LECTIO PRECURSORAE TONY ROSQVIST 11.12.2003

”Dr. Custos, Dr. Opponent, ladies and gentlemen”

A pusher-barge loaded with water-absorbent bulk cargo is sailing around the Hanko peninsula. The captain notices that the sea-going is rough. But he is not worried as he has sailed in similar seas before without problems. Or almost similar seas, this day the rain is pouring down, as it has for a couple of days. The captain knows that after a few hours the difficult part around the peninsula is over, and he can approach the harbour. He turns the ship slightly towards the East when the unimaginable happens: the water-absorbent bulk cargo, as if on slippery ice, moves fast against the wall of the cargo space. The ship starts to lean heavily, stays in the awkward position, and 10 seconds later the ship, its crew and the cargo are upside-down in the waves. Nothing can be done to save four of the six crew members. Two are miraculosly saved through a hole cut in the bottom of the ship some 24 hours later.

This is not a fictious fairytale but a true story dating back about 20 years. The important question is: What went wrong and why? Could it have been prevented by a proper risk assessment?

One captain had announced his unwillingness to transport water-absorbent bulk cargo some time before the accident. He had also stated that a condition for his continuing services would be the pre-control of the humidity of the water-absorbent bulk cargo to meet a specified maximum acceptable humidity level before loading. Some measures had been taken to allow excessive water to flow into scuppers - small outlets for water to escape the cargo hold - but the captain didn’t feel these measures to be adequate. Although an expert in this type of transportation, his statement was considered unconvincing, not backed-up by the majority of other captains. It has to be added at this point that it is usually taken as a matter of pride, in maritime work culture, to be able to transport whatever whenever.

We are now ready to start answering the question put forward ’Could the accident have been prevented by risk assessment?’

There are two *external* requirements related to a risk assessment. Firstly, a decision problem has to be perceived and the *need to carry out a risk assessment has to be acknowledged* by the relevant decision-making body. Secondly, the methods of *risk assessment should be applied in a way that its quality can be verified* or assured for the results and recommendations to be considered complete and credible by the decision-making body. In this speech I will address both requirements briefly, starting with the latter because the thesis addresses this issue.

Applying risk assessment methods for identifying hazards, modelling deterministic and stochastic relationships between quantities and events, and deriving quantitative risk estimates, entail many analyses where the collaboration between the decision-makers, risk analysts, domain experts and stakeholders is crucial for the assessment to be complete and credible. Risk assessment can be viewed as a framework for tying experts' opinions and judgements together in a way that systematically addresses uncertainties of different types; conceptual, model and parameter uncertainties related to modelling complex physical or social phenomena. I will now focus on expert judgements pertaining to the two latter types of uncertainty because the first one, conceptual uncertainty, that is, limitations in understanding and describing the physical and social phenomena, limits the applicability of risk assessment as a method of scrutiny. The views reflect what I consider 'best practices' and are therefore related to the *quality* of risk assessment.

In the case of model uncertainty, I claim that expert judgements are needed to judge the effects of modelling assumptions on the risk estimate to be computed. It is surprising how little attention the effects of modelling assumptions receive in interpreting risk analysis results. In the thesis I argue that these effects should be systematically addressed in terms of the direction of bias that a modelling assumption imposes on the risk estimate. The preferred bias is towards the pessimistic side such that the *net effect on the risk estimate* is deemed conservative. This implies that if the system under study satisfies a risk criterion it is very unlikely that it satifies it falsely (this could in principle be checked if the behaviour of the system is monitored throughout its lifetime). This approach is referred to as the *precationary approach* in the thesis. It is especially relevant in the case where the risk acceptance related to a generic system concept is evaluated. Does acceptance of the generic system automatically imply acceptance of the whole population of actual systems represented by the generic one? From the point of view of precautionary risk decision-making the generic system should be defined as a reference system depicting the bottom-line. The actual system realizations should be at least as good as the reference system in terms of risk.

In the case of parameter uncertainty, expert judgements are related to the specification of risk model parameters. These judgements are quantitative. There are some claims I would like to make stipulating 'best practices':

- experts' judgements should, as a basic rule, be associated with *observable* events or quantities and elicited in terms of familiar scales of performance;
- any uncertainty felt by the experts should, as a basic rule, be formulated in terms of *extremist* percentiles of the probability distribution of the variable, avoiding possible anchoring bias associated with central percentiles;
- if track records of past performance of experts' abilities to make predictions are available, then the computed calibration and entropy scores of the expert should, as a basic rule, determine the relative weight of the expert in the case of several expert judgements on one variable

- if no track records are available (which is the common situation) the aggregation of the probabilities should, as a basic rule, be an *optional mathematical or consensus-based probability aggregation*, the option decided by the experts. Novel algorithms for the mathematical aggregation of experts' percentile judgements are introduced in thesis, as well as a parameter specification procedure that guides the adoption of either means to probability aggregation. Modern IT based decision support systems could be tailored to support the facilitation of the expert work group.

How model and parameter uncertainties are treated in the risk analysis should determine the decision-makers' sense of confidence in risk assessment results and recommendations. The thesis introduces a conceptual framework for the qualification of risk assessment and a related procedure for addressing methodological quality characteristics implying *completeness* and *credibility*, that is, doing right things right. The precautionary approach and the risk model parameter specification procedure outlined in the thesis are argued to represent *qualification criteria*. In general, the framework for qualification can be viewed as a means to communicate quality related issues of risk assessment to the decision-maker.

Back to the question: 'Could the accident with the capsized barge have been avoided by proper risk assessment?'

In a risk assessmet several years later it was found that the humidity of the water-absorbent bulk cargo was *not* the most critical factor for the cargo stability in rough seas. The vertical forces exerted on the cargo makes it possible for the pore pressure in the lowest layer of the cargo to increase to a magnitude which is enough for the horisontal accelerating forces to exceed the friction. Based on the risk model developed which followed the principle of the precautionary approach, a better risk control measure would have been to trim the bulk cargo against the walls to add friction, even if the scuppers would have become useless. Today the water-absorbent bulk cargo is trimmed to the walls of the barge. Also equipment for the monitoring of roll has been implemented on the bridge. The risk of similar accidents has now been significantly reduced.

The question has only been partly answered, however.

In hindsight, I think that most risk assessment teams would have arrived, more or less, at similar risk assessment results and recommendations, irrespective of risk assessment approach. The main problem is that the latent hazard was not perceived by the key stakeholders in the bulk cargo transport business. The voice of one captain was not enough. With this observation I move on to the last chapter of my speech addressing the first requirement related to risk assessment, that is, the emergence of a need to commence one. This is not addressed in the thesis, but I feel it important enough to be brought up in this lectio.

It appears to me that in many work cultures weak signals of the unprecedented are rather viewed as misconceptions than evidence motivating further information gathering. From a risk management point of view it is crucial that weak signals be detected and evaluated based on some kind of rules. The written statement of the captain issued before the accident would by most decision-makers suffice for a strong enough signal motivating further information gathering. Generally, a *periodical survey* of experiences of near-miss situations, odd behaviour of the system and other deviations, would be a means for the risk management to judge the need for risk assessment. Furthermore, *on-going analyses of precursor events* based on risk scenarios, can reveal potential hazards even before any weak signals need to be observed. The meaningfulness of such pro-active tasks depend on company policy and work culture. In particular, the meaningfulness should be obvious for companies which have adopted risk-informed decision-making as the rationale for making strategic decisions concerning safety. It has to be born in mind that risk–informed decision-making is a feasible rationale in making *strategic decisions under uncertainty* in general, where the consequences are measured not only with respect to safety criteria, but also with respect to any economic criteria. Although risk-informed decision-making has its origin in the field of nuclear energy, I feel it has a great potential for improving decision-making under uncertainty in any business area.

With this I will give my subjective answer to the question of whether the accident with the pusher-barge could have been avoided. If a risk assessment had been conducted in time, appropriately qualified and communicated to the decision-making body, then I do believe that the accident could have been avoided.

I ask you professor Enrico Zio, as the opponent appointed by the Department of Engineering physics and Mathematics to make any observations on the thesis which you consider appropriate"

(the candidate keeps standing up…)
(the opponent gives a short overall statement….)
(both sit down for detailed examination ….)
(the opponent gives his final statement)

Thank you very much for your observations professor Enrico Zio

Ladies and gentlemen, if you have observations you would like to make on my disseration, please ask the custos for the floor"

(candidate, custos, opponent out…)