

Overall strategy for risk evaluation and priority setting of risk regulations

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Abstract

This paper presents the framework of an approach to support planning and priority setting for risk control. Such an approach could assist government/regulatory authorities in their allocation of resources among different sectors. The term risk will here be used in a very wide sense, and it will include, but not restrict to, the traditional HES (Health, Environment and Safety) concept. An overall classification of risk ('loss categories'), to be used across sectors and directorates is suggested. The risk evaluation includes a number of factors not accounted for in a standard risk assessment, but should be taken into account when authorities set priorities regarding risk control. Sociological, psychological and ethical perspectives are included, and the need for a discourse during the decision process is pinpointed. The paper also discusses the potential inclusion of cost benefit analyses in such an approach. The indicated approach is denoted Risk Across Sectors (RAS), and suggestions regarding the process to implement it are given. Such an implementation process will by itself increase the knowledge and competence of the involved parties.

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1. Introduction

It has been experienced that regulatory authorities feel that their allocation of resources within the risk area to a large extent is based on 'tradition' [1]. It is rather difficult to establish a scheme for planning 'across sectors', i.e. across regulatory bodies and across various types of risks. Actually, this may be found difficult even across two related areas; say road traffic and rail traffic. So, this paper partly addresses authorities (ministries, directorates), that are not necessarily experts in risk analysis, but who encounter this type of problems in their high level prioritisations and strategic planning. Further, it is hoped that the paper will stimulate a further discussion within the community of risk researchers on how to integrate the various aspects of risk to provide a more 'complete' risk evaluation than is usually carried out today.

The present paper discusses the formulation of an overall, unified strategy for risk evaluation. It should support regulatory authorities in their planning, supervision and inspection in the Health, Environment and Safety (HES) area, and the approach will cover various 'risks' (losses) not included in the traditional HES concept. We indicate an approach denoted Risk Across Sectors (RAS) that should support the authorities in their allocation of resources for control of risk and vulnerability. The authorities should then in their planning and prioritising do both

1. Perform an overall risk assessment across different areas and regulatory bodies. This should include various aspects of risk/vulnerability that are quantified in a relatively straightforward way.
2. Perform a systematic identification of the other relevant factors (e.g. psychological and ethical) that should be taken into account for allocation of the authorities' resources. These factors are accounted for in a more qualitative way.

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Both these two ‘elements’ of the approach are part of the risk evaluation. However, the first element refers to what is sometimes called ‘calculated risk’, (as quantified in various risk analyses, supported by statistics, etc), whilst the second element is related to various judgements, e.g. on the society’s and the individuals’ acceptance of various types of risk, ethical issues, etc. Thus, the RAS concept suggests a strong element of discourse. In this context it is also relevant to discuss the ‘power’ that various parties/actors have to affect the focus and the judgements related to the risk evaluations, (e.g. which groups in society are most vulnerable or exposed to risk).

Thus, it is suggested that the quantification of the ‘calculated risk’ must be combined with the evaluation of a number of other factors/aspects. Such an overall approach will also support the authorities in their work to establish a common prioritising, reporting and follow up system across various sectors of society. In summary, the approach should assist the authorities in their strategic planning, make explicit all factors that could be taken into account for the authorities’ planning and result in a more cost-effective use of resources for reducing and controlling risk. There are problems and pitfalls associated with such an approach. However, it is advantageous to make these dilemmas explicit and open for discussions.

As already indicated, the term ‘risk’ is in this paper used in a rather wide sense, cf. the definition suggested in [2]: *Risk refers to the possibility that human actions or events lead to consequences that affect aspects of what humans value.* For instance, we also include ‘losses’ caused by continuous effects (e.g. psychosocial stress). Therefore, in addition to consider the more traditional risk analysis approach, reference is also made to various sociological, psychological and cultural approaches to risk, cf. [3–5].

The paper first discusses the definition of risk and presents a categorisation of the various losses considered. Next, in Section 3 various cultural, ethical and psychological aspects, relevant for the controls of risk are considered. Further, main principles for risk management, and the potential use of cost benefit analysis are discussed. Following these discussions, we will in Section 5 describe the suggested framework for prioritisation and allocation of resources. Some suggestions for the implementation process of a RAS approach are given.

The paper is to a large extent based on a feasibility study carried out for the *Ministry of Labour and Government Administration* in Norway, [1,6]. This Ministry has the overall responsibility for Norway’s policies for occupational safety and the working environment, including the Directorate of Labour Inspection, the Directorate for Fire and Explosion Prevention and the Norwegian Petroleum Directorate. The suggested approach was discussed with the involved directorates (regulatory bodies), who gave valuable input.

2. Risk definition and classification

2.1. Definition of risk

An important basis for establishing a unified and common strategy for assessing and handling risk is to establish a ‘common language’ concerning this concept. There are various definitions of risk but those traditionally used in the industry can be somewhat narrow for the development of a RAS concept. The term ‘risk’ should here be used in a wide sense, so that it includes the possibility of ‘all’ unwanted events and conditions that in the future can occur related to the human activities. It is also inherent in the risk concept that there is uncertainty related to whether the unwanted event/condition would occur.

Klinke and Renn [2] in their discussion on the risk concept suggest that it should refer to human actions or events leading to consequences affecting what we human value. The RAS approach is based on the definition of risk provided by Klinke and Renn (see Section 1). The main point is that the term risk is used in a wide sense. Somewhat simplified we may say that risk represents the possibility of future loss of human ‘values’. This implies that we focus on negative impacts, even if it is important also to promote the positive, not only to prevent the negative.

2.2. Classification of loss categories

Identification of risk includes (see Fig. 1)

- Identification of hazards/threats (possibly causing unwanted events/conditions),
- Identification of values that are threatened by these hazards, (‘targets’).

Four categories of hazards/threats are listed in the figure

- (A) Acute accidental events/incidents
- (B) Continuous strains or impacts
- (C) Intended harmful actions (sabotage)
- (D) Violations (within the enterprise) of society’s accepted ethical rules/standards

The wide definition of risk applied here implies that we include hazard category (D), which may lead to e.g. loss of reputation (and thus reduced market shares etc), in addition of course to law suit.

Similarly, we suggest six categories of values that may be threatened by these hazards. A unified approach for risk evaluation/prediction will require a common categorisation of the losses. A total of 11 *loss categories* are suggested (Fig. 1):

1. Loss of life in major accidents
2. Loss of life in other accidents
3. Acute personal injury

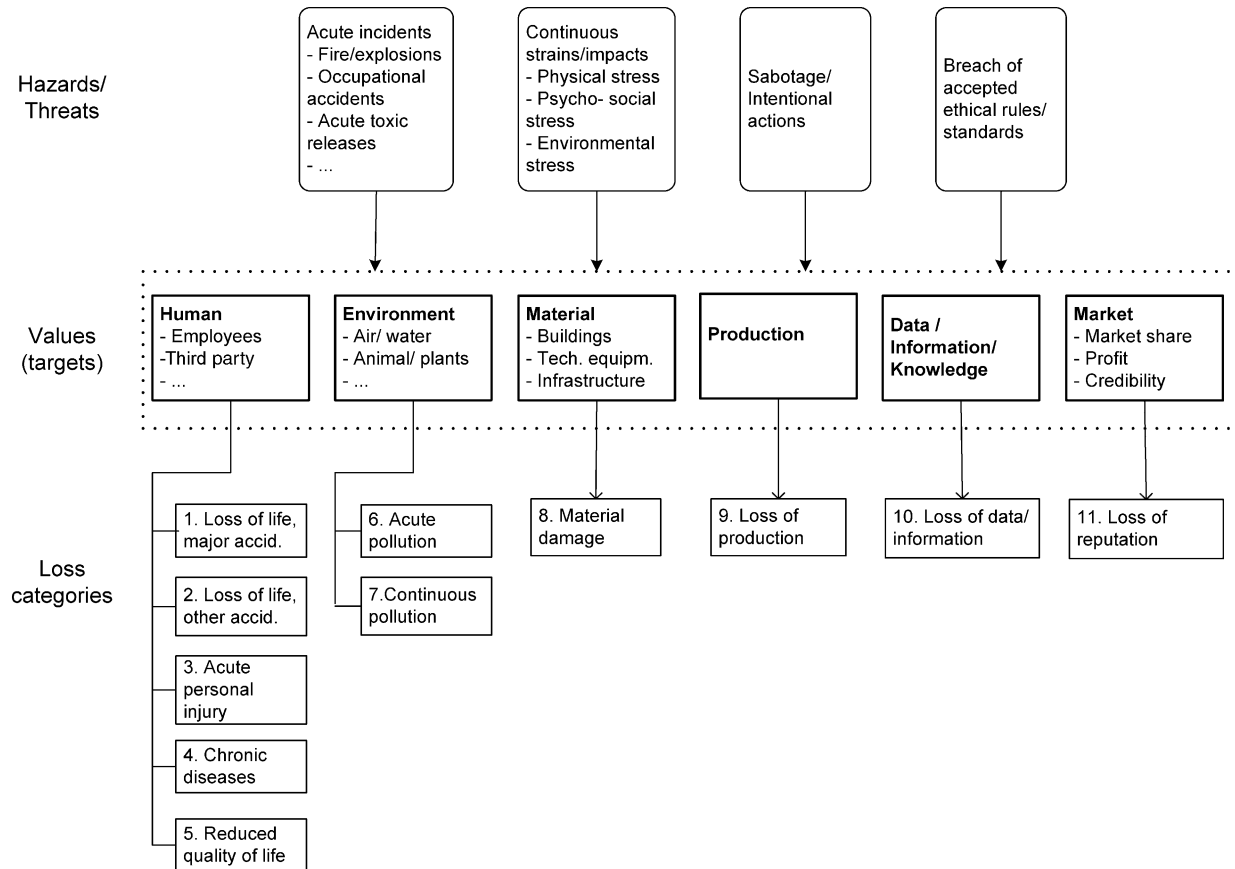


Fig. 1. Illustration of threats, values and 'loss categories' in risk—and vulnerability management.

4. Chronic disease
5. Reduced quality of life; reduced functionality
6. Acute pollution on external environment
7. Continuous pollution on external environment
8. Material damage
9. Loss of production, (could include deferred and damaged production)
10. Loss of data/information/knowledge
11. Loss of reputation

These 11 categories should include most of the potential losses related to human, environment, material and production. In addition, loss of data/information, knowledge and reputation are included. Note that the list is rather extensive concerning 'human losses' (categories 1–5), e.g. considering also chronic diseases and reduced quality of life. As we may want to give a different treatment/evaluation of loss of life in major accidents and in other (minor) accidents, two different categories for loss of life are given. The above list of loss categories is longer than in a typical risk/vulnerability analysis. It could be either extended or reduced, and should thus be seen as an illustration. Note that the perspective here is mainly that of the enterprise (in a wide sense). Thus, for instance a nation's cultural heritage and the human DNA are not explicitly included as 'targets',

(which could be natural if a fully societal perspective was chosen).

The main objective for introducing the term 'loss category' is that the loss within each category is so homogeneous that a common measure of the corresponding risk will apply. So the risk is quantified for all these categories; or at least some semi-quantification can be carried out. However, there is still a problem to compare the risks of different 'loss categories', i.e. 'comparing apples and oranges' see Section 5.1.

3. Sociological, psychological and ethical perspectives

Risk should neither be defined nor managed without placing it in a cultural, sociological and psychological context. It should be clarified in what ways the various perspectives influence the way we look at risk. This is one reason why a RAS approach cannot be defined as a purely quantitative/mathematical model. One needs also to consider for instance the public's acceptance of risk. So priority settings regarding risk should be seen in a social context and be related to ethical questions. Some key issues are discussed below.

3.1. Cultural and sociological factors

The sociologist Eilert Sundt already in the 19th century discussed the differences in attitudes to risk. Sundt [7] claimed that if the newly deployed railway in Christiania (today Oslo) had caused as many fatalities as the fisheries in Northern Norway, the accidents would have been considered carefully until the causes for the accidents were identified. However, for the poor fishermen, no such commotion occurred.

Traditionally risk has been seen as a function of *Probability and Consequence*, e.g. see [8,9]. However, knowledge about the threats/risks and an agreement in the society on how this shall be handled is also important, Refs. [10,11]. To fully perceive risk one should have a cultural understanding of it, and Douglas defines risk as *Knowledge and Agreement*. Some risks are better known than others or are brought into focus by the media. Other risks, which may also be known, can as Sundt claimed, be ‘overlooked’. For instance, we have the knowledge about traffic accidents, but still it can be argued that we seem to accept them or at least we want to prioritise other areas. The definition of Refs. [10,11] does not replace the traditional understanding of risk, but her conceptualisation contributes to better understanding on how risk is constructed culturally. This is particularly important to understand for decision-makers.

3.2. Psychological aspects

One particularly relevant aspect is the public’s perception of risk, for instance the (potential) risk aversion against major accidents. Often major accidents will be seen as more stressful than a lot of minor accidents. It may often be true that ‘We fear the major threats, but are killed by the small accidents’. Rather than to claim that these fears in general are irrational, we suggest that these perceptions are important and should be taken into account. Thus, the RAS method can ‘weight’ fatalities in larger accidents higher than those occurring in a smaller accident. (Such a weighting can also be supported by considering actual societal costs of major accidents).

Jakobsen [12] examined a case that demonstrates how psychological aspects are relevant for decision-makers. Lapps, living widely spread in Northern Sweden, was evacuated by helicopters, prior to a rocket launching drill. Evacuation was chosen despite of the fact that a risk assessment indicated that evacuation was by itself far more dangerous than the risk of being hit by rockets. In this case it was probably ‘impossible’ for the government not to evacuate the people, irrespective of any risk evaluations. Another example is taken from road traffic. Pedestrian crossing actually increases the risk with 30% compared to crossing a road with no pedestrian crossing [13]. Pedestrian crossing with a speed hump reduces the risk [13]. Still, if there is no money to construct a speed hump, the road

authorities will face a challenge explaining why not a pedestrian crossing is established. These examples demonstrate how difficult things can be for the decision-makers. It also shows the importance taking into account cultural, sociological and psychological factors. As [10,11] claims we need knowledge about phenomena and forums to negotiate agreement.

3.3. Ethical perspectives

Sandin et al. [14] claim that all decision-rules are value based. The efforts/resources used to save human lives are a major question. Even if we do not explicitly assign a value to a ‘statistical’ life, the allocation of resources between loss categories will obviously reflect the authorities’ prioritising, and is therefore a major ethical issue. Further ethical questions are to what extent we shall e.g.

- Take into account the risk aversion against major accidents,
- Take into account the age of exposed persons (giving priority to children?),
- Take into account the degree of voluntariness and control of the exposed persons,
- Take into account the human ‘fear of the unknown’, and
- Strive at giving a just treatment of all groups (e.g. vulnerable groups), as opposed to following a pure cost/benefit approach?

Different ethical points of view can imply different prioritisations in a given situation. So a discursive principle (cf. Section 4.1 below) should apply regarding these ethical questions.

To exemplify, can it from an ethical point of view be acceptable to let the resources used to save a ‘statistical life’ be different for various groups within the population? Often people have strong opinions regarding this issue. It is said that one human life could not be seen as more valuable than another. Ramsberg [15] claims that the measure ‘life-years lost’ is a better measure than ‘statistical lives lost’. This is intuitively appealing since it favours the children and ensures that more resources are allocated to protecting them. However, from a perspective of justice, one could argue that all individuals should be treated equally, and then use of *life-years lost* could be more problematic. It is clear that these issues are difficult and the ethical considerations obviously should be taken into account and be the subject of a discourse. The technique of ‘veil of ignorance’, see [16], represents an approach to help resolving these types of problems.

3.4. Experts versus lay-persons

Bauer and Gaskell [17] have discussed the increasingly polarised dialogue between different stakeholder groups like the representatives of industry, consumer organisations, scientific institutions, and the general public. Bauer and

Gaskell claim that the polarisation between these groups regarding biotechnology occurs because of the way the different groups ascribe perception and motivation of other groups. Graham [18] writes that some may disregard even high quality research, if stakeholders financing it are perceived to have an interest in the research results.

Shrader-Frechette [5] argues strongly against the perspective of those experts who claim that the public's perception is irrational and therefore should not be considered. She criticises experts for ignoring the perception of the opinion. It is also a problem that scientists tend to talk about technical risks, while pressure groups for instance in the case of food safety were more concerned about traceability or lack of traceability of food [19]. Sjöberg [20] writes that few experts had foreseen the spread of data virus and few talked about a nuclear disaster in Eastern Europe before Chernobyl. The risk for humans getting the BSE (or 'Mad cow disease') was first categorically denied by experts. In that sense, it may be a sign of soundness that laypersons are sceptical and raise questions. Shrader-Frechette [5] argues that experts and lay-persons should be brought together in order to better describe the risks. Rather than ignoring subjective understanding, subjectivity should be taken into the risk analysis. Sjöberg [20] writes that discourse has a value in itself in a democratic society even if some would claim that laypersons might have a fragile fundament to base their opinions on.

Further, it is most relevant to note that also the experts are the subjects of risk perception. For instance, [21] found that the experts risk perception seemed to be correlated with the interests of their employer and it is therefore really difficult to trace absolute impartiality.

3.5. The power and responsibilities of involved actors/parties

Now there is not just a potential conflict between the expert and the layperson. There are various 'actors' (parties) involved in the society's handling of risk (see Fig. 2). In addition to those directly affected, i.e. so-called first/second/third party, we also have the authorities, company management, labour organisations, the mass media, the general 'public' (e.g. through various interest organisations), etc. All have the possibility to influence the views e.g. on (1) what the society shall consider being a (major) threat to society or individuals, and (2) whether there are groups of persons that should be given particular attention regarding risk reduction. Such views may have a major impact on the priorities; see the above-mentioned example of [7]. So it is worthwhile to contemplate on which groups do have the best opportunity to affect the public or prevailing opinion.

When the authorities set priorities regarding risk control, one should try to deal with such difficult questions. But to what extent should the prioritisations conform with

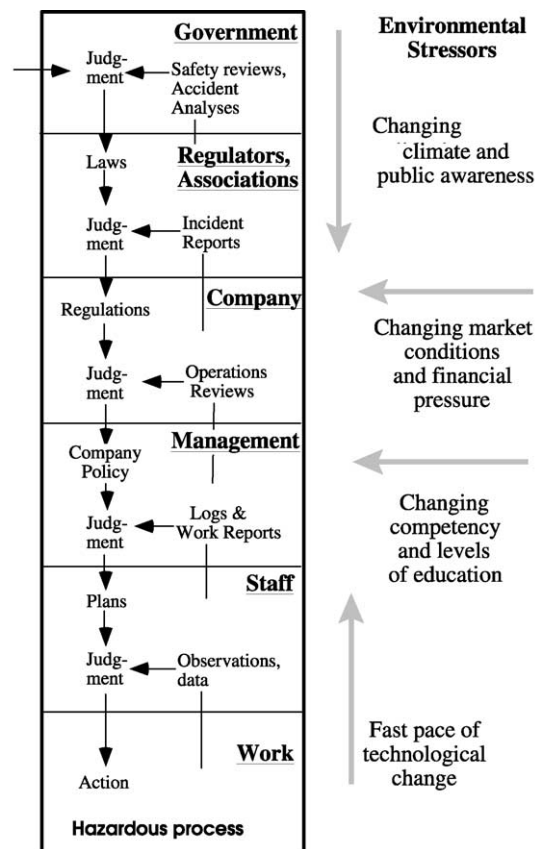


Fig. 2. The socio-technical system involved in risk management [32].

the society's value judgement, when the different groups have different power/ability to affect the society's views? A principle of justice/fairness for all groups might overrule a prevailing opinion on prioritising the risk reducing work in certain areas. First of all the decision-makers must be aware of the problem and find some balance here. The task is challenging, and it is suggested that they should neither fully accept the society's current value judgements; neither force their own judgements on the society.

Also 'model power' is a relevant topic. Bråten [22] discusses this concept, and argues that model power should be considered, because it may give one party the power over others by 'possessing' the model and thus reject or reduce criticism towards the given model.

Next, there are also questions regarding the shared/split responsibilities of all parties involved. All may be responsible (juridically as well as morally) for avoiding hazards and reduce risks. One major question is to what degree the responsibility to achieve safety is transferred to the companies themselves?

Finally, it is important that causes of incidents/deviations are traced back to the 'right' right level in the hierarchy of Fig. 2. For instance, the slip of an operator could be seen as an indication of a more fundamental problem in the company. The overall risk assessment should incorporate all major factors contributing to risk, e.g. like the quality of

current regulations/rules, the company procedures, common practice in the enterprise when it comes to living up to the rules (i.e. ‘safety culture’), the operators’ behaviour/competence, etc. Some kind of influence modelling could be introduced to give a more formal treatment of this aspect in the risk assessment. This topic is not pursued further in the present paper, but is treated e.g. by [23–25].

4. Decision principles regarding risk

4.1. Management principles

The *risk based* (risk informed) management strategy is based on the use of risk analysis, including cost-benefit, quantification of probability and consequence. Klinke and Renn [2] discuss the use of this principle in relation to both a *precautionary* and a *discursive* strategy. In addition we have the *rule-based* approach, where formal rules form the basis for decisions.

Klinke and Renn [2] recommend that the risk-based approach be used when the uncertainty with respect to consequence and probability is not too high. In particular they suggest that this principle be used when the consequences (extent of damage) are high and the probabilities of occurrence are low or uncertain. Thus, it typically applies to reduce the potential of disasters, e.g. nuclear power plant accidents, accident on oil platforms/chemical plants and dam accidents. In our view the risk-based management principle is rather generally applicable.

The *precautionary* principle is used when there is a rather high degree of uncertainty both with respect to consequence and probability of occurrence. This principle means that extra safety margins are used to account for the high uncertainty with respect to what the ‘real risk’ is. Examples are pollution of the ecological system, the increasing greenhouse effect and some applications of genetic engineering. The precautionary principle will require constant monitoring of the situation, continuous research and the development of substitutes. Limiting the risky activity (in time and space) can reduce the risk. Technical expertise must be developed.

The *discursive* principle implies that decisions are made through a discourse, where you reach an agreement on a discussion without a formal use of risk analyses. The problem is not necessarily scientific uncertainty regarding the risk, but a high degree of ambiguity. So there is a conflict e.g. between the views of the public and the scientific view. What science considers as harmless effects (e.g. electromagnetic fields associated with-high voltage power supply) is by many perceived as threats. So this principle applies when both probability and consequence according to ‘our best knowledge’ is low, but nevertheless the risk creates fear amongst the public. Here risk analysis will not (alone) give the answer, unless the expertise will completely overrule the public by characterising its fear as irrational.

Another example is that many could ignore a wide-ranging damage due to delay effects, (e.g. climate changes loss of biological diversity). So the discursive principle is also recommended in some cases where both consequence and probability are supposed to be high (and risk therefore unacceptable), but the consequences appear in the future (and therefore can be perceived as less ‘real’). Application of the discursive principle will require strategies to promote confidence. The knowledge on the (perceived) risk should be increased. Further, involvement of all affected parties is required to integrate remaining uncertainty and doubt in the political treatment.

The RAS approach is mainly based on use of the risk informed (risk based) management principle. It could however be situations where this is not fully appropriate. If it is found that the ‘precautionary’ or ‘discursive’—principle is relevant for some risks, particular follow-up is required. Further, the suggested approach includes a distinct element of discourse. The points of view of e.g. risk experts, politicians and the public opinion should be taken into consideration when the (ethical) foundation of the approach is laid. The actual risk evaluation should also be based on a thorough discussion involving scientists and lay people, as well as politicians. A fairly transparent and understandable methodology is also needed to avoid specific groups to exercise model power.

4.2. Cost-benefit

Cost/benefit (or cost/efficiency) considerations are indeed relevant in risk management. Such a technique appears for instance as part of the ALARP (As Low As Reasonably Practicable) principle [26], and in the evaluation/prioritisation of risk reducing measures. In a RAS context it would be relevant in at least two respects:

1. Cost/benefit of the risk reducing measures that the enterprises themselves carry out, (possibly being imposed by the regulatory authorities).
2. Cost/benefit of the activities of the regulatory authorities.

In both these two applications, it is assumed that the ‘benefit’ is measured as ‘risk reduction’. This could of course be an issue of great controversy, in particular when we add the ‘benefit’ related to different loss categories to get the total ‘benefit’, i.e. ‘adding apples and oranges’.

In the first application of cost/benefit the question of ‘cost’ is often more straightforward. The ‘cost’ is the expenses required to carry out a risk reducing measure. In the application (2), the ‘costs’ are the expenses related to the work of the regulatory authorities (performing inspections, making regulations, etc).

One might argue that the second application above is the fundamental question in the given RAS context: that is, how should the regulatory authorities prioritise so that the society gets ‘most safety’ for the resources they spend?

However, for several reasons, we believe it is problematic to use cost/benefit-analyses directly on regulatory activities. First, a full formalisation of such a cost/benefit optimisation represents a rather complex process. Second, a lot of the input data will be uncertain and thus the result will lack credibility. It is for instance extremely difficult to come up with a number for the actual benefit (i.e. risk reduction) due to the various regulatory activities. We will not know how the risk level in the society would change if some regulatory activity was increased, reduced or completely dropped. Finally, it will actually be problematic to consider just the cost/benefit *ratio*. Should the authorities reduce a regulatory activity in a specific sector or a specific outlying location, simply because it is costly (and thus less cost-effective)? Such an approach would probably contradict a ‘principle of justice’; i.e. that personnel in all sectors and all geographical locations should be offered the ‘same’ level of safety?

So our conclusion is that both ‘benefit’ and ‘cost’ (in the meaning defined above) are indeed two relevant factors in our context, but an approach based only on the cost/benefit

ratio is too simplistic. Also see e.g. [27] regarding ‘problems’ with a proper use of cost/benefit analyses. Further see e.g. [28–31] on cost-benefit analysis and on the evaluating the cost-effectiveness of regulatory activities.

5. The RAS framework

Based on the previous discussions we now present main elements of the RAS framework. First we comment on the risk assessment. Next some relevant ‘additional criteria’ are presented, and finally, a way to combine these aspects is discussed.

5.1. Risk assessment

Several (11) loss categories were introduced in Section 2 (see Fig. 1). The actual number of loss categories used may depend on the application. Table 1 suggests (or at least indicates) a typical risk measure for each of the 11 suggested

Table 1
Suggestion for ‘loss categories’ and corresponding risk measures

	Loss category	Risk measure	Comments
1	Loss of life, major accidents	Mean number of fatalities per year, (or mean number of Life-years lost)	‘Major accident’ could be defined as an accident with more than five fatalities. Statistics will often give insufficient basis for estimating this risk. Here it is particularly important to utilise risk analyses
2	Loss of life, other accidents	Mean number of fatalities per year, (or mean number of Life-years lost)	Losses due to life long serious disablement should probably be incorporated in this category rather than in loss category 3
3	Acute personnel injury	Mean number of days absent per year due to acute injuries	Prediction of <i>future</i> absence/disablement to be included
4	Chronic disease	Mean number of days absent per year due to chronic diseases	Prediction of <i>future</i> absence to be included
5	Reduced quality of life and reduced functionality	First define categories for quality of life, for instance 1–5, where 5 is the worst condition	The interface with loss category 4 must be clarified
6	Acute pollution on external environment	Weighted value of expected total (acute) spill per year	The amount of spill is weighted with respect to (1) Toxicity of the spill (2) Vulnerability of the environment at the location of the spill
7	Continuous pollution on external environment	Weighted value of expected total (‘continuous’) spill per year	The amount of spill is weighted with respect to (1) Toxicity of the spill (2) Vulnerability of the environment at the location of the spill
8	Material damage	Expected cost per year for repair/replacement of damaged material or repair, etc, due to incidents/accidents	Should restrict to include corrective repair
9	Loss of production	Expected loss (in monetary units) per year as a result of lost/deferred production or reduced quality, due to incidents/accidents	Lost customer relationships due to delayed/no delivery could be included
10	Loss of data/information/knowledge	Expected loss (in monetary units) per year as a result of loss of data/information/knowledge	Must decide whether cost is related e.g. to loss in profit or loss in production. Note: This category should also be concerned with the protection of civil rights (cf data inspectorate); making it much more difficult to define a measure of risk
11	Loss of reputation	Expected yearly reduction in marked shares/profit, due to any undesirable events that cause drop in reputation within the marked/society	Could alternatively consider the reduction due to ‘unfortunate events’ for a well-defined score of the company’s reputation. (It could be most relevant to consider the reduction compared to some ‘optimal value’)

categories. This table also provides some comments and suggestions on possible modifications/refinements of the indicated risk measure. It is seen that several issues have to be addressed in order to arrive at appropriate measures, taking all relevant aspects into account.

Observe that all risk measures are of the form ‘Expected loss *per year*’. The intention is that these measures shall reflect the *total* expected losses, i.e. giving the risk ‘volume’. This is opposed to other commonly used risk measures, as the probability of loss of life *per person* (which can also be relevant). At this stage we ignore questions of discounting. Generally, the approach should not be too sophisticated, but efforts should be made to treat all categories in a similar way.

Note that the suggested approach does not mix the different loss categories into one overall measure of expected loss (risk). Such a mix would certainly give rise to controversies, and it is seen that a lot of relevant information would be ‘lost’ in the subsequent discussion if a merging of loss categories was carried out.

Once the measures of risk are specified, there will be a major task to estimate/predict the risk, based e.g. on risk analyses, historical data and various judgements. The statistical/historical data are relevant to the extent that they provide information on the potential for future losses. At a national level it is required to provide estimates both for the total risk and the risk within the administrative sectors (directorates, regulatory bodies). Table 2 exemplifies how this could be presented for three directorates, A, B, and C.

For each loss category (1–11) an estimate of the total risk (at the national level) is established. As explained, the numbers R_1 – R_{11} give predictions of the ‘risk volume’. These risks are also estimated within the sectors of each directorate, A, B and C; here presented by giving the contribution in percentages for each sector (body). So if it is estimated to occur say 100 fatalities in loss category 1 next year, the Table predicts that 30 of these fatalities will occur in activities within the responsibility of directorate A, etc.

Such an overview of the total risk will be useful for the authorities, and the risk estimates R_1 – R_{11} provide input when the authorities make priorities regarding the 11 loss categories. In a second step when allocation of resources between directorates is considered, the percentages of risk allocated to Directorate A, B and C, respectively should be part of the input.

5.2. Additional criteria for prioritisation and allocation of resources

A risk estimate, as presented in Table 2, will be rather basic for prioritising amongst regulatory tasks and allocation of resources. The idea is that higher risk should indicate a higher need for efforts by the regulatory authorities. However, as previously stressed the ‘calculated risk’ as obtained in such a table does definitely not give a complete set of decision criteria, as there are several other relevant factors to consider.

So, Table 2 can only be part of the input when the authorities prioritise their resources across sectors and loss categories. Therefore, a number of so-called *additional criteria (factors)* are introduced, see Table 3 below. This table is based on (represents a summary of) the previous discussions, but should *not* be seen as a complete or final list. It is rather a checklist for relevant conditions regarding resource planning and allocation of risk control (HES) efforts, and it should be subject to a thorough discussion by the involved parties/authorities, before the final implementation of a RAS approach. The table presents a format for a systematic rationale behind the prioritisations and an overview to justify the decisions.

The first two factors in Table 3 directly relate to the cost/benefit of the activities of regulatory bodies (cf discussion in Section 4.2). In particular factor 1 will be difficult to evaluate and apply in practice. However, some rankings could be possible.

The psychological factors (3) are indeed relevant when it is decided how much resources are to be allocated to handle loss categories 1 and 2 (loss of life). The presence of highly exposed groups (groups with high individual risks) may also require more use of the regulatory authorities’ resources (factor 4).

The degree of transfer of responsibility (factor 5) may depend on e.g. the maturity of the industry; also see Section 3.4.

Some factors are difficult to apply, as ethical considerations may imply conflicts, e.g. see factor 6. Thus, the decision criteria must have an ethical foundation. For instance, are all groups treated in a just way (irrespective of ‘power’ and media focus); or are there ‘forgotten’ groups?

Table 2

Example of total estimated (‘calculated’) risk for different loss categories; also giving a percentage distribution between directorates (regulatory bodies) A, B and C

	Loss categories (1–11)					
	(1) Loss of life, major accident	(2) Loss of life, other accidents	(3) Acute personal injury	(4) Chronic diseases
Predicted risks R_1 – R_{11} →	R_1 (fatalities per year)	R_2 (fatalities per year)	R_3 (days absent per year)	R_4 (days absent per year)
Directorate A	30%	60%	10%	20%		
Directorate B	20%	30%	90%	40%		
Directorate C	50%	10%	0%	40%		

Table 3
‘Additional criteria’ for prioritisation of regulatory activities/resources

	Additional factors/criteria	Comments
1	The ‘benefit’ (reduction of risk) that will be the effect of risk supervision and regulatory activities	Should consider this effect, even if it will be difficult to assess. Possibly some ranking can be carried out regarding which areas where supervision will have the highest effect
2	The ‘cost’ (use of resources) required by the authorities for carrying out supervision/regulatory activities	Relevant when we compare regulatory activities judged to have similar effect. (Cf. discussion in Section 4.2)
3	Psychological/sociological factors, e.g.: (a) the perceived risk by the public, (including the individuals ‘fear for the unknown’) (b) the public’s aversion against major accidents (c) the degree of voluntariness and control of exposed persons	Relevant e.g. when considering the use of resources to control loss category 1. (Cf. discussion in Section 3)
4	Sectors or particular groups exposed to high risk, for instance having a high Fatal Accident Rate (FAR) ^a or Individual risk (IR) ^b	Relevant e.g. for loss category 1: Highly exposed groups might require particular attention by authorities (higher use of resources), even if this is not deemed to give a correspondingly high reduction in risk
5	The scope for transfer/delegation of responsibility to e.g. the company/enterprise	By transfer of responsibility the authorities may reduce the use of resources, or that new type of expertise is brought in
6	The importance for the society of a specific business sector. (Some will claim that a high importance of a sector could imply that a somewhat higher risk could be accepted. On the other hand, in some sectors we have stricter rules and regulations because the sector is important. This is a subject of discussion)	This is an ethical challenge. If this criterion is taken into account, it could be in conflict with a ‘principle of justice’: all groups should be ‘guaranteed’ similar risk (cf. factor 4)
7	Specific sector has particular needs, e.g. due to (a) a new type of suffering/disease has appeared (b) major technological changes have evolved (c) the overall risk picture demonstrates a negative trend (d) certain accident causes is judged to require specific attention (e) industry sector has generally proved ‘immature’ regarding risk handling (f) due to high uncertainties about the actual risk related to a new activity it is deemed necessary to perform an extensive and strict use of the discursive or precautionary principle	The various authorities could extend this list with particular conditions/needs; so this could serve as a ‘safety valve’, covering factors not accounted for elsewhere. See Section 4.1 regarding factor 7f

^a FAR, Mean number of fatalities per 10⁸ working hours.

^b IR, Probability that a specific individual should suffer a fatal accident during one year’s exposure.

Finally, during a process of allocating resources between sectors, the various regulatory bodies will probably come up with various arguments (‘specific needs’) for a higher level of attention within certain sectors. Some arguments of this type are summarised as factor 7 of Table 3.

Note that the additional factors can be evaluated qualitatively. But there is also a possibility to perform a (semi)quantitative evaluation, e.g. by introducing some ranks (scores) to give the current ‘status’ of these in a relevant sector.

5.3. Combining risk assessment and the additional criteria

The introduction of a RAS approach within a ministry, would require that a process be initiated, involving the relevant authorities. It is suggested that an initial phase should be carried out by a working group, were e.g. relevant input data is established and investigated, and were a simplified version of the approach is tested out. The RAS approach could be defined to consist of four steps (Fig. 3):

1. Formulation of the general foundation, e.g. the ethical principles, the loss categories and the additional criteria to be used in the approach.

2. Risk assessment concerning

- Estimates of total risk for each loss category, i.e. risks R_1, R_2, \dots
- Estimates of how the above risks are distributed (in %) amongst the sectors/directorates.
- Assessments of the status of the chosen additional criteria.

3. Allocation of available resources between the loss categories, (1–11).

4. For each loss category, examine the prioritisation of resources between the different regulatory bodies, (say A, B and C).

So in the *first step*, fundamental principles should be formulated and given a more precise meaning; like e.g. a ‘rule of justice’ between various groups in society. Further, the precise measures of risk for each loss category must be formulated, (cf. Table 1). Also this task will include some ethical considerations; e.g. whether the age of the diseased is considered, not just the number of fatalities (cf. loss categories 1 and 2).

A balance between quantitative and qualitative evaluations should be considered. Further, there is a large number of actors (e.g. those directly exposed, having economic

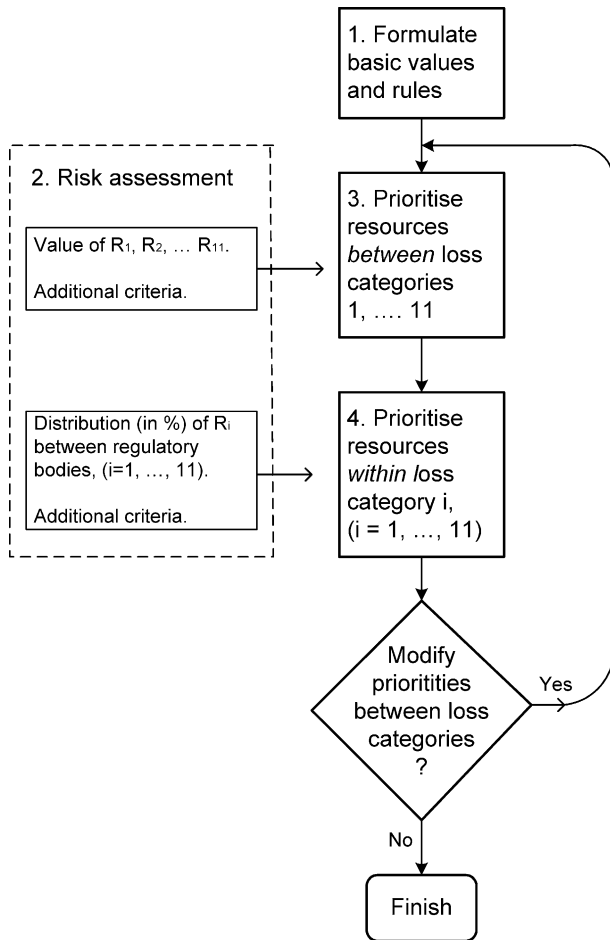


Fig. 3. Illustration of the RAS approach.

interests, authorities, and media). Thus, regarding the ‘fundamental rules’, a relevant task is to identify those who have the power to set the agenda and promote their own interest; (cf. the additional criteria 3, 4, 6).

Step two, risk assessment, can of course represent some very laborious tasks, and at least as a start one must be content with rather rough estimates. Both the ‘total’ risks, R_1, R_2, \dots , within each loss category, and the distribution of these amongst the directorates should be assessed; cf Table 2. Next the value (‘status’) of the chosen additional criteria, cf. Table 3, should be evaluated for the various sectors and loss categories.

In *step three* considerations are required regarding the comparison of ‘apples and oranges’; that is the ‘weighting’ of the risks between the various loss categories. It is not required to *explicitly* specify the value of a ‘statistical life’. However, if we let say

E = Average use of resources per mean number of predicted fatalities, (loss category 2) one could introduce also e.g.

N_1E = Average use of resources per mean number of predicted fatalities in a major accident, (loss category 1).

N_3E = Average use of resources per predicted 100,000 days sick leave, (loss category 3).

Then the decision-makers should contemplate the order of magnitude of parameters like N_1, N_3 , etc. It is important to underline that this is not a purely mathematical exercise, but a political judgement based on ethical considerations.

So in this 3rd step, there is carried out a prioritisation of the resources targeted towards the control of the various loss categories. These considerations are made on a national level, rather independent of the involved directorates. The inputs to this allocation are the estimated risk values R_1, R_2, \dots for the chosen loss categories, together with an overall evaluations of some of the additional criteria.

In *step four* we consider one loss category at a time; and the needs of resources for each directorate within this loss category are investigated. These are based on the distribution in % of the risk values $R_i (i=1,2,\dots)$, provided in Table 2, together with the status of the relevant additional criteria for each directorate.

Note that there should be a possibility of a feedback from step four to the allocation performed in step 3. That is, when the various loss categories have been discussed more thoroughly in step four, it can be decided to modify the allocation of resources *between* the loss categories performed in step three; see Fig. 3.

The additional criteria will in particular play an important role in step four. Observe that not all factors are relevant for all loss categories. These may be described purely qualitatively, or some ‘scores’ may be used.

It is foreseen that the introduction of such an approach will be rather challenging. Thus, it is suggested first to apply a rather simplified version, taking into account only a limited number of additional criteria. Further, in a first application, the objective should probably not be to arrive at a fixed allocation of resources, but rather to provide input to a further discussion regarding basic priority settings. Then one may primarily aim at presenting clearly as possible the premises for the allocation without calculating the ‘correct’ allocation.

6. Discussion and conclusions

This article suggests the framework of an approach to support planning, prioritisations and the formulation of national ambitions regarding risk. It is denoted Risk Across Sectors (RAS), and the main application discussed here is the prioritisation of resources to control/reduce risk, which has to be carried out by government/regulatory authorities. It is suggested to use a wide definition of *risk*.

It is obviously not a simple task to perform overall planning and prioritisations to control risk. Nevertheless, resources must be allocated, and choices and prioritisations must be carried out. To use such a principle first of all means making the choices more explicit than what is done today.

Further, the foundation of the decisions will be better documented and can be tested/re-examined. This is in itself valuable in an open and democratic society, and lay a foundation for communicating the choices.

Involved parties should first of all agree on a common specification of the risk concept, including definition of ‘loss categories’. The main elements of the RAC approach are represented by the estimation of the total ‘risk volume’ of the ‘calculated risk’, see Table 2; together with the evaluation of other factors (‘additional criteria’), see Table 3. This framework gives a natural starting point for the planning, and gives the basis for a discussion between involved parties. And in total this provides a broad evaluation of the risk.

So it is not recommended to reduce the risk to one single measure, (i.e. incorporating all aspects of risk in a single mathematical formula). Similarly, it is not recommended that the RAS principle be based on a pure cost/benefit evaluation. However, both *cost* and *benefit* (of regulatory activity) could, together with other additional criteria, be utilised in the prioritisations.

Generally, openness about risk is important and there should also be participation and ownership to decisions. So even if the decision process is ‘risk informed’, the implementation of a RAS principle incorporates a distinct element of discourse.

Several ethical considerations are required as a basis for the approach. The problem of justice to all groups (e.g. highly exposed ones), the efforts towards various types of risk (e.g. ‘value of life’ versus material loss), prioritisation of children, major accidents are some relevant topics.

An implementation of the RAS approach will provide increased knowledge and competence concerning the status and trends of the risk level in different sectors. The whole process is intended to increase the awareness of essential factors for the efficiency of regulatory activities and risk reduction. Thus, it should contribute to a more efficient use of resources.

Obviously, the indicated approach can be rather resource demanding, as apparently it accounts for virtually ‘all’ relevant factors. In practice this may be rather impossible to carry out, and the complexity could be drastically reduced. The point is that an overview of ‘all’ the factors are given to the decisions makers, so that they are better informed and can choose the most relevant factors for their priority settings. It is our opinion that the method outlined here should be developed further and given a more definite content through a discursive process with the involved parties.

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