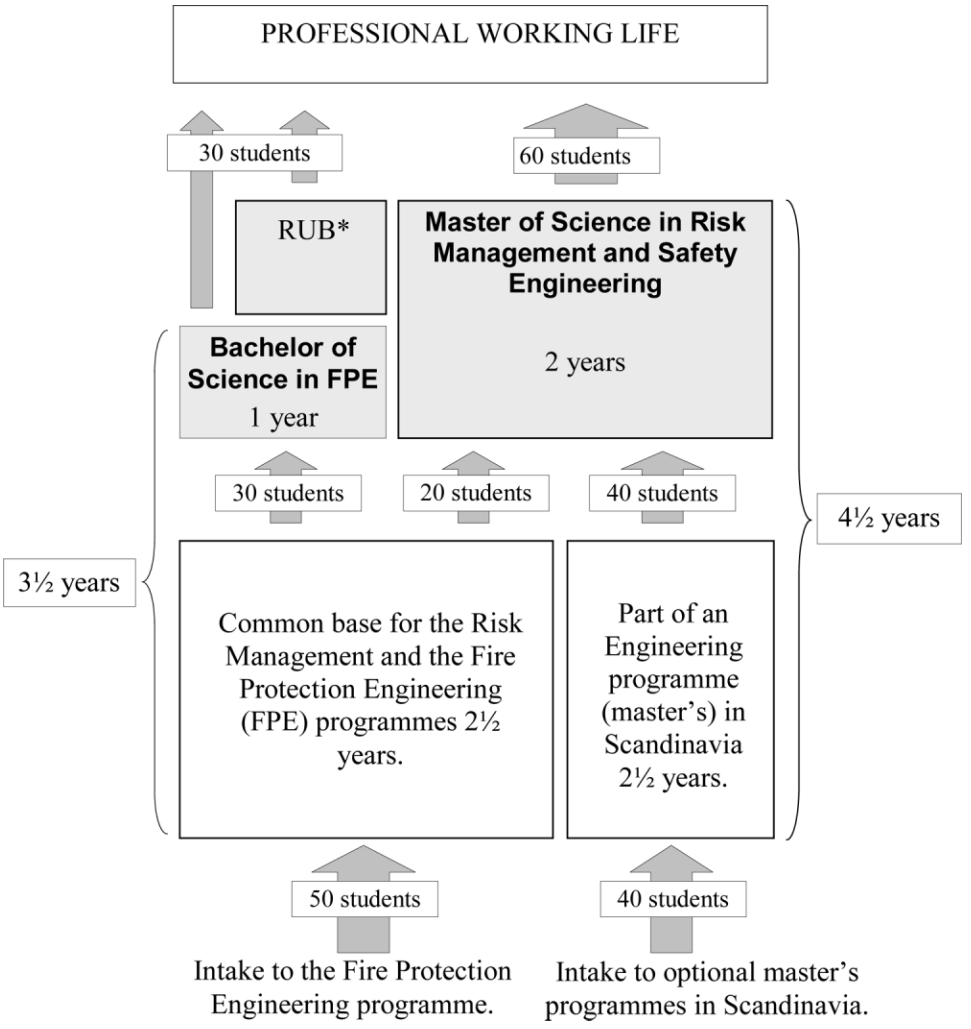

Fig. 4. Educational system for the Risk Management and Safety Engineering Programme and the Fire Protection Engineering Programme. *=One year course at the Swedish Rescue Services Agency College.

also, have to be rearranged. This will not mean many great changes in content, but some course development will be carried out, and the sequence of courses will be changed slightly.

The new programme will mean the introduction of several new elective courses for the fire protection engineering students to choose from. The possibility of continuing to a master's degree after having concluded their bachelor of science in fire protection engineering will also be considerably improved. The only realistic alternative at the moment is to study civil engineering courses in roads and waterways and, where necessary, to take basic courses from the first and second year out of five. It will now be possible to complement the fire protection engineering program with a master's degree in risk management and safety engineering in about one additional year of studies.

The programme in risk management is, to a certain extent, in competition with the 1-year course given by the Rescue Services Agency College. As the intake to the fire protection engineering programme just has increased, the objective is that the number of applicants completing the bachelor's programme in fire protection engineering will be roughly of the same order of magnitude as at present. This competition will, however, place higher requirements on the educational providers.

8. Conclusions

There is a great confidence that the programme will be successful. This is based on the structure of the programme and the means of recruiting students. Industry and governmental agencies are already proposing subjects for the senior thesis and job proposals are available before the first batch of students has got its degree.

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