Abstract

The M.Sc. at Lund University is based on a multi-disciplinary approach to risk management and has the objective of providing industry and the public sector with risk managers able to be professionals in the following areas of risk:

- Safety risks
- Health risks
- Ecological/environmental risk

This paper gives a brief presentation of the structure and contents of the programme.

Introduction

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 organizational structures. Information technology ties units together in large complex and interdependent 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 also 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 organizations and individuals, toward a world of “produced uncertainty and organized irresponsibility”. Counter-forces have to be found and used as soon as possible.
It will rarely be possible to eliminate risks entirely. All life involves some risk, and any innovation brings risk as well as reward – so the priority must be to manage risks better. We need to do more to anticipate risks, so that there are fewer unnecessary and costly crises, like BSE or failed IT contracts, and to ensure that risk management is an integral part of all delivery plans. But we also need to be sure that innovations are not blocked by red tape and risk aversion, and that there is a proper balance between the responsibilities of government and the responsibilities of the individual. Risk managers will always have to make decisions under uncertainty with limited resources at hand.

Programme objectives

To meet up to the present and future demands of risk management, Lund University started a two-year engineering programme leading to a Master of Science in Risk Management and Safety Engineering in 2001. 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 organizations and the requirements of society, to formulate and work with management systems, especially in the areas of safety, health and the environment so as to establish a low level of risk with regard to finance and sustainable development.

The main focus, with 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 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, engineering education should provide the basis for the application of risk analysis as a systematic work process according to Figure 1 in the following areas:

- Systematic collection 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 with consideration for the requirements of organizations and society regarding safety, the environment, health, conservation of resources, and economy.

The education should also increase the depth and breadth of knowledge, and create the capability of communicating and collaborating with many different categories of technical and
non-technical individuals, as well as being able to work in risk management on the local, regional, national and international scale.

Figure 1. Flow chart for risk management [2, 3].

Programme structure and content

The programme consists of compulsory courses, elective courses, and senior thesis (M.Sc. dissertations), see Figure 2. The compulsory course block covers 40 credits (one year full-time studies). 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 measures. 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 are both traditional, with lectures, and project based.

In the end of the first year the students can start to extend and specialize 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 and methods.
The programme is largely based on students themselves selecting the elective courses in order to create a personal profile and specializing 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 also important to recognize the different levels of risk management maturity in different engineering disciplines. The approaches taken in different industry sectors are far from harmonized [4]. It is impossible to cover all aspects of risk management and safety engineering in a master’s programme, but it should provide the basis from which an overall view of how risks affect organizations can be applied. Facility in assimilating new knowledge is therefore an important quality, as well as being able to communicate this knowledge to others.

Description of compulsory (mandatory) courses

**Risk Analysis Methods**
(Swedish credits: 10, ECTS credits: 15)

Upon completion of the course, the student should be able to provide support in risk analysis for groups working with risk management. In the field of safety, the student should be able to carry out a quantitative risk analysis for an industrial plant. In the fields of health and environment, it should be possible for the student to perform a danger analysis. The analysis methods with which the student should be familiar range from qualitative and semi-quantitative to quantitative risk analysis methods. The management of uncertainty plays a central role and is an important part of the course. Methods for the quality assurance of models and input data with regard to analysis will be dealt with.
Statistical Methods for Safety Analysis  
(Swedish credits: 5, ECTS credits: 7.5)

The course aims to give the necessary knowledge of statistical methods for safety analysis and to apply the methods to some scenarios. The following content forms the base of the course: statistical tools for risk assessment, Bayes' theory, Weibull distribution and other extreme value distributions, event intensities and the Poisson process, statistical correlation and Monte Carlo-simulation, use of means, standard deviations and quantiles for risk assessment, risk computations, safety index and extrapolation of small risks.

Managerial Economics, Basic Course  
(Swedish credits: 5, ECTS credits: 7.5)

The purpose of the course is to give basic knowledge in Managerial economics. In the course the following issues are addressed: basic concepts, models and management control system, product costing and capital budgeting techniques, profitability assessment, understanding of a company's annual financial report and accounting analysis, the external accounting systems of industrial companies and marketing.

People, Technology, Organization and Risk Management  
(Swedish credits: 5, ECTS credits: 7.5)

The course imparts knowledge about the role and function of people and organizations in man-technology systems especially focusing on safety taking competitiveness and working life quality into consideration. After the course the student should be acquainted with the basics of human errors. Furthermore the student should have the foundations for design and assessment of man-technology systems, products and organizations for safety from an MTO-perspective (MTO = Man, Technology and Organization). The student should also be acquainted with the basics of risk management systems from an MTO-perspective.

In the course the following issues are addressed: Human factors and ergonomics, their role in risk management. The Rasmussen model and a holistic view of risk management. The GEM-model. Perception. Cognition. Memory. Learning. Human errors - taxonomy and theories, latent errors, safety barriers, situational factors, Rasmussen's SRK-model. Stress, arousal, Yerkes Dodson's law (inverted U), psycho-social and physical factors and risk. Decision making including dynamic decision making. Team and team training. The remedies: selection, training and good man-technology systems. Product development and interface design for safety, usability tests, standards and guidelines, scenarios, function and task analysis, heuristic analysis, expert assessments, 'walk-throughs'. Analysis of some major accidents with a focus on MTO causes. MTO-risks in some branches. Risk management systems from an MTO perspective. Safety Culture. Human and organizational factors in risk analysis.
Safety, Health and Environmental Law  
(Swedish credits: 5, ECTS credits: 7.5)

Issues regarding the handling of risks in the legal perspective are full of nuances and very complex. The various areas are often covered by detailed regulations, which are updated concurrently with developments. Special emphasis will therefore be placed on ensuring that students are familiar with the legal system concerning safety, health and the environment. The course covers learning to find and apply current regulations, as well as obtaining a more general understanding of the system, which is important when solving practical problems. Some international, mainly EU, matters will be dealt with.

Economic Models for Risk Management  
(Swedish credits: 5, ECTS credits: 7.5)

The aim of the course is to provide knowledge in economic theory and its applications and to lay a foundation for the use of economic models in connection with risk and uncertainty. The main areas of application are the calculation of investments, life cycle cost analysis (LCC) and problems associated with decisions that have to be made in situations of risk and uncertainty, for example, insurance.

The course includes the following: risk management in technical and economic systems (from both industrial and societal perspectives), risk reduction, risk management in economic documentation, efficient risk management, diversification/hedging/insurance, risk aversion, problems associated with principal-agent relations, and economic evaluation of risks in investment calculations and national economic analysis.

Risk Management Processes  
(Swedish credits: 5, ECTS credits: 7.5)

The aim of the course is to bring together and integrate elements in other courses. The general goal is to provide knowledge on the methods and techniques used in the risk management process. Upon completion of the course, the student will also be familiar with the basics of project management, especially risk management projects. This knowledge will be applied to a project, which forms part of the course. The course will bring together risk analysis, risk evaluation and the reduction/control of risks to risk management, i.e. the student will practice his or her ability to make decisions, in the project, based on the analysis and evaluation of risks. The aim is also to create conditions for the reduction of loss, damage and injury, and interruptions in operations in an optimal way for the organization (based on the analysis and evaluation of risks), and to:

- transform uncertainty regarding undesirable events into more predictable, controllable and budgetable conditions,
- prepare an organization for that which is unlikely, but possible.

The knowledge gained during this course will facilitate communication with other parts of a company or organization, and considerable emphasis will be placed on risk communication, i.e. the communication of risk management to the public.
Examples of elective courses

**Applied Process Industry Safety**  
(Swedish credits: 5, ECTS credits: 7.5)

The magnitude of the risks in a processing plant is determined, to a large extent, during the planning and design stages. It is therefore of great importance that those involved in risk management (in areas including safety, health and the environment) in the process industry have knowledge concerning the basic technical issues. The goal is that students will gain basic knowledge and sufficient knowledge regarding the important aspects of ensuring the safety of a processing plant, in order to be able to apply risk management methods included in the Risk Management Programme. This course is also suitable for students who have not studied pure process engineering.

**Emergency Management**  
(Swedish credits: 5, ECTS credits: 7.5)

The course is intended for those who have, or expect to have, leading positions in a) the management of accidents and/or b) planning for preparedness in the case of accidents. The actual goals are:

- to provide insight into the effects of crises and accidents on socio-technical systems,
- to provide insight into the problems encountered in managing socio-technical systems that have been affected by accidents,
- to provide insight into strategies employed in managing various types of accidents in socio-technical systems,
- to provide insight into how a state of preparedness can be developed for the management of accidents in socio-technical systems.

**Risk Based Land Use Planning**  
(Swedish credits: 5, ECTS credits: 7.5)

The aim is to provide the student with the basic knowledge required so that he or she can take part in planning at an early stage, to ensure that risk analysis is included in a strategic phase of land use planning (urban planning). To acquire knowledge on the basics of planning methodology: description of objectives, inventories, analysis and the development of a proposal. To put this knowledge into practice in outline planning and detailed planning. Parts of the course will also be dealt with on a more detailed level. Parallel with the land use planning part of the course, another part of the course aims to provide knowledge on how various kinds of risks can be dealt with in land use planning, based on risk analysis. This part of the course provides insight into the use of legislation as a means of ensuring that risks are considered in land use planning. The student will be expected to understand the points of view of various central, regional and local authorities regarding "risk consideration in land use planning". The course also includes lectures, seminars and literature that elucidate problems associated with the vulnerability of society and consideration of contingency planning in land use planning.
Consequence Analysis
(Swedish credits: 5, ECTS credits: 7.5)

Upon completion of the course, the students should:
- have good knowledge of the properties of dangerous chemicals,
- be conversant with the theory behind rescue operations following accidents involving chemicals,
- be able to carry out consequence evaluation following the accidental release of chemicals,
- be able to use GIS to plan operations following the accidental release of gas or liquids.

Fire Chemistry and Explosions
(Swedish credits: 10, ECTS credits: 15)

Upon completion of the course, students will: be able to assess the risk of fire where the fuel consists of gases, liquids or solids; be able to describe how the fire will develop regarding the heat generated, radiation, smoke and poisonous gases; be able to assess the risk of personal injury; have an understanding of the basic processes of heat transfer and be able to apply this knowledge in practice in fire physics; have gained knowledge on the properties of materials in relation to fire; be able to determine the causes of fires.

Senior Thesis
(Swedish credits: 20, ECTS credits: 30)

The senior thesis is intended to demonstrate the student’s ability to apply knowledge acquired during the course of studies, and that the student is able to carry out a specific task in an independent manner.

The thesis consists of work corresponding to twenty weeks of full-time studies, 20 credits and should be carried out as the final part of the educational programme.

The work may be undertaken at the University, at an industrial site, in a municipality, or at a research institute in Sweden or abroad. However, a faculty member from the University must always act as the supervisor. The project work may be theoretical and/or experimental depending on the student's background and interests. The project work is summarized into a written thesis and presented at a seminar and published in full text on the programme website.

Experiences during a three year period

The experience so far, when almost 40 students have graduated and 70 students are in the programme is that senior thesis is both well received by practitioners and also of high scientific standard. Theses have already been presented at international conferences [5] and new topics for master’s thesis are continuously received from the industry and the public sector.
There is strong competition for access to the programme. The 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 (bachelor degrees), are educated together, but with the possibility of specializing and extending themselves in a range of different areas, which results in a very interesting and varied range of competences and interests.

So far, students are employed even before graduating and the demand for well educated risk management professionals seems strong both in industry and the public sector. Figure 3 shows in what sectors the graduating students have started to work.

![Figure 3. Sectors where the first graduate students have been employed.](image)

**Research umbrella**

The multi-disciplinary knowledge base at Lund University has been a necessary condition for the implementation of the programme. Lund University is currently undertaking a special effort in the area of risk research. A multi-disciplinary 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 organizations in the Öresund region, LUCRAM is intended to contribute to developing and disseminating knowledge of research and education in risk analysis and management. Nevertheless, to be able to maintain a high quality master’s programme international collaboration and benchmarking is necessary.

**References**


