*Examination:*
**Risk Assessment and Decision Support (BOM125)**

Date: 2015-03-19

Time: 08:30-12:30

Examiner: Andreas Lindhe, GeoEngineering, 2060

Aids: Enclosed formula sheet, approved calculators, rulers, pens and dictionaries can be used.

Grade intervals: 31-41 = 3
42-52 = 4
53-70 = 5

**Note! Do not forget to number and submit the annexes (pages) that you use to answer the questions.**

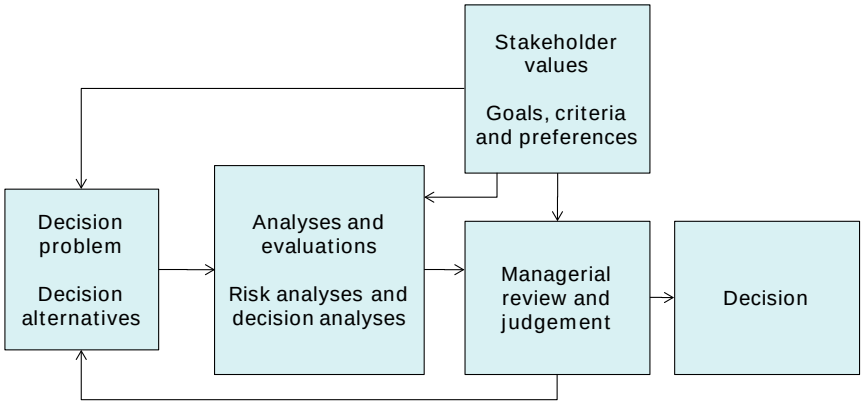
Questions regarding the examination results will be answered by Andreas Lindhe, Lars Rosén and Jenny Norrman after appointment.

**Q1. Risk assessment and decision-making (10p)**

a. Describe the purpose of performing a risk assessment? (4p)
b. Explain how risk assessment can be linked to decision-making and how a final decision is obtained (include e.g. what may affect the final decision) (6p)

Answers:

a. Identify hazards, determine probabilities and consequences in order to estimate the risk, consider whether the risk is acceptable or not, analyse possible actions, etc.
b. See the schematic illustration below. Risk assessments aim to support decision by providing useful information on, for example, risk levels and the effect of risk-reduction measures etc.




**Q2. Multi-criteria decision analysis (MCDA) (10p)**

*Short answers please!*

a. What is MCDA and what can it be used for? (2p)
b. What are the main advantages of MCDA in comparison with cost-benefit analysis? (2p)
c. When building an MCDA-model, what criteria should be included and how can they be identified? (2p)
d. How can the performance of analysed decision alternatives be measured with respect to different criteria? What are potential difficulties when measuring the performance? (2p)
e. How can you make certain that the final result of an MCDA is transparent? (2p)

Answers:

a. MCDA is a system to compare and rank options. Each option is assessed with regard to how well it fulfills a number of criteria. These criteria can be of a wide variety, measured in quantitative to qualitative units. It can be used as a decision support when choosing between options, but it can also be used as a way of investigating different options with regard to their weaknesses and potential improvement.
b. The main advantage is that MCDA can take aspects into consideration which are not easily monetized, and it can combine different types of measures. It has also the potential to invite stakeholders into the process to a higher degree than a CBA-analysis.

c. All criteria which are relevant to the decision-maker, i.e. criteria which can influence the decision situation should be included. How they are identified depends on who is the decision-maker and how the decision-process is formed. If it is a single decision-maker and a closed process a simple inventory is sufficient. For a more open process and a more broad view on the decision-situation, stakeholders can be invited to contribute to the inventory. This is often done by brainstorming, but could also be done by means of questionnaires.

d. The criteria can be measured in many different ways. It can be measured on a quantitative scale (e.g. €, km, tonnes), it could be measured on semi-quantitative scales (e.g. scores 0 – 100). Some MCDA tools can also handle qualitative measures (e.g. a scale from good to bad). In the AHP-system, all scoring (and weighting) is done by pair-wise comparison.

*e.* By thorough documentation of all stages in the MCDA, from building of the model (selection of criteria) to the construction of scoring scales, the procedure for scoring and the motivations, the weighting and the investigation of the results by means of sensitivity or uncertainty analysis.

**Q3. Cost-Benefit Analysis (CBA) (10p)**

You are the appointed expert for a project where the societal profitability of different alternatives for reducing risks will be evaluated. The project is about decreasing both the long-term health risks and the technical risks at a drinking water supply system, caused by an industrial area upstream the water supply. You suggest using CBA for evaluating the profitability of the identified risk reduction alternatives. Explain shortly to your client the following:

a. What is the main difference between risk valuation *ex post* and *ex ante*? (4p)

b. For one alternative you have an initial cost of 12 million SEK during the first year. You then expect to have annual benefits of 0.5 million SEK for a period of 50 years. There will be no costs other than the initial cost. Explain to your client how the net present value (NPV) changes depending on whether choosing a low discount rate (1.5 %) or a higher discount rate (4 %). Quantify to support your explanation. (6p)

Answers:

a. Valuation ex post estimates the WTP for avoiding a consequence as if it occurs with certainty, whereas valuation ex ante estimates the WTP for avoiding a risky situation. Ex ante includes people's preferences with respect to both probability and consequences of the situation.

b. 1.5 % rate: NPV = 17.50 – 12 = +5.5 MSEK; 4 % rate: NPV = 10.74 – 12 = -1.26 MSEK.

**Q4. Decision analysis and decision theory (5p)**

a. Explain what the ALARP region is. (2p)

b. Two different types of decision-criteria that can be applied in risk management are: utility-based decision criteria and right-based decision criteria (e.g. discussed in the textbook, Burgman Chapter 12). Explain the difference between these two categories of decision criteria. (2p)

c. Which type of decision criteria was applied in the project assignment in the course? (1p)

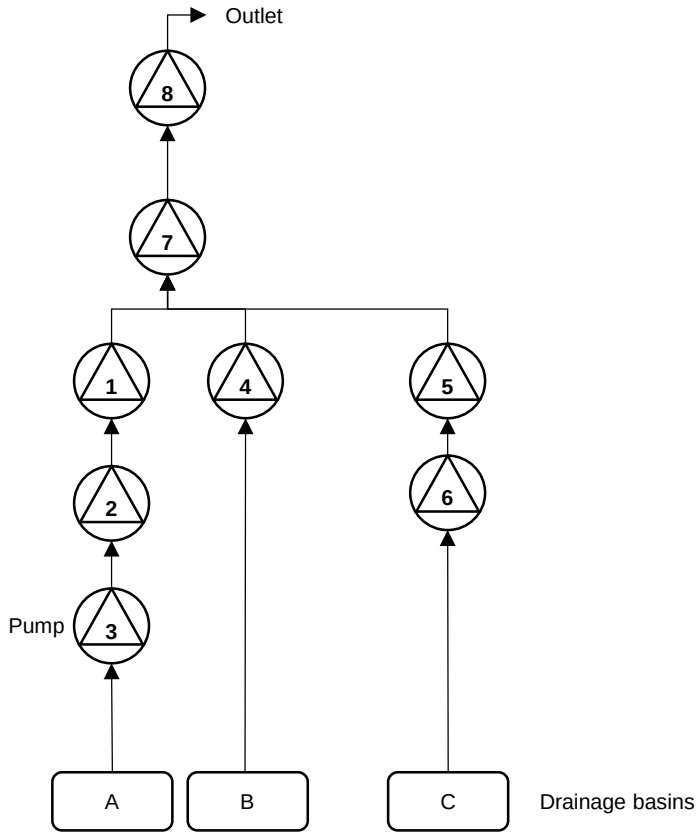
Answer:

a. ALARP – As Low As Reasonable Practicable – is a region where the risk acceptability is depending on the possibilities to reduce the risk, a region between the "not acceptable risk" region and the "acceptable risk" region. Often it is stated that "the risk can be accepted if it is economically and technically unreasonable to reduce it". However, to actually define what is reasonable is not that easy, this will depend on who is asked.
b. Utility-based decision criteria are based on the valuation of outcomes, i.e. places a value/utility on the outcome and seeks the alternative that maximizes the outcome in the desired manner. Rights-based decision criteria however, are more concerned with equity, rights, processes and allowed actions. For example, a certain risk level must be reached regardless of costs and benefits.
c. Utility-based criteria: to maximize the net present value.

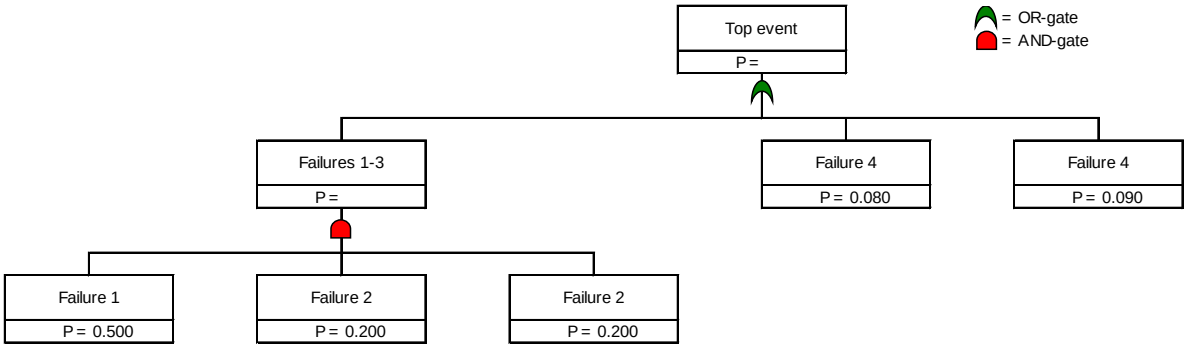
**Q5. Risk assessment methods (15p)**

a. The diagram below illustrates a system of pumps used to discharge water from three drainage basins at a construction site. To be able to continue the work at the construction site, water must continuously be pumped from all three drainage basins. You are asked to construct a fault tree in order to analyse the critical event of not being able to pump water from all drainage basins (top event). (8p)

   Note: The pipes are not supposed to be included in the fault tree, so focus only on the pumps. The two pumps common for all drainage basins (7 and 8) must both work in order to pump water to the outlet. In order to pump water from drainage basins A to the common pumps, it is enough that one of the pumps (1, 2, 3) is working. For drainage basins C both pumps (5 and 6) must work to be able to pump water to the common pumps.



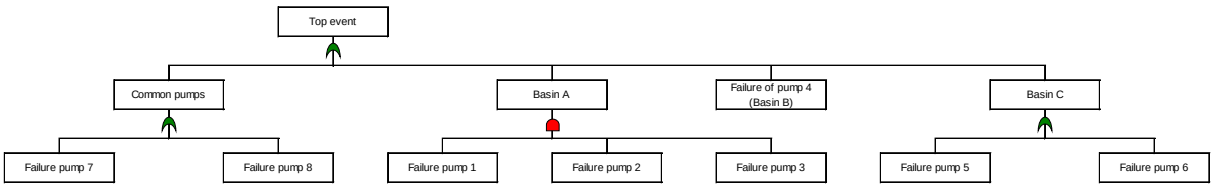

b. Calculate the probability of the top event in the fault tree below (present your calculations). (3p)




c. Describe the basic principles of event tree analysis and use an example to illustrate how it may be applied. (4p)

Answers:

a.




b. 0.180

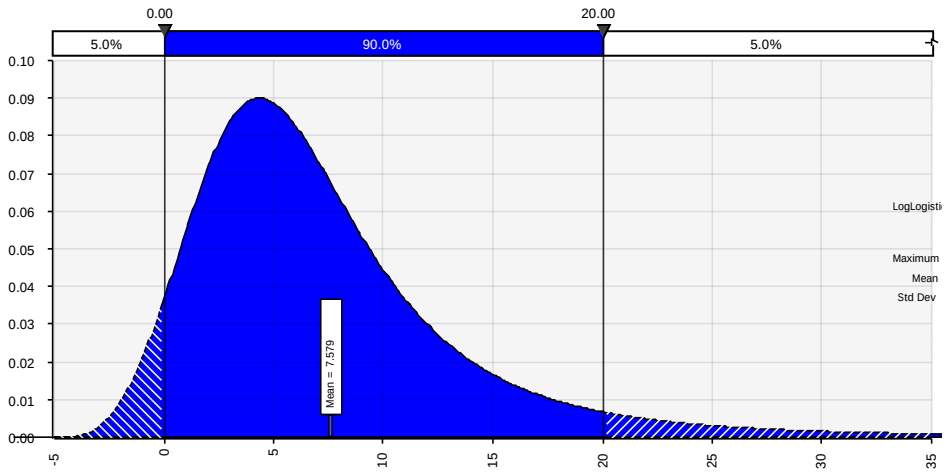
c. Event trees analyse the question “What can this initial event lead to?”. It links possible outcomes following an initiating event based on, for example, the success or failure of safety barriers. The model has a horizontal structure which proceeds in time from left to right. To be able to construct a correct event tree it is necessary to have a good understanding of the analysed system as well as causes and consequence relationships etc. The results of an event tree analysis are probabilities for possible outcomes. The probabilities can be combined with information on consequences in order to calculate expected consequences. See illustrations in hand-outs.

**Q6. Uncertainty analysis (10p)**

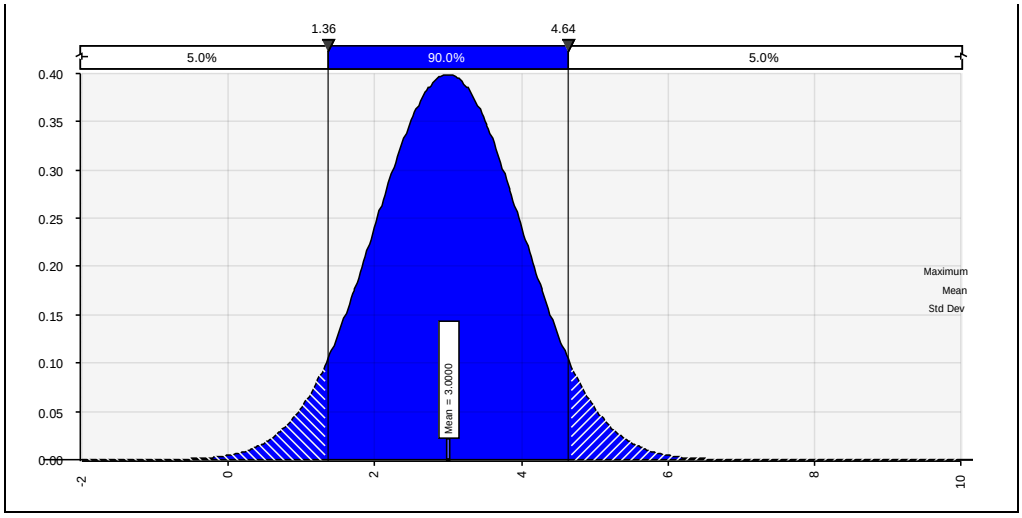
a. Shortly explain the purpose of using Monte Carlo simulations in risk assessments (incl. the basic principles). (5p)

b. Bellow the probability distributions for the expected benefit of two alternative risk reducing measures are presented. Thus, the effect of the different measures (Alternatives 1 and 2) is expressed as the expected economic benefit (MSEK). Discuss the difference between the two alternatives based on the probability distributions (i.e. advantages and disadvantages of the two alternatives with respect to the uncertainties etc.). (5p)

**Alternative 1**

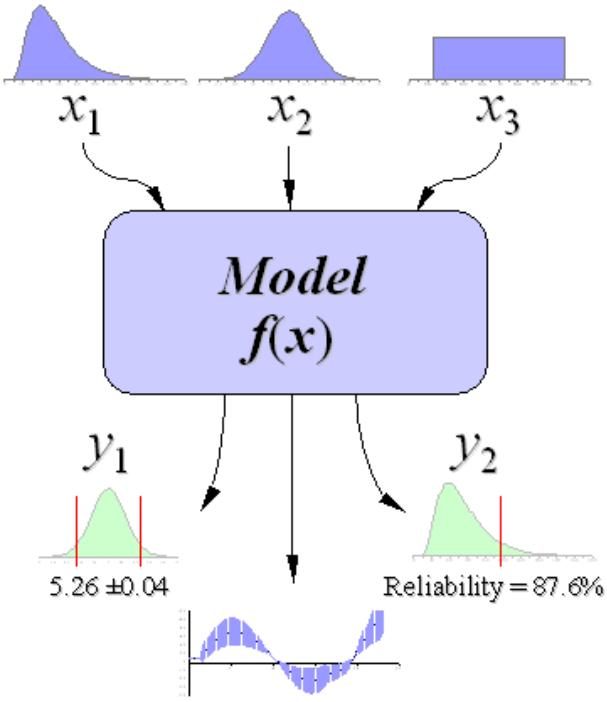



**Alternative 2**




Answer:

a. Consider and model uncertainties in input data and results, see illustration below. Results incl. histograms, sensitivity analysis etc.




b. Alt 1 has a 5 % probability of being below 0, i.e. have a negative benefit. Alt. 1 is also related to greater uncertainties compared to alt. 2. However alt. 1 may result in a much greater benefit (Mean=7.6, P90=20 MSEK) compared to alt. 2 (Mean=3, P90=4,6 MSEK). Alt. 2 is likely to provide a lower benefit but is not as uncertain as alt. 2 and it is extremely unlikely the benefit will be <0.