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# Open Risk Assessment

A New Way of Providing Scientific Information  
for Decision-making

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## OPEN RISK ASSESSMENT

A new way of providing scientific information for decision-making

Kansanterveyslaitos  
Ympäristöterveyden osasto  
Ympäristöterveyden riskianalyysin tutkimusyksikkö

KTL-National Public Health Institute, Finland  
Department of Environmental Health  
Centre for Environmental Health Risk Analysis

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## Open Risk Assessment

### A new way of providing scientific information for decision-making

by Jouni T. Tuomisto and Mikko Pohjola (wiki editors)

with the help of the Risk research group (KTL) and the Intarese project

This document is a preliminary description of the idea of open risk assessment. It has been written as a wiki project using open participation within the project. The printed version is a direct compilation of the contents of the wiki pages, and some features would function better as hypertext rather than printed pages. In addition, the content is under active development, and substantive changes to the contents of this document are expected to occur within days after the document is printed. Therefore, we encourage you to refer to the online version as soon as it becomes available to you. Internal copies will be distributed within Beneris ([http://www.pyrkilo.fi/beneris/index.php?title=Image:Open\\_risk\\_assessment.pdf](http://www.pyrkilo.fi/beneris/index.php?title=Image:Open_risk_assessment.pdf)) and Intarese ([http://www.pyrkilo.fi/intarese/index.php?title=Help:Pyrkilo\\_guide\\_2](http://www.pyrkilo.fi/intarese/index.php?title=Help:Pyrkilo_guide_2)) projects, but the open access version will occur also at Heande ([http://www.pyrkilo.fi/heande/index.php?title=Image:Open\\_risk\\_assessment.pdf](http://www.pyrkilo.fi/heande/index.php?title=Image:Open_risk_assessment.pdf)) hopefully in the near future. You may also locate the document by searching the unified resource name from the Internet: URN:NBN:fi-fe20071905

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## Summary: Pyrkilo organises information and values using open participation

- **Pyrkilo theory** is a theory that attempts to answer the following research question:  
**How can scientific information and value judgements be organised for improving societal decision-making in a situation where open participation is allowed?**
- **Pyrkilo method** is a method that applies the contents of the pyrkilo theory in practical risk assessments.
- **Open risk assessment** is a risk assessment (covering both the process of making it, and the final product) that has been carried out utilising the pyrkilo method.

Pyrkilo as a method differs from other risk assessment methods in three essential aspects:

1. The risk assessment product IS a **causal diagram** where all elements are described as **variables** using a specified structure. This sets structural limits to the contributions.
2. **Formal argumentation** (according to the pragma-dialectical argumentation theory) is used as the primary means to describe and resolve any disputes about scientific or valuation issues within the assessment.
3. The principles of **mass collaboration** are used in the risk assessment work. In practice, anyone is allowed to contribute (i.e. bring in information and value judgements that are within the scope of the assessment), unless there are explicitly specified reasons to restrict participation in the particular case.

Pyrkilo method approaches risk assessment as interpretation and combination of scientific information and value judgments for use of the society. Risk assessment is thus an activity that takes place in the interface between science and society. Risk assessment consists of a process of making it, and the resulting product. The product (risk assessment report) consists basically of the question(s) to be asked, the causal diagram about the risk situation, and the results and conclusions based on the causal diagram.

**The purpose of a risk assessment** is to improve societal decision-making in a particular risk situation.

- ← The assessment should provide relevant information about the risk situation in a quantitative form.
  - ← In general, **the information provided is about predictions on the impacts of possible decisions on some outcomes that have a societal value** .

It is possible to define the **general properties of good risk assessments** according to the following three different categories:

- Quality of assessment product content
- Applicability of the assessment product



- Efficiency of the assessment process

**Quality of content** refers to the goodness of the description of reality that is produced in the assessment. It consists of the properties called informativeness, calibration and internal relevance.

**Applicability** consists of the properties called external relevance, usability, availability and acceptability. Acceptability can be further defined as acceptability of premises and acceptability of the assessment process. The applicability properties become realized in the use of risk assessment product.

**Efficiency** can be divided into two properties, intra-assessment efficiency and inter-assessment efficiency. The previous refers to efficiency of the process within a single assessment and the latter to efficiency of the process in making a series of assessments.

The **assessment product**, a causal diagram, consists of variables, which are descriptions of particular pieces of reality. It should be noticed that, according to the principle of open risk assessment, the variables are NOT owned by any single risk assessment, but they can be freely used in any risk assessment where they are relevant. Because of this, there is a special need to describe variables in a way that they are self-explanatory and self-calculable (as long as the upstream variables are known in the causal chain).

Variables can be used for describing several kinds of things, e.g. physical phenomena, value judgments and decisions. All kinds of variables are defined using the following attribute structure described in the table below:

Attribute	Question to be answered	Comments
<b>Name</b>	What is the name of the variable?	Two variables must not have identical names.
<b>Scope</b>	What is the question to which the variable answers?	This includes a verbal definition of the spatial, temporal, and other limits (system boundaries) of the variable.
<b>Unit</b>	What is the unit of measurement?	
<b>Definition</b>	How can you derive or calculate the answer?	The definition uses algebra or other explicit methods if possible. It also contains all such links from other variables that are necessary to define the variable.
<b>Result</b>	What is the answer to the question defined in the scope?	If possible, a numerical expression or distribution.

The **process of carrying out a risk assessment** can be considered as consisting of four simultaneously on-going sub-processes that are continuous throughout the whole risk assessment:

1. Collection of scientific information and value judgements
2. Synthesis and manipulation of scientific information and value judgements
3. Communication of the outcomes of collection and synthesis
4. Management of collection, synthesis and communication sub-processes

The assessment process progresses from defining the assessment questions to providing sufficiently complete answers in iterative phases as follows:

1. **Scoping** of the assessment: Defining the purpose, question(s), intended use, boundaries, and the participatory width of the process.
2. **Applying** previously created readily available information about the issues being assessed.
3. **Drawing** a causal diagram including decisions, outcomes, indicators and other variables.
4. **Designing** variables: Defining the attribute contents for individual variables.
5. **Executing** variables and analyses: Collecting the data needed, executing the models, defining the results of variable and making assessment-specific analyses.
6. **Reporting** the assessment: Communicating the results and conclusions to the users.

The phases 1-3 are collectively called **the issue framing phase** .

**Open risk assessments** are challenging things to accomplish. Even a single-user work on risk assessments is complex. When a non-restricted group of people is allowed to participate, there are specific technical problems to manage the process, not to mention the contents. Therefore, tools have been developed to facilitate open risk assessments.

Necessary parts of an open risk assessment system are:

- Process management system
- Content management system
- Collaborative workspace

**The process management system** gives guidance for the work and offers tools to make risk assessments, collect information, and manage the contents.

**The content management system** contains information and data about environmental health issues and risks. The products of risk assessments (assessment reports and variables) are located here.

**Collaborative workspace** is a virtual working platform that allows open groups to participate in risk assessments. It is an interface for the users to access the system contents, make their contributions to the assessment and communicate between each other.

Key words: open risk assessment, pyrkiilo, environmental health, stakeholder participation, argumentation, mass collaboration, societal decision-making

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Tiivistelmä: Pyrkilö jäsentää tietoa ja arvoja avoimen osallistumisen avulla

- **Pyrkilö-teoria** on teoria, joka pyrkii vastaamaan tähän tutkimuskysymykseen:  
**Kuinka tieteellistä tietoa ja arvoarvostelmia voi jäsentää yhteiskunnallisen päätöksenteon tueksi tilanteessa, jossa avoin osallistuminen on sallittu?**
- **Pyrkilö-menetelmä** on menetelmä, joka soveltaa pyrkilö-teoriaa käytännön riskinarvioinneissa.
- **Avoin riskinarviointi** on riskinarviointi (kattaen sekä valmistusprosessin että lopullisen tuotoksen), joka on toteutettu käyttäen pyrkilö-menetelmää.

Pyrkilö-menetelmä poikkeaa muista riskinarviointimenetelmistä kolmessa olennaisessa suhteessa:

1. Riskinarvioinnin tuotos ON **syy-seurauskaavio**, jossa kaikki osat on kuvattu **muuttujina** käyttäen tiettyä muuttujarakennetta. Tämä pakottaa osallistumisen noudattamaan määriteltyä rakennetta.
2. **Muodollista väittelyä** (pragma-dialektisen väittelyteorian mukaisesti) käytetään ensisijaisena menetelmänä kuvaamaan ja ratkomaan ristiriitoja ja erimielisyyksiä riskinarvioinnissa. Tämä koskee niin tieteellistä tietoa kuin arvoarvostelmiakin.
3. **Joukkoyhteistyön** periaatteita käytetään riskinarviointityössä. Käytännössä kaikki saavat mahdollisuuden osallistua, ellei ole nimenomaisia, ääneen lausuttuja syitä rajoittaa osallistumista kyseisessä tapauksessa. Osallistuminen tarkoittaa omien tietojen ja arvojen mukaantuomista arviointiin siltä osin, kuin ne ovat arvioinnin rajauksen puitteissa.

Pyrkilö-menetelmä tarkastelee riskinarviointia tieteellisen tiedon ja arvoarvostelmien tulkintana yhteiskunnan hyödyksi. Tavoitteena on yhteiskunnallisen päätöksenteon tukeminen. Riskinarviointi on siis tieteen ja yhteiskunnan rajapinnassa tapahtuvaa toimintaa. Riskinarviointi koostuu arviointiprosessista ja prosessin synnyttämästä tuotoksesta. Tuotos eli riskinarviointiraportti sisältää esitetyt päätöksentekoa palvelevat kysymykset, syy-seurauskaavion tarkasteltavasta riskitilanteesta ja tulokset ja päätelmät perustuen syy-seurauskaavioon.

**Riskinarvioinnin tarkoitus** on parantaa yhteiskunnallista päätöksentekoa tietyssä riskitilanteessa.

← Niinpä arvioinnin pitäisi tarjota merkityksellistä tietoa riskitilanteesta määrällisessä (kvantitatiivisessa) muodossa.

← Yleensä **riskinarvioinnin tarjoama tieto on ennusteita harkittavien päätösvaihtojen semmoisista seurauksista, joilla on yhteiskunnallista merkitystä**.

On mahdollista määritellä **hyville riskinarvioinneille tyypillisiä ominaisuuksia**. Nämä ominaisuudet voidaan jakaa kolmeen luokkaan:

- Riskinarvioinnin tuotoksen sisällön laatu
- Riskinarvioinnin tuotoksen käyttökelpoisuus

■ Arviointiprosessin tehokkuus

**Sisällön laatu** tarkoittaa sitä, kuinka hyvin se kuvaa todellisuutta arvioinnin rajauksen puitteissa. Laatu koostuu kolmesta ominaisuudesta: tietopitoisuus (informatiivisuus), tarkkuus (kalibraatio) ja merkityksellisyys rajauksen puitteissa (sisäinen relevanssi).

**Käyttökelpoisuus** koostuu ominaisuuksista nimeltä ulkoinen merkityksellisyys (relevanssi), käytettävyys, saavutettavuus ja hyväksyttävyyys. Hyväksyttävyyys jakautuu edelleen lähtöoletusten ja prosessin hyväksyttävyyteen. Käyttökelpoisuuden hyvyys tai huonous näkyy siinä, miten riskinarvioinnin tuotosta käytetään.

**Tehokkuus** voidaan jakaa kahteen ominaisuuteen: arvioinnin sisäiseen ja ulkoiseen tehokkuuteen eli tarvittavien resurssien määrään tuotoksen tekemiseksi. Sisäinen viittaa yhden arviointiprosessin tehokkuuteen, ulkoinen taas suuremman arviointiprosessien joukon tekemisen tehokkuuteen.

**Riskinarvioinnin keskeinen tuotos**, syy-seurauskaavio, koostuu muuttujista. Ne ovat kuvauksia jostakin määrittelystä todellisuuden osasta. On syytä huomata, että avoimen riskinarvioinnin periaatteiden mukaan muuttujia EI omista mikään yksittäinen riskinarviointi. Päinvastoin, yhtä muuttujaa voi vapaasti käyttää kaikissa riskinarvioinneissa, joissa se on asiaankuuluva. Tämän takia on erityisen tärkeää kuvata muuttujat niin, että ne ovat itsensä selittäviä ja itsenäisesti laskettavissa (kunhan syy-seurauskaavion ylävirrassa olevat muuttujat tunnetaan).

Muuttujia käytetään kuvaamaan monenlaisia asioita, kuten fysikaalisia ilmiöitä, arvoarvostelmia ja päätöstilanteita. Kaikki muuttujat määritellään käyttäen samaa attribuuttirakennetta, joka on kuvattu taulussa.

Attribuutti	Kysymys, johon vastataan	Huomautuksia
<b>Nimi</b>	Mikä on muuttujan nimi?	Kahdella muuttujalla ei saa olla samaa nimeä.
<b>Rajaus</b>	Mikä on se kysymys, johon muuttuja vastaa?	Tämä sisältää sanallisen määrittelyn ajallisista, paikallisista ja muista muuttujan rajoista (systeemin rajat).
<b>Yksikkö</b>	Missä mittayksikössä tulos ilmoitetaan?	
<b>Määritelmä</b>	Kuinka tulos voidaan johtaa tai laskea?	Määritelmä käyttää laskentakaavoja ja muita täsmällisiä ja aukikirjoitettuja menetelmiä aina, kun se on mahdollista. Se sisältää myös linkit muuttujiin, joita tarvitaan tämän muuttujan määrittelyyn.
<b>Tulos</b>	Mikä on vastaus rajauksessa esitettyyn kysymykseen?	Ilmoitettava numerona tai jakaamana, jos mahdollista.

**Riskinarvioinnin toteuttaminen** sisältää neljä yhtäaikaista aliprosessia, jotka jatkuvat koko riskinarvioinnin ajan:

1. Tieteellisen tiedon ja arvoarvostelmien kerääminen
2. Tieteellisen tiedon ja arvoarvostelmien jäsentäminen ja käsittely
3. Keräämisen ja jäsentämisen tuotoksista viestittäminen
4. Keräämisen, jäsentämisen, ja viestittämisen aliprosessien hallinta

Arviointiprosessi etenee arviointikysymysten määrittelystä riittävän kattavien vastausten antamiseen seuraavissa iteratiivisissa vaiheissa:

1. Arvioinnin **rajauksen määrittely** : Tarkoituksen, kysymysten, käyttökohteen, rajausten ja osallistumisen laajuuden määrittely
2. Aiemmin tuotetun arviointiin liittyvän informaation **soveltaminen**
3. Päätökset, lopputulemat, indikaattorit ja muut muuttujat sisältävän syy-seurauskaavion **piirtäminen**
4. Muuttujien **suunnittelu** : Yksittäisten muuttujien attribuuttien määrittäminen
5. Muuttujien ja analyysien **suorittaminen** : Tarvittavan datan keruu, mallien ajaminen, tulosattribuuttien määrittäminen ja arviointikohtaisten analyysien toteuttaminen.
6. Arvioinnin **raportointi** : Tulosten ja johtopäätösten viestittäminen käyttäjille.

**Avointen riskinarviointien** toteuttaminen on haasteellinen tehtävä. Jo yhden ihmisen tekemä arviointityö on monimutkaista. Kun sallitaan rajoittamattoman ryhmän osallistuminen arviointityöhön, ilmenee monia teknisiä prosessin hallinnan ongelmia, puhummattakaan sisällön hallinnasta. Tämän vuoksi avointen riskinarviointien tueksi on kehitetty työkaluja.

Avoimen riskinarvioinnin järjestelmän oleelliset osat ovat:

- Prosessin hallinnan järjestelmä
- Sisällön hallinnan järjestelmä
- Yhteistyöskentelytila

**Prosessin hallinnan järjestelmä** tarjoaa opastusta sekä työkaluja riskinarvioinnin toteuttamiseen, tiedon keruuseen ja sisällön hallintaan.

**Sisällön hallinnan järjestelmä** sisältää informaatiota ja dataa ympäristöterveyteen liittyvistä asioista ja riskeistä. Arviointituotteet (raportit ja muuttujat) tallennetaan tähän järjestelmään.

**Yhteistyöskentelytila** on virtuaalinen työskentelyalusta, joka sallii avointen ryhmien osallistua riskinarviointeihin. Se toimii rajapintana, jonka kautta käyttäjät pääsevät käsiksi järjestelmän sisältöön, toteuttavat kontribuutionsa arviointeihin ja viestivät toisilleen.

**Asiasanat:** avoin riskinarviointi, pyrkilö, ympäristöterveys, sidosryhmät, osallistuminen, väittely, joukkoyhteistyö, yhteiskunnallinen päätöksenteko.

# Anyone can participate in an open risk assessment

## A new theory of risk assessment

The current definition of *pyrkilo* is the following:

**Pyrkilo theory** is a theory that attempts to answer the following research question: **How can scientific information and value judgements be organised for improving societal decision-making in a situation where open participation is allowed?**

**Pyrkilo method** is a method that applies the contents of the pyrkilo theory in practical risk assessments.

**Open risk assessment** is a risk assessment (covering both the process of making it, and the final product) that has been carried out utilising the pyrkilo method.

Some of the terms used are (tentatively) defined below.

- Scientific information = information that can be obtained by using the scientific method [1]
- Value judgement = preference or value a person or a group assigns to a particular condition or state of the world
- Societal decision-making = process of reaching conclusion about actions that can be taken by the institutes of the society, or the members of the society in general, in aim to increase societal values
- Societal values = value judgements that are so widely accepted in the society that they can be thought of representing a large part (not necessarily majority) of the members of the society
- Improving decision-making = practices that, on average, lead to decision-making that, on average, leads to outcomes with higher societal values than an alternative practice
- Open participation = a process where a non-organised, non-fixed, non-restricted group of individuals can get information from and contribute to the outcome of the process (in this context, a risk assessment report).

Pyrkilo is currently most actively used in the field of risk assessment. Pyrkilo as a method differs from the other risk assessment methods in three essential aspects:

1. The risk assessment product IS a **causal diagram** where all elements are described as **variables** using a specified structure. This sets structural limits to the contributions. In traditional risk assessments, the assessment product typically is a report using a structure of a book, not that of a causal diagram. The causal diagrams are used for illustration only, or within models that calculate some results to the assessment report.
2. **Formal argumentation** (according to the pragma-dialectical argumentation theory) is used as the primary means to describe and resolve any disputes about scientific or valuation issues within the assessment. In traditional risk assessments, there is guidance to describe major disputes, but there are no structural rules for this. In addition, many disputes are (implicitly) resolved using conventions without challenging the foundations of the convention.
3. The principles of **mass collaboration** are used in the risk assessment work. In practice, anyone is allowed to contribute (i.e. bring in information and value judgements that are

within the scope of the assessment), unless there are explicitly specified reasons to restrict participation in the particular case. The traditional risk assessments are expert-driven exercises with possibly some public hearings about the scoping or results, but little involvement of the stakeholders to the actual making of the assessment.

## References

1. ↑ Popper, Karl R. 1935. Logik der Forschung. Julius Springer Verlag.

**Dispute** is a difference in opinion about a state of the world, or the preferability of a state of the world.

When a diverse group of contributors participate in making a risk assessment, it is obvious that disputes may arise. One of the most instructive features of risk assessment is to understand both these disputes and the reasons why a particular outcome occurs. The risk assessment method must include guidance to deal with disputes, find resolutions and document the choices made so that they can be defended afterwards. Argumentation theory offers a basis for these methods.

Formal argumentation (according to the pragma-dialectical argumentation theory [2]) is used as the primary means to describe and resolve any disputes about scientific or valuation issues within the assessment. In traditional risk assessments, there is guidance to describe major disputes, but there are no structural rules for this. In addition, many disputes are (implicitly) resolved using conventions without challenging the foundations of the convention. The new method attempts to achieve more in dealing with disputes.

Van Eemeren and Grootendorst have operationalised the dispute resolving problem in the following way: "When should I, as a rational critic who judges reasonably, regard an argument as acceptable?" [3]. Their answer is, very briefly, that disputes are solved using formal argumentation. The proponent and opponent of a statement can give arguments supporting their own statement (or other arguments) or attacking the other discussant's statement or arguments. There are certain criteria that each argument must fulfil, such as rationality and relevance. The dispute is resolved when one discussant is able to base his/her argumentation on arguments that both discussants agree on.

The **structure of a discussion** has three parts:

- Dispute (what are the conflicting statements?)
- Argumentation (a hierarchical thread of arguments related to the statements)
- Outcome (the statements that remain valid after the discussion)

**Possible arguments** include

- **-#1: an attack against another argument (or statement)** –Jouni 14:30, 31 August 2007 (EEST)
- **-#2: a defence of an argument** –Jouni 14:30, 31 August 2007 (EEST)
- **-#3: a comment** –Jouni 14:30, 31 August 2007 (EEST)

An argument must always be signed. Otherwise, it is not valid.

## An example of a resolved dispute

### Can the collaborative workspace calculate?

**Dispute:** It is possible to calculate variable results in the collaborative workspace.

**Outcome:** Accepted.

#### Argumentation:

←#1: not part of scoping (and not very feasible either I think...)—Anne.knol 16:45, 15 March 2007 (EET)

←#3: At least some (simple) common calculation methods that nearly everyone uses might be provided. If they are provided directly in the scoping diagram (by clicking on the variables) or not may be decided later. —Alexandra Kuhn 10:20, 19 March 2007 (EET)

←#2: It is not directly a part of the scoping, but it puts demands on the scoping tool if this should be possible to do. As for the feasibility I dont know, but KTL are already doing something like this with the wikimedia <-> analytica tool —Sjur 12:04, 16 March 2007 (EET)

## Theoretical background

The theoretical background referred to here is the pragma-dialectical approach to argumentation theory, also known as the Amsterdam school of argumentation, developed by Frans van Eemeren and Rob Grootendorst from the University of Amsterdam. Only the main aspects of the theory in this scope are presented here and a more detailed and thorough representation of the theory can be found from e.g. van Eemeren, Grootendorst, Henkemans: Argumentation - Analysis, Evaluation, Presentation. Lawrence Erlbaum Associates Inc., 2002. The view presented here (as well as pragma-dialectics itself) also builds on critical rationalism as philosophical basis.

Traditionally the main objective of the pragma-dialectical approach is to resolve a difference of opinion by means of argumentative discourse. Critical rationalism in practice means that there are no absolute truths, so everything can be questioned and standpoints are always accepted only as temporarily and they can be discarded or changed if better/improved ones are found.

Pragma-dialectical argumentation can also be seen as a means for knowledge production, i.e. to bridge the gap between current knowledge base and the needed knowledge e.g. within a group. From the point of view of environmental health risk assessment, this is probably the most useful aspect of using argumentation in risk assessments. Arguing for and against is used as a means to explore the validity, acceptability and correctness of the central standpoints/statements in focus. Accordingly the standpoints/statements are refined, reformulated, discarded etc. as appears necessary along the argumentative discourse.

The pragma-dialectical argumentation theory presents an ideal case that always differs from real live implications of argumentation. Nevertheless the theory can well be used in making the argumentation schemes and especially the strengths/weaknesses of argumentation explicit. It thus offers a way of improving the analysis and evaluation of real-life argumentation and improves argumentative presentation. It does not however guarantee exact definite results, but is always situation and context specific and easily affected by the view taken by the analyst/evaluator/presenter.



## Basic building blocks of argumentation

The essential terminology in relation to our uses of the theory that requires some explanation is explained here.

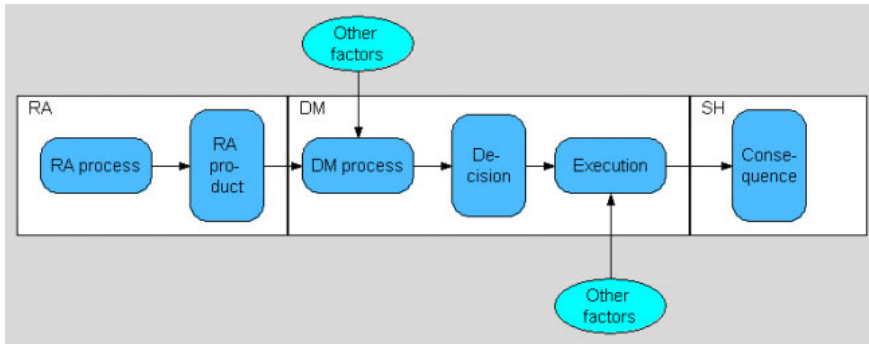
- *Protagonist*. The party that expresses a standpoint and is ready to defend that standpoint with arguments. The protagonist bears the burden of proof, i.e. is obliged to defend his/her standpoint by argument(s) in order to have his/her standpoint accepted.
- *Antagonist*. The party that expresses doubts and/or counterarguments on the standpoint expressed by the protagonist. Note that the antagonist does not need to express an opposing standpoint to question the protagonist's standpoint, also expressing a doubt towards it is enough.
- *Standpoint*. A statement expressed by the protagonist, representing his/her view on some matter. Standpoint is the focal point of an argumentative discussion. Standpoints can be positive or negative and defending them means to justify or refute the standpoint respectively.
- *Argument*. A defensive or attacking expression in relation to the standpoint or another argument. Defensive arguments are expressed by the protagonist(s) and attacking arguments are expressed by the antagonist(s).
- *Premise*. Assumption presumed true within the argumentative discourse at hand. Premises form the basis and the background of the discourse. Can be explicit or left implicit, but those premises that are likely to be perceived differently by the protagonist and the antagonist should be made explicit and agreed on before starting an argumentation.

## References

1. ↑ Popper, Karl R. 1935. *Logik der Forschung*. Julius Springer Verlag.
2. ↑ van Eemeren, F. H. & Grootendorst, R. 2004. *A systematic theory of argumentation*. Cambridge: Cambridge University Press.
3. ↑ van Eemeren, F. H. & Grootendorst, R. 2004. *A systematic theory of argumentation*. Cambridge: Cambridge University Press.

## Risk assessments take place in the interface between science and society

It is important to consider and understand the **role of risk assessment in its societal context** and to identify the relations of risk assessment with its surrounding reality. The following diagram shows a roughly simplified description of the role and relations of risk assessment in the overall process of societal decision making from the risk assessor's point of view. The diagram is described briefly below.



The risk assessment process (horizontal oval) produces a risk assessment product (vertical oval) as its output with the intention of feeding it as an input to the decision-making process. The decision-making process then produces a decision, presumably using the risk assessment product as an input alongside other inputs. The decision is then executed leading to specific consequences within the society. The white boxes on the background depict the primary areas of interest and influence of risk assessors (RA), decision-makers (DM) and stakeholders (SH). The *other factors* nodes refer to all the other influences to the processes along the chain that are primarily out of reach of the influence of the risk assessors and thus may either support or compromise the effectiveness of the risk assessment outputs. The arrows in this diagram describe causal relations.

The diagram above can be considered as distinguishing the groups of actors along the chain and their roles in a relatively traditional way. The risk assessors (RA) could also be replaced with a more general group called *the contributors to risk assessment* and the distinction between the decision-maker and stakeholder groups can be considered as artificial. The new approaches to risk assessment blur the lines between the roles of these different groups making more or less everyone a stakeholder and also a potential contributor to risk assessment. These views are considered in more detail in mass collaboration in risk assessment and Help:Managing stakeholder involvement. However, the above diagram represents the currently existing reality and the common perceptions of risk assessment and societal decision making relatively well.

The assessment product is the center of attention when considering risk assessment. It is the manifestation of the assessment process that produces it. Ultimately it is, however, the process of using the risk assessment product and the intended or expected consequences of that, which set the requirements for what the assessment product should be like and how it is to be produced. In other words: the intended use purpose defines the assessment product, which then defines the process of producing it.

Since, normally the risk assessors, or more generally the contributors to risk assessment, can only have direct influence to the assessment product and the process of producing it, but it is anyhow the use process that set the requirements for them, risk assessments can not be carried out in isolation from the societal decision-making. Instead, risk assessment should be seen as interpretation of scientific information for the use of the society. Risk assessment is thus an activity that takes place in the interface between science and society.

In order to be able to address this issue properly it is reasonable to consider the sphere of risk assessments to cover three different individual, but inter-related parts:

- risk assessment process
- risk assessment product
- use process(es), *relating roughly to everything from decision-making process onwards*

Risk assessment process is about *collecting* scientific information and values from various different kinds of sources and *synthesizing* them into the form of a risk assessment product. Risk assessment product is a *description* of a particular piece of *reality* produced according to the needs it is intended to address. These needs are derived from the use process and *translated* into the purpose and scope and other structural requirements for the assessment product.

## Risk assessment is always done for purpose

**The purpose of a risk assessment** is to improve societal decision-making in a particular risk situation.

- ← The assessment should provide relevant information about the risk situation in a quantitative form.
  - ← In general, **the information provided is about predictions on the impacts of possible decisions on some outcomes that have a societal value** . However, the scope of the information can be narrowed in a particular case e.g. in the following ways:
    - The only decision considered is business-as-usual. This results in estimates of the burden of the current situation.
    - Outcomes considered are not explicitly valued, but implicitly it is assumed that they relate to something that has intrinsic value. For example, pollutant concentrations can be estimated, although it is the related health impact that has the intrinsic value.

Risk assessments should always be done for a purpose. When the purpose is identified and kept clear in mind and preferably explicated and made public, it helps to guide the process in producing a desired kind of assessment product. The ultimate general purpose is to improve societal decision making by providing good descriptions of chosen parts of reality for the use of the decision-makers. The process of describing the purpose is now considered as an essential and integral part of the method. Proper identification of the purpose of risk assessment crucially affects the assessment process and the content and essence of the final product. For further details, see General properties of good risk assessments.

It is probably relatively easy for most people to agree that the ultimate underlying goal, or in other words general purpose, of risk assessments should be good societal decisions. This means that a risk assessment should always be designed and carried out in an attempt to progress towards this goal. For each particular risk assessment the situation is naturally different and thus the outputs and outcomes of each assessment are and should always be case-specific and in accordance with the setting of the particular case. The ultimate purpose should still be kept clear in mind when planning or carrying out as well as evaluating an assessment or using its outputs. It is thus highly recommended that the purpose of each risk assessment is identified and defined explicitly already in the early phases of the process and also made public if applicable.

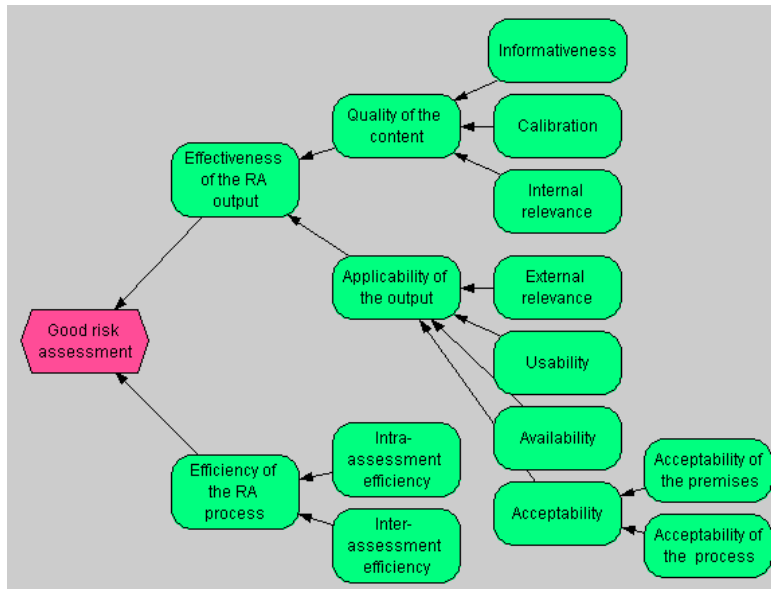
## Good risk assessments share certain properties

It is possible to describe the **general properties of good risk assessments** . They are based on considerations about the general purpose of risk assessments and the relations of risk assessments with their societal context. The general properties can be used as the general performance criteria for evaluating risk assessments. These properties also have certain implications to the methodological requirements when striving for good risk assessments.

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The diagram below illustrates the general properties of good risk assessments as a tree

structure. The goal, good risk assessment, is the node on the left of the diagram and the required properties to achieve this goal are then defined and divided moving towards right in the diagram. It is important to notice that the arrows in this diagram describe how particular properties lead to the ultimate objective.



The general properties of good risk assessments consist of three different categories:

- Quality of assessment product content
- Applicability of assessment product
- Efficiency of assessment process

The first two, quality of content and applicability of output together form *effectiveness of assessment product*, so the properties of good risk assessments overall cover both the effectiveness and the efficiency of risk assessment. The effectiveness here means the potential of the assessment to have intended influence on the decision-making processes where the risk assessment outputs are used. Effectiveness thus also indicates the potential of advancing towards the general ultimate goal of risk assessment, improved societal decisions. The effectiveness properties can further be divided into two categories, quality of content and applicability. The categories and the properties belonging to both effectiveness and efficiency are describes in more detail below. **RU RU**

**Quality of content** refers to the goodness of the description that is produced in the assessment in describing reality. It consists of the properties called informativeness, calibration and internal relevance.

**Informativeness** is the *tightness of spread* in a distribution (All results estimates of variables should be considered as distribution estimates, not point estimates). The tighter the spread, the smaller the variance and the better the informativeness. Informativeness is a property of each individual variable, but the informativeness of each variable is also affected by the informativeness of the variables *upstream* in the causal chain.

**Calibration** means the *correctness* of the result estimate of a variable, i.e. how close it is to the *real* phenomenon it describes. Evaluating calibration can be complicated in many situations, but it is necessary to realize it as an important property, while evaluating the goodness of result estimates of an assessment.

**Internal relevance** can be described as the coherence of the assessment, i.e. does the description include the necessary variables and their inter-relations to describe the whole assessed issue sufficiently in relation to the endpoints of the assessment.

**Applicability** refers to the potential of transferring the content of the assessment to those who are intended to use it or who are affected by the use of it (decision-makers and other stakeholders, respectively). Applicability consists of the properties called external relevance, usability, availability and acceptability. Acceptability can be further defined as acceptability of premises and acceptability of the assessment process. Whereas the properties related to quality of content can often be evaluated more or less objectively, properties related to applicability are evaluated subjectively by different actors, based on their role in the societal context of risk assessment.

**External relevance** can be described as the comprehensiveness of the assessment, i.e. does the description include and address the right phenomena in relation to the (use)purpose of the assessment. **RU**

**Usability** refers to issues that affect the understanding of the content. These are such as e.g. clarity of presentation, language used etc. Usability is strongly influenced also by the capabilities and other properties of the users and is often not fully controllable by the ones who produce the description. Usability can anyhow be improved especially if the use purpose of the assessment is understood and the *intended users and uses* are identified and defined.

**Availability** refers to the openness of access of the intended users to use the product in relation to their needs. The openness is related to issues such as e.g. chosen media of the description, spatial and temporal accessibility and restrictions of access to parts of description content.

**Acceptability** is especially strongly influenced by the role of *the acceptor* in relation to the assessment process. E.g. the risk assessor community evaluates their acceptance primarily in relation to the quality of the content of the assessment product, the decision-makers evaluate their acceptance primarily in relation to their information needs for decision-making and stakeholders are primarily concerned about the consequences of the decisions and their executions. Different actors may of course represent different groups simultaneously or take different points of view into the issue. This blurring of roles is considered more in mass collaboration in risk assessment and managing stakeholder involvement. Acceptability from all different perspectives can be divided into **acceptability of the premises** used in making the assessment and **acceptability of the assessment process** .

Whereas the properties related to effectiveness are primarily related to the output of the assessment, **Efficiency** is a property of the assessment process. Basically efficiency can be described as the goodness of the output in relation to the efforts spent in producing the output.

**Intra-assessment efficiency** means the efficiency within a certain assessment, i.e. the spending of efforts in carrying out a particular single assessment in relation to the output and outcomes produced. The output here refers to the product of the assessment and the outcomes refer to the overall effects of the processes along the chain which the output has influence on.

**Inter-assessment efficiency** refers to the reduction rate of the marginal efforts needed for

each new assessment with the same quality of output when making a series of assessments. This means in practice the ability to avoid doing the same work again if it has been already done in a previous assessment.

The properties of good risk assessment described above can be used as the **general performance criteria of risk assessment**. The success of risk assessments should thus be evaluated against these goodness properties. As was mentioned above, the ultimate goal should be good societal decisions, but the decision-making process is basically out of reach of risk assessors and there are always several external factors that influence the decisions and their evaluation. Therefore it is more fair for risk assessors if instead the risk assessments are evaluated based on the effectiveness *potential* of the assessment product and the efficiency of the assessment process.

In general terms it can be said that the properties related to the quality of content are the most crucial ones. Assuring the goodness of the description should thus be the first priority in risk assessment. Anyhow, the goodness of the description has most likely very little significance to the society if the applicability of the assessment remains low. It is therefore also important to explicitly consider all of the aspects of effectiveness when designing or carrying out risk assessments. The requirement for efficiency is mainly related to the practical limitations and inevitably scarce resources for making the assessments. It is necessary to strive for making the best use of the resources.

The performance of risk assessment is tightly related to its purpose. When the purpose of a particular assessment is defined properly, also the performance criteria can be set in more detail. It is also necessary to evaluate the performance against these criteria, during the assessment process as well as after the assessment process when the intended effects are to become realized.

It is relatively easy to see that **different categories of the properties described above relate to different parts of risk assessment** :

- quality of content → risk assessment product
- applicability → use process
- efficiency → risk assessment process

Identifying, defining and considering the general properties of good risk assessments also has its **implications to the methods that are used in risk assessment**. The methods should be such that these properties become adequately covered. Several different kinds of methods are needed to be used and combined:

1. methods to ensure/enhance the quality of the description content
2. methods to ensure/enhance the applicability of the risk assessment output
3. methods to ensure/enhance the efficiency of the process

## Open participation in risk assessment

**Why allow open participation?**

*"History shows us that the common man is a better judge of his own needs in the long run than any cult of experts."*<sup>[4]</sup>

The reasons behind open participation has been identified e.g. by Fiorino<sup>[5]</sup> as either **normative, substantive or instrumental** and by the Economic Commission for Latin America and the Caribbean <sup>[6]</sup> as either **ethical, political, pragmatic or epistemological**. Building on

these categorisations, the reasoning behind stakeholder involvement is discussed in this text under three headings as follows:

1. Normative and ethical reasons
2. Instrumental, pragmatic reasons
3. Epistemological, substantive reasons

Fulfilling the **normative** requirements and addressing **ethical** concerns is the minimum level that must be done in a risk assessment. In many cases the minimum level of participation is legally enacted in order to ensure the rights of stakeholders to participate in the societal decision making processes.

An example of the basis of normative arguments is the Aarhus convention, which aims at access to information, public participation in decision-making, and access to justice in environmental matters [7] Aarhus Convention. Open participation is also a means to manage the legitimacy problem, which is caused by uncertainty about the evidence of harm and owing to the Liberal foundation of the regulatory system, evidence of harm is the key to justifying regulatory interventions [8]. Another ethical reason for open participation is that government should obtain the consent of the governed [9].

The **instrumental, pragmatic** reasons for open participation are mainly related to increasing the sense of ownership, trust and acceptance of the decisions and the information that they are based on. In relation to risk assessment, the pragmatic reason for open participation is that it increases the effectiveness of the risk assessment in terms of increasing the applicability of the assessment output. For example, open participation may increase the usability of the assessment output by making the assessment product more comprehensible to non-specialists. Open participation most often also increases the acceptability of the assessment output, by allowing all interested parties to contribute to it. For example, the U.S.EPA has actively used public participation and dispute resolution in its work to facilitate the process and improve the acceptability of outcomes.

Probably the greatest potential of benefiting from open participation lies in making use of the diverse knowledge and plurality of views of stakeholders. Stakeholders may possess some local or other special knowledge about the phenomena being assessed that is not held by the specialists or that is not available in any official databases or information sources. Maybe even more importantly stakeholders represent their values and are thus a crucial source to be considered when identifying the public perceptions towards risk related phenomena and other value judgments. In brief, non-experts see problems, issues, and solutions that experts miss. More inclusive procedures enrich the generation of options and perspectives, and are therefore more responsive to the complexity, uncertainty and ambiguity of the risk phenomena [10] and more intensive stakeholder processes tends to result in higher-quality decisions [11].

Overall, the reasons behind open participation in risk assessment are basically very practical: it can be used as a means of improving the quality of the content of the assessment product, the applicability of the assessment product and sometimes even the efficiency of the assessment process. Collection and synthesis of the knowledge and views of a diverse group of people tends to lead to better outputs than just relying on the knowledge and views of a single or few individuals. Also, inclusion of diverse groups to contribute to the work tends to increase the acceptability of the outputs and can help to improve the usability of the outputs. Even the efficiency of the work process can be enhanced by open participation, although the effect of unsuccessful or badly managed collaboration can also turn out counterproductive in this sense.

### **What does open participation mean?**

Open participation means allowing a large group of unorganized people to participate, share

information and questions, and utilise the products of others. It means more than just dividing tasks within a group into pieces that belong to someone. It is a way of working together on a shared set of tasks for a common goal. It makes use of the collective knowledge of groups and plurality of views in order to improve the output of the work. Its best properties can be seen in situations where there is a diverse (and possibly unknown) group of potential participants who possess different kinds of knowledge and represent a variety of value judgments about the issue that is being worked on

Open participation can be seen as an approach building on group communication which results are manifested and explicated in the product of the work. The product also serves as a platform or a medium for communication between the contributors. This means that the contributions to developing the product are messages that are sent by the contributors in form of manipulating the object that is being worked on and received by other contributors through observing the product. Through this communication by contribution the product thus develops into an explication of the shared understanding about the issue that is being worked on. In essence, allowing open participation means adopting mass collaboration as the way of working.

The concept of openness is an important issue in risk assessment. It defines the way the interaction between the contributors is organized and managed. Important dimensions of openness are at least:

- openness of participation
- openness of access
- openness of influence
- openness of temporal presence

Openness of **participation** refers to who, and on what basis, are allowed (or inversely not allowed) to contribute to the assessment. Openness of **access** refers to what parts of the assessment are available for different participants to contribute to. Openness of **influence** refers to what extent may a particular contribution have influence on the target of work. Openness of **temporal presence** refers to the when is it possible, e.g. in what phases, to make ones contributions. The overall openness is a product of all these dimensions.

The level of openness in terms of the above-mentioned dimensions should be organized in relation to the purpose and goals of the assessment taking into account the situational practicalities, such as e.g. legal requirements, public perceptions on the issues to be assessed, available resources etc. The level of openness can be adjusted separately for different (groups of) participants as needed and the level of openness may also vary in time as well as from assessment to another.

### **Challenges of open participation**

Open participation creates requirements for the process of the assessment. The methods applied must be able to accommodate an unknown number of people who work with the assessment at the same time. In addition to the expected benefits in improving the outputs of risk assessments, open participation also brings about challenges, which need to be addressed and managed. These are e.g. disputes rising from different perceptions and values among the participants and balancing openness and efficiency of the assessment process. Anyhow, the potential benefits of openness in improving the effectiveness of assessments are so substantial that it is worthwhile to take the pain of dealing with these challenges.

Open participation is expected to work best when a) the object of production is information or culture, which keeps the cost of participation low for contributions; b) tasks can be chunked into bite-size pieces; c) the cost of integrating these pieces into a good-quality product is low [12]. In the light of these three properties, risk assessments are promising objects for mass collaboration. However, the assessment must be divided into small, fairly independent pieces that can easily be combined.



Based on three case studies from different continents, Fraser and co-workers concluded that the process of engaging people provides an opportunity for community empowerment; that stakeholders and decision-makers consider participation irrelevant unless it formally feeds into decision-making; and that the assessment and risk management should not be too much restricted by political boundaries, because the problems do not follow them<sup>[13]</sup>. These findings emphasize the importance of participation but also clarifies its challenges. It seems that a method that makes wide participation possible is *a priori* better, as it is not exhausted even if there is a need to widen an assessment outside the originally intended group of participants.

Pyrkilo method follows the conclusions by Fraser, the method can be used for community empowerment. Participation and the resulting contribution does formally feed into a content-specific point in the assessment. If the contribution changes the value of the variable, it has an impact through the causal chain on all downstream variables, including the outcome indicators, and finally conclusions. Thus, this approach should be attractive to the stakeholders who want their knowledge or opinions heard.

To facilitate such synthesis of diverse knowledge and plurality of views, carrying out risk assessments needs some kind of a collaborative workspace which functions as the platform for mass collaboration. A collaborative workspace serves the purpose of providing e.g. the following functionalities:

- facilitating communication between participants
- facilitating documentation and representation
- dealing with disputes
- managing openness

The methods for managing open participation should ideally be flexible enough to allow any level of openness in any dimension as needed. Since the common contemporary approaches to risk assessment have rather restrictive than open strategies to participation, it in practice means that new methods should be developed with the aim of being able to allow and tolerate more openness.

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No.1: Risk governance; Toward an integrative approach.

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# Open risk assessments consist of variables

## The information structure of risk assessment

According to the pyrkiilo method the assessment products, descriptions of reality, are constructed following a **formal universal information structure** . It covers both hierarchical and cause-effect relations between objects within the information structure.

The information structure contains the following kinds of objects that have a standardized format:

- Risk assessments
- Classes
- Variables

Assessments are collections of information for helping decision-making, and the end product of a risk assessment process, that are constructed according to the intended use purpose of the assessment. They can be described as collections of variables, collected with reference to the use purpose that the assessment is intended for, complemented with information about the scope of the assessment and assessment-specific analyses and conclusions.

Classes are sets of objects (variables or classes) that share similar properties. They can be used in describing general information that is shared by more than one variable or class or sharing general information among the classes and variables of similar kind.

Variables are descriptions of particular pieces of reality. They can be descriptions of physical phenomena, or descriptions of value judgements. Also decisions included in an assessment are described as variables. **D~**

Variables are objects of event-medium composite -type. They thus describe both the events that occur within the scope of the variable and the medium where these particular events take place. In practice, the events can only be observed through the changes in the state of the medium, and it is therefore reasonable to describe the events and particular media as such composites rather than as separately.

In pyrkiilo method all the variables included in an assessment must be causally related , directly or indirectly, to the endpoints of the assessment, and the causal relations must be defined. The event-media structure is the carrier of the cause-effect relations between the variables. An event occurring in a medium causes a change in state of that medium leading to another event to occur changing the state of that medium, causing yet another event to occur and so on. In addition to variables, also classes as generalizations of properties possessed by variables can be causally related to each other.

The full-chain approach used in Intarese project can be taken here as an example of causality on a very general level. The full chain generalizes the environmental health risk issues to follow the source to impact chain as follows: sources cause emissions, causing concentrations, that cause exposures, doses and health effects, that lead to societal impacts.

In addition to the formally structured objects, there may objects that do not have a standardized format related to risk assessments, such as data and models that are used in defining assessments, classes and variables and their attributes. These freely structured objects are outside the information structure, but can be e.g linked or referred to within the formal defined objects.

## Risk assessment goes from the question to an answer

**Risk assessment product structure** describes the general structure of the outputs of risk assessments.

- A risk assessment product is a description of a certain piece of reality
- The descriptions are produced according to the (use) purposes of the product
- The risk assessment product is a description of all the relevant phenomena in relation to the chosen endpoints and their relations as a causal network
- The risk assessment product combines value judgements with the descriptions of physical phenomena
- The basic building block of the causal description is a **variable**, i.e. everything is described as variables.
- All variables in a causal network description must be causally related to the endpoints of the assessment.

**Risk assessment product** is a collection of information for helping decision-making, and the end product of a risk assessment process. It has the following attributes:

Attribute	Subattributes	Comments
<b>Name</b>		Identifier for the assessment
<b>Scope</b>	<ul style="list-style-type: none"> <li>■ Purpose</li> <li>■ Boundaries</li> <li>■ Scenarios</li> <li>■ Intended users</li> <li>■ Participants</li> </ul>	In some assessments, the only <i>Scenario</i> is business-as-usual For <i>participants</i> , both minimum required and maximum allowed are described
<b>Definition</b>	<ul style="list-style-type: none"> <li>■ Decision variables</li> <li>■ Indicators</li> <li>■ Other variables</li> <li>■ Analyses</li> </ul>	A list (set) of variables included <i>Indicators</i> is equal to the outcomes of interest Analyses may include optimizing
<b>Result</b>	<ul style="list-style-type: none"> <li>■ Results</li> <li>■ Conclusions</li> </ul>	Results of assessment-specific analyses Conclusions on indicators given scope Many results are described within variables, not here

## Variables are building blocks for risk assessments

**Variable** is a description of a particular piece of reality. It is the basic building block of a risk assessment. It can be a description of physical phenomena, e.g. yearly average of PM<sub>2.5</sub> concentration in Kuopio in 2006, or a description of a value judgement, e.g. willingness to pay to avoid lung cancer. Variables (the scopes of variables) can be more general or more specific and hierarchically related, e.g. yearly average of PM<sub>2.5</sub> concentration in Finland in 2006 (general variable) and daily average of PM<sub>2.5</sub> concentration in Kuopio on January 1st, 2006.

In order to make coherent descriptions of reality in assessments, the assessments must have a certain clear structure. As we also want to produce descriptions that are coherent between assessments, there must be a universal structure for all assessments. Variables with a certain set of attributes, and linkages between these variables is the universal structure of the

assessments. For further details, see Guidance and methods for indicator selection and specification | Building blocks of risk assessments. The universal assessment structure is essential for coherent inclusion of causality in assessments, enabling of collective structured learning, collaborative work as well as combining value judgements with descriptions of physical reality.

### Variable structure

In the new risk assessment method, variables have a specified structure with five basic attributes (and possibly some sub-attributes).

Attribute	Question to be answered	Comments
<b>Name</b>	What is the name of the variable?	Two variables must not have identical names.
<b>Scope</b>	What is the question to which the variable answers?	This includes a verbal definition of the spatial, temporal, and other limits (system boundaries) of the variable.
<b>Unit</b>	What is the unit of measurement?	
<b>Definition</b>	How can you derive or calculate the answer?	The definition uses algebra or other explicit methods if possible. It also contains all such links from other variables that are necessary to define the variable.
<b>Result</b>	What is the answer to the question defined in the scope?	If possible, a numerical expression or distribution.

**Name** attribute is the identifier of the variable, which of course already more or less describes what the real-world entity the variable describes is. The variable names should be chosen so that they are descriptive, unambiguous and not easily confused with other variables. An example of a good variable name could be e.g. *daily average of PM<sub>2.5</sub> concentration in Helsinki*.

**Scope** attribute defines the boundaries of the variable - what does it describe and what not? The boundaries can be e.g. spatial, temporal or abstract. In the above example variable, at least the geographical boundary restricts the coverage of the variable to Helsinki and the considered phenomena are restricted to PM<sub>2.5</sub> daily averages. There could also be some further boundary settings defined in the scope of the variable, which are not explicitly mentioned in the name of the variable.

**Unit** attribute describes what units the result is presented in. The units of interconnected variables need to be coherent with each other in a causal network description. The units of variables can be used to check the coherence of the causal network description by the *unit test* explained above in the general assessment process description.

**Definition** attribute describes how the result of the variable is derived. It consists of sub-attributes to describe the causal relations, data used to estimate the result, and the mathematical formula to calculate the result. Also alternative identified ways to derive the variable result can be described in the definition attribute as reference. The minimum requirement for defining the causality in all variables is to express the existence of a causal relation, i.e. that a change in an *upstream* variable affects the variables *downstream*.

**Definition has three sub-attributes** that have particular purposes in the method:

- **Causality** lists the upstream variables (i.e. causal parents) of the variable. It expresses

their functional relationships (the variable as a function of parents) or probabilistic relationships (conditional probability of the variable given parents).

- **Data** describes any non-causal information about the variable, such as measured data about the variable itself, measured data about an analogous situation including an error model, or expert judgements about the result.
- **Formula** is the actual computer code that calculates what is described under titles *Causality* and *Data*, making a synthesis of the two. In a general form, the formula can be described as **result = function(parameters)** , where function is the computer code using parameters such as upstream variables as input.

**Result** attribute is an answer to the question presented in the scope of the variable. The result is preferably quantitative, i.e., numerical, but this is not necessary. The result may be a different number for different *locations*, such as geographical positions, population subgroups, or other determinants. Then, the result is described as

$$R | x_1, x_2, \dots$$

where R is the result and  $x_1$  and  $x_2$  are defining the locations. A *dimension* means a property along which there are multiple locations and the result of the variable may have different values when the location changes. In this case,  $x_1$  and  $x_2$  are dimensions, and particular values of  $x_1$  and  $x_2$  are locations. A variable can have zero, one, or more dimensions. Even if a dimension is continuous, it is usually operationalised in practice as a list of discrete locations. Such a list is called an *index*, and each location is called a *row* of the index.

Uncertainty about the true value of the variable is one dimension. The index of the uncertainty dimension is called the *Sample* index, and it contains a list of integers 1,2,3... . Uncertainty is operationalised as a sequence of random samples from the probability distribution of the result. The  $i^{\text{th}}$  random sample is located in the  $i^{\text{th}}$  row of the Sample index.

Several variables may share the same dimension. One variable may use several indexes along the same dimension. Therefore, several variables may share the same index or use different indexes along a particular dimension. This creates a need to handle index conversions within dimensions. Although the following goes into technical details that have not yet really been sorted out and tested, it is discussed here for completeness.

- A variable may have an *interpolation function* for a dimension. This is a function that defines how a value can be calculated for a new location based on values of other locations along that dimension. The function is used to transform the variable from one index to another index along a particular dimension.
  - The function may utilise several dimensions at the same time, such as in two-dimensional spatial transformations.
  - The interpolation function may be deterministic or probabilistic. If it is probabilistic, it is enough to take one sample for each row of the Sample index.
- There may be *correlation functions*. These functions tell how two or more variables are related to each other across the uncertainty dimension. Vines (hierarchical rank correlations) are examples of these functions.

### General attribute structure

Each attribute may contain three kinds of information:

- Actual content (only this will have an impact on other objects)
- Narrative description (to help understanding the actual content). Includes uncertainty

analysis.

- Discussion (argumentation about issues in the actual content)

For a detailed description of discussions, see Help:Dispute.

### Connection to the PSSP structure

A universal information structure has been suggested. This is called PSSP (Purpose, Structure, State, Performance). The variable structure is closely connected to PSSP, and the relationships can be described in the following way.

PSSP	Variable structure
Purpose	The purpose of a variable is to describe a particular piece of reality.
Structure	Scope, Unit, and Definition describe the structure of the variable.
State	Result is the state of the variable.
Performance	Performance relates to the variable uncertainty: How well the scope is defined, and how well the current uncertainty can be reduced if a large amount of information became available.

### There are different kinds of variables

Although all variables share the same basic structure, it is useful to distinguish different kinds of variables based on their use or position in a risk assessment.

- **Endpoint variables** are variables that describe phenomena which are outcomes of the assessed causal network, i.e. there is no variables downstream from an endpoint variable according to the scope of the assessment. In practice endpoint variables are most often also chosen as indicators.
- **Intermediate variables** include all other variables besides endpoint variables.
- **Key variable** is a variable which is particularly important in carrying out the assessment successfully and/or assessing the endpoints adequately.
- **Indicator** is a variable that is particularly important in relation to the interests of the intended users of the assessment output or other stakeholders. Indicators are used as means of effective communication of the assessment results. Communication here refers to conveying information about certain phenomena of interest to the intended target audience of the assessment output, but also to monitoring the statuses of the certain phenomena e.g. in evaluating effectiveness of actions taken to influence that phenomena. In the context of integrated assessment indicators can generally be considered as pieces of information serving the purpose of communicating the most essential aspects of a particular risk assessment to meet the needs of the uses of the assessment. Indicators can be endpoint variables, but also any other variables located anywhere in the causal network.
- **Decision variables** are possible decisions that are in consideration within a risk assessment. The main interest of the assessment is then the comparison of outcomes resulting from the different decision options. More of decision variables can be found from a separate page.

Variables are versatile objects. They are able to describe all of the following aspects of reality:

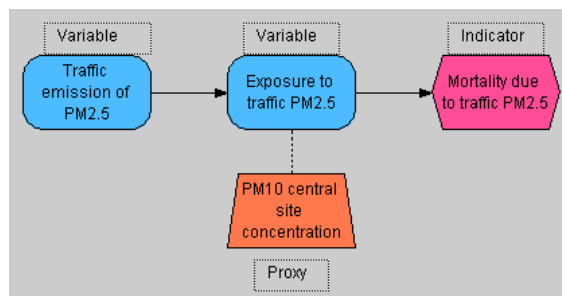
- **Causal relationships** linking variables in the different steps in the causal chain from

- source to impact (mainly in the definition/causality attribute);
- Different environmental, social, economic and infrastructural **contexts** in which risks might arise and play out (mainly in the scope attribute);
  - Physical and chemical **processes** that generate, transform and transport the hazards (agents) from source to the target organs in the human body (mainly as variables that are defined as functions);
  - **Indicators** to describe and communicate the causal chain and impacts (variables selected for reporting);
  - Different **policy measures** that might be taken to address the risks, and thus different assessment scenarios that might be compared (decision variables);
  - **Appraisal** of the impacts (and the policy scenarios to which they relate), in the light of agreed value systems and rules for evaluation (variables describing value judgements or derived from value judgement variables).
  - **Adaptation and feedback loops** arising as a result of adaptation to the risks, at both individual and institutional level. A feedback loop is described as a variable that is indirectly dependent on the result of itself **at a previous time point**.

Ideally, all variables in the full-chain can be expressed quantitatively. In order to use the full chain approach quantitatively in an integrated assessment, it is necessary to acquire data for the variables, or to estimate these variables by modelling the underlying causal processes.

### Proxies are not indicators

The term indicator is sometimes also (mistakenly, in the eyes of the new risk assessment method) used in the meaning of a proxy. Proxies are used as replacements for the actual objects of interest in a description if adequate information about the actual object of interest is not available. Proxies are indirect representations of the object of interest that usually have some identified correlation with the actual object of interest. At least within the context of the new risk assessment method, proxy and indicator have clearly different meanings and they should not be confused with each other. The figure below attempts to clarify the difference between proxies and indicators:



In the example, a proxy (PM<sub>10</sub> site concentration) is used to indirectly represent and replace the actual object of interest (exposure to traffic PM<sub>2.5</sub>). Mortality due to traffic PM<sub>2.5</sub> is identified as a variable of specific interest to be reported to the target audience, i.e. selected as an indicator. The other two nodes in the graph are considered as ordinary variables. The above graph has been made with Analytica, here is the original Analytica file.

### Specifying indicators and other variables

When the endpoints, indicators and key variables have been identified, they should be



specified in more detail. Additional variables are created and specified in addition to the endpoints, indicators and key variables as is necessary to complete the causal network. Specifying these variables means defining the contents of the attributes of each variable. The four plausibility tests are very useful in specifying variables.

**Plausibility tests** are procedures that clarify the goodness of variables in respect to some important properties, such as measurability, coherence, and clarity. The four plausibility tests are clairvoyant test, causality test, unit test, and Feynman test.

1. **Clairvoyant test** (about the ambiguity of a variable): If a putative clairvoyant (a person that knows everything) is able to answer the question defined in the scope attribute in an unambiguous way, the variable is said to pass this test. The answer to the question is equal to the contents of the result attribute.
2. **Causality test** (about the nature of the relation between two variables): If you alter the value of a particular variable (all else being equal), those values that are altered are said to be causally linked to the particular value. In other words, they are directly downstream in the causal chain, or children of the particular variable.
3. **Unit test** (the coherence of the variable definitions throughout the network): The function defining a particular variable must result (when the upstream variables are used as inputs of the function) in the same unit as implied in the scope attribute and defined in the unit attribute.
4. **Feynman test** (about the clarity of description): If you cannot explain it to your grandmother, you don't understand it well enough yourself. (According to the quantum physicist and Nobel laureate Richard Feynman.)

The specification of variables proceeds in iterative steps, going into more detail as the overall understanding of the assessed phenomena increases. First, it is most crucial to specify the scopes (and names) of the variables and their causal relations. As part of the specification process, in particular the name and scope attributes, the **clairvoyant test** can be applied. The test helps to ensure the clarity and unambiguity of the variable scope.

Addressing causalities means in practice that all changes in any variable description should be reflected in all the variables that the particular variable is causally linked to. At this point, the **causality test** can be used, although not always necessarily quantitatively. In the early phases of the process, it is probably most convenient to describe causal networks as diagrams, representing the indicators, endpoints, key variables and other variables as nodes (or boxes) and causal relations as arrows pointing from *upstream* variables to *downstream* variables. In the graphical representations of causal networks the arrows are only statements of existence of a causal relation between particular variables, more detailed definitions of the relations should be described within the definition attribute of each variable according to how well the causal relation is known or understood.

Once a relatively complete and coherent graphical representation of the causal network has been created, the specification process for the identified indicators may continue to more detail. The indicators, the *leading variables*, are of crucial importance in the assessment process. If, during the specification process, it turns out that the indicator would conflict with one or several of the properties of good indicators, such as calibration, it may be necessary to consider revising the scoping of the indicator or choosing another *leading variable* in the source - impact chain to replace it. This may naturally bring about a partial revision of the whole causal network affecting a bunch of key variables, endpoints and indicators. For example, it may happen that no applicable exposure-response function is available for calculating the health impact from intake of ozone. In this case, the exposure-response indicator may be replaced with an intake fraction indicator affecting both the *downstream* and *upstream* variables in the causal network in the form of e.g. bringing about a need to change the units the variables are described in.

The description, unit and definition attributes are specified as is explained in the previous section. The **unit test** can be applied to check the calculability, and thus descriptive coherence, of the causal network. When all the variables in the network appear to pass the required tests, the indicator and variable results can be computed across the network and the first round of iteration is done. Improvement of the description takes place through deliberation and re-specification of the variables, especially definition and result attributes, until an adequate level of quality of description throughout the network has been reached. The discussion attribute provides the place for deliberating and documenting deliberation throughout the process.

### Importance of indicators in the assessment process

Indicators have a special role in making the assessment. As mentioned above, indicators are the variables of most interest from the point of view of the use, users and other audiences of the assessment. The idea thus behind the indicator selection, specification and use is to highlight the most important and/or significant parts of the source-impact chain which are to be assessed and subsequently reported. The selected set of indicators guides the assessment process to address the relevant issues within the assessment scope according to the purpose of the assessment. It could be said that indicators are the *leading variables* in carrying out the assessment, other variables are subsidiary to specifying the indicators.

However, within the context of integrated risk assessment, selecting and specifying indicators may sound more straightforward than it actually is. Maybe, identification of indicators and specification of the causal network in line with the identified indicators, could grasp the essence of the process better. Instead of merely picking from a predefined set of indicators, selection here refers rather to identifying the most interesting phenomena within the scope of the assessment in order to describe and report them as indicators. Specification of indicators then is similar to specification of all other variables, although indicators are the ones that are primarily considered while other variables are considered secondarily, and mainly in relation to the indicators.

In principle, any variable could be chosen as an indicator and the set(s) of indicators could be composed of any types of indicators across the full-chain description. In practice, the generally relevant types of indicators, such as performance indicators can be somewhat predefined and even some detailed indicators can be defined in relation to commonly existing purposes and user needs. This kind of generality is also helpful in bringing coherence between the assessments.

### On the generalizability of variables

Aim: Variables must be generalizable so that they can be used without additional knowledge of the context. In other words, the context must be described well enough inside the variable.

→ Because of this, the variables must be estimates about the truth, and not deliberate under- or overestimates. Biased estimates are common in risk assessment because usually the assessments want to avoid false negative results much more than false positive results. In other words, it is much worse if there is a risk and you don't find it than if there is no risk and you think there is.

→ Decisions may be based on risk aversion, but the estimates of variables must be best estimates, because you cannot know which decisions will be based on the variable.

### Technical issues in Mediawiki

- Each variable is a page in the *Variable* namespace. The **name** of the variable is also the name of the page. However, draft variables may be parts of other pages.
- The **scope** is the first paragraph(s) on the page, before the first sub-title. Scope starts with the word **Scope** in the previous line (wiki code `'''Scope'''<br>`). The name should be

repeated in the beginning of scope in bold, followed by text "describes..." and then a description of the scope (whenever the contents fits in this format). Subtitles are NOT used with Scope; this way, it locates above the table of contents.

- All other attributes (**unit, definition, result** ) are second-level (==) sub-titles on the page.
- Description of the attribute content is added at the end of that content; discussions on the content are added to the Talk page, each discussion under an own descriptive title.
- References to external sources are added to the text with the `<ref>Reference information</ref>` tag. The references are located in the end of the page under subtitle References. However, reference is not an attribute of the variable despite it is technically similar.
- In the formula, computer code for a specific software may be used. The following are in use.
  - `Analytica_id`: Identifier of the respective node in an Analytica model.  
`<anacode>Place your Analytica code here. Use double Enter to make a line break.</anacode>`
  - `<rcode>Place you R code here. Use double Enter to make a line break.</rcode>`

#### See also

- heande:Heande:Structures of the building blocks of open risk assessments
- heande:Help:Open risk assessment
- Seven challenges in integrated assessment: From properties to collaboration

## Decisions are described as variables

**Decision variables** are special kinds of variables: they contain information about possible policy options. Structurally they are similar to other variables, but they the decisions have a special role in causal diagrams, as that is usually the starting point of the diagram. The descriptions of decision variables and scenarios are performed according to the variable structure and using the standard functionalities of the toolbox.

A **scenario** is a particular value from the distribution of plausible options (values) of a decision variable. It can also be a set of particular values from several decision variables. For policy assessments, often several scenarios are defined and then compared to each other, e.g. if the impacts of a certain policy (measure) is assessed. A good analysis practice is that a **business-as-usual scenario** (BAU) is always included in an assessment. BAU is a scenario where active measures are not taken in addition to those that have already been decided. A particular set of scenarios can be saved and used in several risk assessments. A scenario therefore can be a part of an assessment but is not an assessment itself.

The result of a decision variable contains the range of the plausible options. This range should be generalizable to all assessments. For a particular assessment, the assessor may choose values from within (but not outside) the range of plausible values as he pleases, as long as the business-as-usual option is included. The business-as-usual option is distinguished from other options by the shape of the result distribution: the business-as-usual option should have a clear peak, while other options should show a more or less uniform distribution (or some other distribution reflecting the probability of each decision outcome). A particular plausible option, decided by the risk assessor for a particular risk assessment, is called a scenario. Therefore, a scenario is a property of a risk assessment, **not** a property of a variable.

## Value judgements are crucial parts of an assessment

**Value judgement** means a preference for a certain state of the world, expressed by an

individual or by a society.

Risk assessment is about estimating impacts that have positive or negative value judgements attached to themselves or to the determinants that causally affect them. These values must be acknowledged in the process of making the assessments, not only in the risk management phase, otherwise there is a risk of compromising the relevance of the assessment. Combining phenomena of physical reality with the value judgements related to them requires methods to distinguish these two things from each other and bringing the value judgements to explicit scrutiny within an assessment.

## Causality forms the backbone of an assessment

**Causality** means that there is a causal influence between two variables (or objects): if the value of the one upstream is changed, the object downstream changes as well. Causal relationships are represented as arrows in causal diagrams. However, the *lack of a causal relationship*, i.e. a lack of an arrow between two variables is a stronger statement than an arrow. One operationalization of causality is a Bayesian belief network.

The new risk assessment method is based on the full-chain approach. This implies that the assessment products produced in the assessments should be causal network descriptions that cover the relevant phenomena from emissions to exposures to health effects and their impacts in accordance with the chosen endpoints and purpose. However, it should be emphasized that the method does not only describe issues that are associated with the full chain. It describes those issues that **cause** effects along the full chain, and it describes how the causes and effects are related. This, of course, makes risk assessment a challenging, or even difficult, process. Strict emphasis on causality, however, should be the way to e.g. estimate the impacts of policies on emissions and consequently to health effects. For further details, see Guidance and methods for indicator selection and specification

## Classes contain general information

**Class** is a specific set, where the set contains all things as items that fulfil a defined criterion. The purpose of a class  $D$  in risk assessment is that general knowledge may be attributed to a class, and then it can be utilised in the description of any item (variable) that fulfils the inclusion criterion. This improves the inter-assessment efficiency of risk assessment work.

A class may contain information about e.g. a good function that should be used to calculate the result, or a range of plausible values for a certain type of variable. Examples of these are given below.

**A general dose-response function** can be a class. For example, the multi-stage model for cancer dose-responses can be defined as

$$P(d) = 1 - \exp(-q_0 - q_1d - q_2d^2)$$

This function has four parameters:  $q_0$  (the "background"),  $q_1$  (the "slope" at low doses),  $q_2$  (the "curvature" parameter) and  $d$  (lifetime daily dose of the chemical of interest). The function can be applied to a particular chemical among a wide range of chemical carcinogens, if the chemical-specific parameters  $q_0$ ,  $q_1$ , and  $q_2$  are known. The result attribute of this class is equal to the general form of the multi-stage function. The function is used in the definition/formula attribute of a dose-response variable of a particular chemical, together with the chemical-specific parameters. The result attribute of this variable is the dose-response of the particular chemical, with one parameter,  $d$ . This variable can then be applied in a case-specific risk assessment, when the parameter  $d$  is replaced by the dose in an exposure scenario in that assessment.

This is an efficient way of organising information: all discussion about the plausibility of the multi-stage model in general is located in the class. Therefore, this discussion is held only once, for all chemicals and all assessments. Also the discussion whether the multi-stage function applies to a particular chemical is located there. The resolution of that discussion applies to all risk assessments on that chemical. The chemical-specific dose-response variable contains the discussion about the best estimates of the chemical-specific parameters. And again, the variable is applicable to all risk assessments on that chemical. A particular risk assessment can focus on estimating the exposures. The whole dose-response part of the assessment is ready-made.

**Prior values for variables** can also be located in classes. For example, imagine a class "Plausible range of PM<sub>2.5</sub> annual average mass concentrations in ambient air." This is a uniform probability distribution of concentrations ranging possibly from 3 µg/m<sup>3</sup> (in Antarctic) to 300 µg/m<sup>3</sup> (in downtown Delhi). This can be applied in PM<sub>2.5</sub> variables for checking for implausible values. The range (i.e., the value of the result attribute of the class) can be located in the definition/data attribute of e.g. a variable "PM<sub>2.5</sub> annual average concentration in downtown Kuopio." If we do have measurements from Kuopio, we can do Bayesian updating using the range as the prior. This way, we can operationalise the use of both the case-specific measurements and the general knowledge from the class.

In practice, when new variables are created, they can partly be described using the results of existing classes, as long as the variable belongs to these classes. Possibly there should be a possibility to overrule the class information with case-specific information, if this is explicitly mentioned. However, deviations from the general rule should be defended.

The attributes of a class closely resemble those of a variable. However, the interpretation is slightly different, as can be seen from the table. In addition, the usage of data is not clear at the moment.

Attribute	Subattributes	Comments
Name		
Scope		What defines the items of the class, i.e. the inclusion criterion
Unit		
Definition	<ul style="list-style-type: none"> <li>■ Causality</li> <li>■ Data</li> <li>■ Items</li> </ul>	<ul style="list-style-type: none"> <li>■ Upstream classes or variables in the causal chain (or parameters, if the class is a function)</li> <li>■ Data about the common properties</li> <li>■ List of items (i.e. classes or variables) belonging to the class</li> </ul>
Result		Common properties that are shared by all items in the class

### Technical issues about classes in Mediawiki

When we want to describe a general property, we must create a Class category. The class is a set of items that all share this general property. All variables that belong to this class or its subclass are allowed to inherit the property. I say 'are allowed' because this does not happen automatically in Mediawiki: the editor must create the link.

You need two things: a template and a category. The template contains the general property (i.e., the *result* attribute of the class), and the category defines, which variables or classes belong to this class. All templates that apply to a given class are listed in the category page.

In this way, it is easy to find all templates that apply to a variable that belongs to the class. Just define the relevant category, and then go through the descriptions of the category to see whether they contain properties that should be used in the variable or class. Actually, an editor should take a position to **all** properties applicable to the variable under edition. Not all properties have to be used, but reasons should be given why some were selected and some not. If there is a dispute whether a variable or class belongs to a particular class, this argumentation is located on the Talk page of the particular class, not on the Talk page of the item.

Often there may be several templates describing the same property. They may just be alternative approximations of the actual thing (which is not known perfectly, or it may be impractical to calculate it perfectly), and the choice between them is a matter of practice or convention. However, if there is a true conflict between two properties so that they cannot be true at the same time (not even as approximations), a discussion must be created on the Talk page.

# The work on an open risk assessment has several phases

## Parts of the risk assessment process

The **process of carrying out a risk assessment** can be considered as consisting of four simultaneously on-going sub-processes that are continuous throughout the whole risk assessment **D**:

1. collection of scientific information and value judgements
2. synthesis and manipulation of scientific information and value judgements
3. communication of the outcomes of collection and synthesis
4. management of collection, synthesis and communication sub-processes

The risk assessment process is continuous interplay of these four sub-processes that may appear in different forms during different phases of the process (for description of the phases see Help: The phases of a risk assessment)

1. **Collection** of scientific information and value judgements can be considered as gathering these information types or meta-information about them and bringing it available for the participants of the risk assessment. Within the collection sub-process, the information stays freely structured, i.e. is not formalized according to the risk assessment information structure.
2. **Synthesis** of scientific information and value judgements can then be described as adapting the collected information into the form of risk assessment information structure. This formalized information can be also further manipulated within the assessment, in the form of the information structure.
3. **Communication** means that the outcomes of the collection and synthesis that become manifested in the (intermediate) risk assessment product also need to be communicated among the participants of the assessment.
4. The **management** sub-process is managing the processes of collection and synthesis of scientific information and value judgements, and communication. This also includes technical facilitation of the other sub-processes.

The outcome of the whole process, the **assessment product**, is a causal network description of the relevant phenomena related directly or indirectly to the endpoints of the assessment, in accordance with the purpose of the assessment. The final description should thus:

- Address all the relevant issues as variables
- Describe the causal relations between the variables
- Explain how the variable result estimates are come up with
- Report the variables of greatest interest and conclusions about them to the users

The greatest improvement, and at the same time challenge, in the new risk assessment method is the explicit emphasis on **causality** throughout the source-impact chain. Although it may often be very difficult to exactly describe causal relations in the form of e.g. mathematical formulae, the causalities should not be neglected. By means of coherent causal network descriptions that cover the whole source-impact chains it is possible to understand the phenomena and to be able to deal with changes that may take place in any variables in the

causal network.

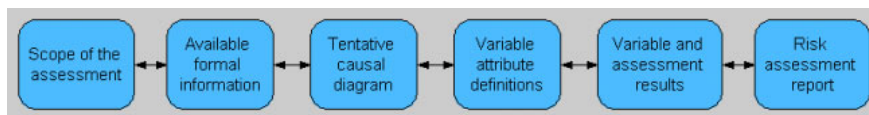
Even if the result estimates for individual variables were come up with by means of measurements, model runs, external reference data or expert judgements, the causal relations between variables should be attempted to be defined simultaneously. The least is to have statements about the existence of causal linkages, although they may be vaguely understood and defined. During the assessment the estimation of variable results should be an iterative interplay between information from data sources and definition of causal relations.

It is quite a long, and not necessarily at all a straightforward, way from creating a general view of the assessment question to creating a complete causal network description of the phenomena of interest. Some of the challenges on this way are:

- What are the all the relevant issues that should be covered in the assessment?
- How are the causal relations between variables defined and described?
- How are the individual variables defined and described?
- What is the right level of detail in describing variables?
- What are the most important issues within the assessment that should be communicated to the users of the output?

Below is a diagram that schematically describes the evolution of an assessment product developing from identification of the assessment purpose to a complete causal network description. The diagram is a rough simplification of the process, although the arrows between the nodes pointing both ways try to emphasize the iterative nature of the process. The diagram rather describes a gradual transition of focus along the progress of work than subsequent events taking place in separate phases.

In the diagram below, the boxes represent different developmental steps of the assessment product which are representations of the improving understanding about the assessed phenomena and simultaneously the focus of attention as the process progresses towards its goals. The activities are considered to take place in between the boxes. The diagram is made in the form of a workflow description and it does not explicitly address e.g. questions of collaboration and interaction between different contributors to the assessment.



The progress of the assessment process and the development of the product along these phases is described in more detail in the phase-specific descriptions. However, it should yet again be reminded that the above description is a rough simplification and that in practice there are several different iteration loops of defining, refining and re-defining the causal network description as the process progresses.

## The phases of a risk assessment

The risk assessment work has six phases. The work during a particular phase is always built on the results of the previous phases. The phases are not clear-cut periods in time, because the work is iterative in nature, and the previous phases must frequently be revisited when the development of the product and feedback brings in new understanding. Thus, the next phase is usually started when the previous phase is still a draft at least in some aspects.



The phases of risk assessment are called:

1. **Scoping** of the assessment. In this phase the purpose of the assessment, the question(s) asked in the assessment, intended use of the output, the temporal and spatial boundaries of the scope of the assessment, and the participatory width of the process are defined and described.
2. **Applying** previous information about the issues being assessed. In this phase the existing information that is available e.g. in the encyclopedia, as existing variables from previous assessments, or as classes (general properties shared by a group of variables) are sought out and applied.
3. **Drawing** a causal diagram. In this phase the decisions, outcomes, and variables of importance related to the assessment are described in the form of a sketch of a causal network diagram.
4. **Designing** variables. In this phase the variables included in the assessment (the causal network diagram) are described more precisely, including defining causal relations between them. This phase may also include definition of quality criteria and plans for collecting the necessary data or models to estimate the results of the variables. It should be noted that previously this phase was considered to apply to the assessment as a whole. Now we have realised that in practice the design work happens separately for each variable (although usually approximately at the same time). The same applies to the next phase, execution.
5. **Executing** variables and analyses. This phase is actually about collecting the data needed, executing the models described in the Definition attributes of different variables, and storing the results in the result distribution database. Assessment-specific analyses such as optimisation, decision analysis, value-of-information analyses and so on are carried out.
6. **Reporting** In this phase, the results of indicators and assessment-specific analyses are communicated to the users of the outputs. The results are discussed and conclusions are made about them, given the scope of the risk assessment. The communication includes necessary background information.

The phases 1-3 are collectively called **the issue framing phase**. D<sup>~</sup>

The list consisting of six phases of risk assessment process has been created by combining the views from the Intarese appraisal framework and the assessment process description in guidance and methods for indicator selection and specification, also originally produced for Intarese project D<sup>~</sup>, through several discussions in different situations involving several people from e.g. Intarese, Beneris, and Heimtsa projects.

## (1) Scoping: An open risk assessment work starts from scoping

### Purpose/goal of the phase

As the name indicates, the scoping phase attempts to define the scope of the assessment. This includes identification of:

- The purpose of the assessment
- The questions asked in the assessment
- The users, uses and possible other interested audiences of the assessment outputs
- The temporal and spatial boundaries of the assessment
- The participatory width of the assessment process

- The scenarios to be considered within the assessment (not mandatory)

#### **Activities carried out during the phase**

- Initial scoping as the basis for discussions
- Collection of information and views through consultation of intended users and other stakeholders

#### **Outcome of the phase**

Basically the output of this phase, the scope of the assessment, is realized in the form of text containing information about the above-mentioned issues. During the scoping phase of the assessment it is also possible to create a scoping diagram that helps in describing or framing the relevant issues related to the assessment. This diagram does not have to be a strictly causal description, but it may be helpful in considering the causalities between the factors related to the issue already from the very beginning of the process.

## **(2) Applying: General information should be used when possible**

#### **Purpose/goal of the phase**

During this phase existing information that is readily available is collected and included in the assessment. This kind of information can be found in the encyclopedia, in the form of e.g. existing variables from previous assessments, or as classes (general properties shared by a group of variables).

Applying general information is based on the idea of intentionally producing generally applicable pieces of information that can also be used as the building blocks of new assessments. In addition, the approach builds on the principle of mass collaboration, which implies that the pieces of information produced in a particular assessment are set commonly available for use in other assessments. What is new in this concept is that there are specific procedures for extracting pieces of information from previous work and assessments, and making them centrally available for others. This enhances the efficiency and effectiveness of the assessments carried out by applying the new risk assessment method.

#### **Activities carried out during the phase**

During this phase the users collect all readily available parts belonging to the scope of the assessment.

#### **Outcome of the phase**

Depending on the similarity of the particular assessment with previously made assessments, the outcome after this phase may be a more or less full coverage of the variables that are to be included in the assessment. Anyhow, the outcome helps in identifying what parts of the assessment will require most attention and what parts can be covered with information from previous assessments.

## **(3) Drawing: Causal diagrams link issues together**

#### **Purpose/goal of the phase**

Drawing causal diagrams is about making graphs with nodes (variables) and arrows (causal links) with some explanatory text. **D** With the help of causal diagram it is possible to clarify the aims, the key components and the structure of the assessment. The following types of

contents should be described in the form of a causal digram

- Endpoints of the assessment
- Indicators, i.e. the variables of most interest to the users of the outputs
- Decision variables
- Key variables, i.e. the variables that are crucial for the assessment
- Other variables needed to assess the other variables mentioned above

### **Activities carried out during the phase**

After the scoping and applying phases, there should be a good general level understanding of what is to be included in the assessment and what is to be excluded. Also, there should be a strong enough basis for identifying what are the endpoints of the assessment, what are the most important variables within the assessment scope in order to carry out the assessment successfully, what are the most interesting variables within the assessment scope from the point of view of the users and other audiences of the assessment output and what decision options are to be considered in the assessment. These overlapping sets of different variable types provide a good starting point for taking the first steps in carrying out the assessment work.

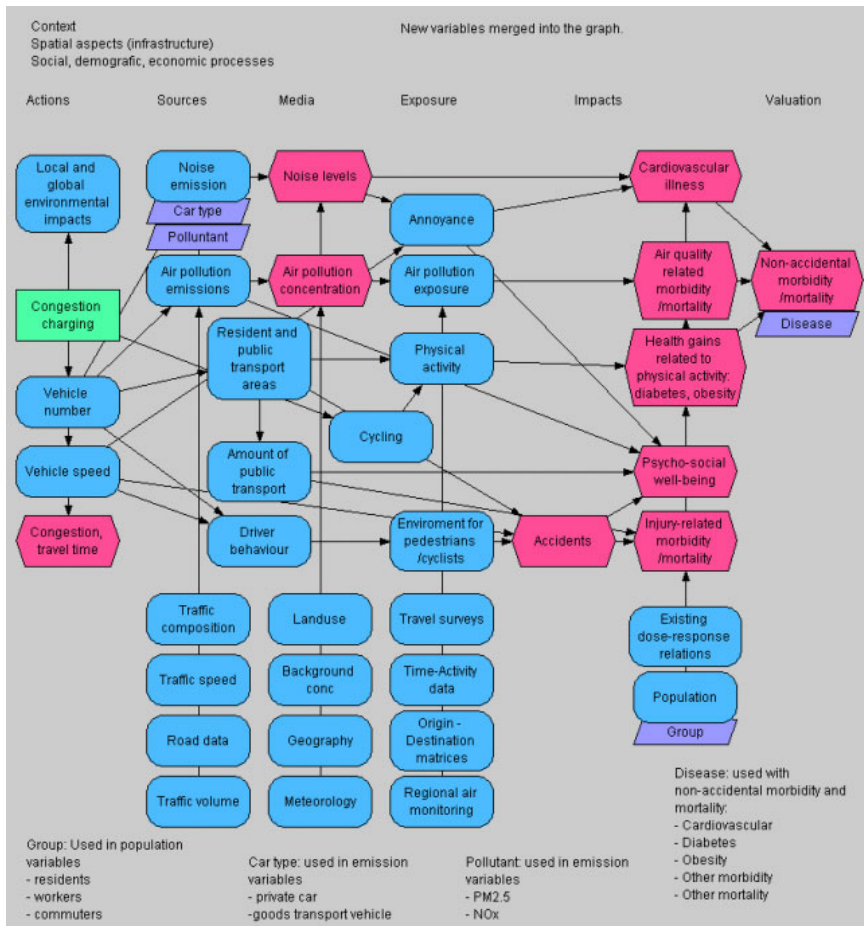
The identified variables are located along the source-impact chain forming the skeleton of the causal diagram. The skeleton is then completed with necessary additional variables so that the whole source-impact chain is covered and all the variables included in the assessment are causally related, directly or indirectly, to the endpoints.

### **Outcome of the phase**

At this point there should be a complete tentative causal network diagram covering the whole source-impact chain and including about all of the variables that are seen necessary to estimate within the assessment. It is, however, enough to have identified the names and tentative scopes of variables and have statements of the existence of causal relations between all the variables. This is, in essence, the description of the Definition attribute of the assessment.

The causal diagram is a graphical representation of the risk assessment situation. Variables and their relations form the diagram. The diagram provides a graphical summary of the assessment and helps the assessors in identification of the issues to be assessed and targeting their work during the later phases of the assessment.

Below is an example of a complex causal diagram. The green rectangle is a decision variable; purple hexagons are indicators; and blue nodes are other variables. The variables are roughly located along the source-impact chain, with the steps along the chain described on the top of the figure.



## (4) Designing: The contents of variables form the substance of an assessment

### Purpose/goal of the phase

During this phase the variables described in the causal diagram are described more precisely, including also defining the causal relations in more detail. It may also contain quality criteria and plans for collecting the necessary data or models needed to estimate the variable results.

### Activities carried out during the phase

The work in this phase happens in iterative process between collection of information, synthesis of the information into the form of the information structure, and discussions about the descriptions of variables. The work of this phase is actually also a continuous interplay with the following phase, executing variables.

### Outcome of the phase

This phase produces the descriptions of the attributes for all the included variables. The descriptions may be in the forms of e.g. text, tables, figures, hyperlinks, and computer code.

## **(5) Executing: Variables and assessment-specific analyses need computing**

### **Purpose/goal of the phase**

This phase is about collecting the data needed, executing the models described in the Definition attributes of the variables, and storing the results in the result database.

This phase also performs assessment-specific analyses such as optimisation, decision analysis, value-of-information analyses and so on. These analyses are also discussed and conclusion are made about them. Also conclusions about the results of indicator variables given the scope of the risk assessment are made. The scope of these analyses is assessment-specific, and it goes beyond a single variable.

### **Activities carried out during the phase**

When the causal network has been developed into a relevantly complete and coherent description of the phenomena of interest on the variable level, the attention may be turned into evaluating the quality of the content of the description. This means e.g. deliberating if the result estimates of variables are good representations of the real-world entities that they describe, are the causalities properly defined, and are the assessment endpoints, key variables and indicators thus reliably estimated. This phase includes e.g. considerations of uncertainties, importance of variables, data quality etc. When the marginal benefit of additional efforts becomes small enough, i.e. additional work does not improve the output remarkably anymore, the assessment can be considered ready.

- Data collection
- Expert elicitation
- Modelling & estimation
- Assessment-level analyses
- Testing & validation
- Deliberations and discussions

### **Outcome of the phase**

The outcome of this phase could be described as good quality causal network description. It means that all the necessary variables in relation to the scope of the assessment are described to a sufficient degree, providing the answers to the questions asked in the assessment. This is materialized as the definitions of the result attributes of each variable and the result attribute of the assessment.

## **(6) Reporting: The conclusions make the message to decision-makers**

### **Purpose/goal of the phase**

In this phase the information created in the assessment is compiled and conveyed to the intended users.

### **Activities carried out during the phase**

- Interpretation

- Communication with users & stakeholders
- Evaluation
- Documentation & presentation

### **Outcome of the phase**

The outcome of this phase, and thus also the outcome of the whole assessment, becomes realized in the form of an assessment report that concludes the major findings of the assessment. It could contain e.g. the following parts:

- Name of the risk assessment
- Scope: Purpose, Boundaries, Scenarios, Optimizing, Analyses, Intended users, Participation in the assessment
- Variables (set of variables included): Decision variables, Outcomes of interest (=indicators), Other variables
- Results of indicator variables, other selected variables, assessment-specific analyses
- Conclusions on indicators given scope
- Summary

# Open risk assessments require new kinds of work

## Why not allow anyone to participate?

In contemporary risk assessment related discussions, and discussions in general about the interfaces between science and policy, **stakeholder involvement** has been widely recognized as an issue of great importance within the overall process of societal decision making. This text approaches the topic from the point of view of actively involving stakeholders in the risk assessment process.

### Introduction

Risk assessment is a process for analysing and synthesizing information so that it is useful for societal decision-making about the phenomena being assessed. Risk assessment process is a deliberation process between scientists, authorities or decision-makers, and other stakeholders, which at some point comes to a conclusion. In environmental health the process should take into account societal values or preferences for different health states and outcomes, and thus integrate technical assessment and public values<sup>[14]</sup>. In order for the risk assessments to fulfill their purpose, it is necessary to involve stakeholders to risk assessment process. Stakeholder involvement can be used as a means of improving the quality of the content of the assessment product, the applicability of the assessment product and sometimes even the efficiency of the assessment process.

### Definition of stakeholder

When discussing stakeholder involvement it is good to be clear what is meant with the word stakeholder. Below are given a couple of exemplary definitions of related terms picked from other sources:

- **Stakeholder:** *any group or individual with an interest in an Environment Agency decision, whether through influencing the decision-making or being affected by the decision. Stakeholders may be citizens, organisations or specialists.*<sup>[15]</sup>
- *[T]he term **the public** is used [...] in the broadest sense to include anyone, including both individuals and organizations, who may have an interest in an Agency decision.*<sup>[16]</sup>
- **Stakeholders** *are representatives from organizations or interest groups who have a strong interest in the Agency's work and policies.*<sup>[17]</sup>

The way the concept of a stakeholder in environmental health risk assessments is applied in this text is a kind of a generalisation of the definitions given above: **Stakeholders are any individuals or organisations that have or may have interest in the issues that are being assessed.** This allows the group of stakeholders to potentially represent all possible views and needs that exist. Basically anyone can be considered as a stakeholder in relation to the assessment product that is being worked on.

### Different kinds of stakeholders

Already in the few lines of introductory text, several different types of groups were identified and mentioned as examples of possible stakeholders: scientists, authorities, decision-makers, individual citizens, organisations, specialists, interest groups and others. There are infinite ways to categorize stakeholders into groups.

If we follow the idea expressed in the text explaining the principles of collaborative work, that

in relation to the assessment product everyone is potentially a stakeholder, there are no fundamental differences between stakeholders. Therefore grouping stakeholders into categories should be based on practical reasons, e.g. according to the role of each stakeholder in society in relation to a particular assessment. A probably easily acceptable way of dividing stakeholders into groups is as follows:

- Risk assessors
- Decision-makers
- Other stakeholders

Risk assessors refers to the group of people that have a formal position of contributing to an assessment based e.g. on their profession or by having been assigned to the job of carrying out an assessment. Most often these people tend to be scientists or other specialists on the particular field of the issues being assessed. Of course being a scientist or a specialist does not inevitably imply that one would always be a risk assessor. Specialists or scientists may well also be in some other roles in relation to an assessment, e.g. as decision-makers or even more often as individual citizens.

Decision-makers are the ones who are intended to use the output of an assessment in the decision making process. They thus have a formal responsibility in relation to realizing the intended effects of an assessment by using the outputs of the assessment in societal decision making.

The group of other stakeholders (which are most commonly referred to as *the stakeholders*) could be divided into a whole collection of different subgroups: industrial and commercial organisations, non-governmental organisation (NGO's), individuals etc. Despite the apparent lack of connection between these subgroups, from the point of view of risk assessment there is one fundamental property that they share: the potential interest in the possible consequences of the decisions based on the assessment output.

### **Reasons to involve stakeholders in risk assessment**

The reasons behind participation of public or stakeholders have been identified e.g. by Fiorino [18] as either **normative, substantive or instrumental** and by the Economic Commission for Latin America and the Caribbean [19] as either **ethical, political, pragmatic or epistemological**. Building on these categorisations, this text groups the reasoning behind stakeholder involvement into three categories as follows:

1. Normative and ethical reasons
2. Instrumental, pragmatic reasons
3. Epistemological, substantive reasons

The three categories of stakeholder involvement are not exclusive, but rather should be seen as different foci that can be also addressed simultaneously.

Fulfilling the normative requirements and addressing ethical concerns about stakeholder involvement is the minimum level that must be done in a risk assessment. In many cases the minimum level of stakeholder involvement is legally enacted in order to ensure the rights of stakeholders to participate in the societal decision making processes. However, the legal requirements often stress the involvement in the decision-making rather than directly in the assessment process itself.

The instrumental, pragmatic reasons to involve stakeholders are mainly related to increasing the sense of ownership, trust and acceptance of the decisions and the information that they are based on. In relation to the risk assessment, the pragmatic reason for stakeholder involvement is that they increase the effectiveness and efficiency of the risk assessment. For example, involvement increases the usability of the assessment output by making the description of the assessed phenomena more comprehensible to non-specialists. Another



example; stakeholder involvement increases the acceptability of the assessment output, because all interested parties contributed to it.

Probably the greatest potential of benefiting from stakeholder involvement lies in making use of the diverse knowledge and plurality of views of stakeholders. Stakeholders may possess some local or other special knowledge about the phenomena being assessed that is not held by the specialists or that is not available in any official databases or information sources. Maybe even more importantly stakeholders represent their values and are thus a crucial source to be considered when identifying the public perceptions towards risk related phenomena and other value judgments.

### **Approaching stakeholders**

Although stakeholders have a (potential) interest in the issues of assessment, it does not necessarily imply that they are willing to commit themselves to collaborative work. For example, decision makers can be lacking the time, representatives of industry might not see the benefits of participation and perhaps individual citizens think it will be too bureaucratic. Stakeholders probably need to be approached, if it is seen important to have them involved. This paragraph discusses four different approaches to stakeholder management.

Most often, not all stakeholders have an equal stake in the risk assessment, neither may they be of equal importance in every phase of the assessment. For example, the involvement of industry in the process of issue framing is not crucial for the acceptance and relevance of the assessment outputs, because decision makers use the output. In contrast, industry involvement in defining specific variables within the assessment may yield unexpected important contributions. **D**

Because interests and the importance of stakeholders differ, one should decide to what extent a particular stakeholder (group) needs to be involved in a particular phase of the assessment. In identifying and defining this two stakeholder dimensions are important: (a) stakeholder power and (b) stakeholder commitment/interest. Stakeholder power refers to the stakeholders' ability to obstruct or to accelerate the assessment process. Stakeholder commitment/interest refers to the stakeholders' willingness to execute its power; stakeholders either want to be involved or are not interested. The two dimensions combined provide **four types of stakeholders, which each require a different approach for involvement** .

- Powerful and interested stakeholders need to be involved actively. For example, the decision makers are invited into a meeting for defining their information needs, or industry representatives are invited to express their opinion.
- Powerful, but NOT-interested stakeholders need to be kept satisfied. How this should be done, depends on their wishes. For example, a financial contributing party could be satisfied with an end report of the assessment.
- NOT-powerful, but interested stakeholders need to be informed. For example, interested citizens, interest groups, and decision makers could be informed about the design and execution of the assessment.
- NOT-powerful and NOT-interested stakeholders may probably be ignored, because they are not willing to collaborate and are not of importance in the phases of the assessment.

(NB. It could be that a particular group of stakeholders (risk assessors, decision makers, industry, authorities, etc.) is typified differently per risk assessment phase.)

The benefit of applying the above typification is the identification of key-stakeholders in each phase of the risk assessment. Consequently, the (key-) stakeholders can be involved in such a manner that matches their expectations. This in turn increases their commitment and optimizes the effectiveness (relevance, acceptability, applicability) and efficiency of the risk assessment.

## **Stakeholder involvement as mass collaboration**

Stakeholder involvement is a form of mass collaboration. In this perspective stakeholders should be considered as potential contributors to the assessment product, a description of a piece of reality, and the assessment process should be designed as such that it enables the involvement of stakeholders directly to the assessment process and that the contributions of stakeholders can be included in the description. This makes it possible to make the best use of the knowledge and values of stakeholders in the assessment. Also the instrumental, pragmatic aspects of stakeholder involvement aiming for better applicability of the assessment output can be addressed through direct participation in the assessment work.

## **Openness in stakeholder involvement**

The concept of openness is an important concept in collaborative work and therefore an important aspect also in relation to stakeholder involvement. It defines the way the interaction between the contributors is organized and managed. As defined in collaborative work, important dimensions of openness are at least:

- Openness of participation
- Openness of access
- Openness of influence
- Openness of temporal presence

The level of openness in stakeholder involvement in terms of the above-mentioned dimensions should be organized in relation to the purpose and goals of the assessment taking into account the situational practicalities, such as e.g. legal requirements, public perceptions on the issues to be assessed, available resources etc. The level of openness can be adjusted separately for different (groups of) stakeholders as needed and the level of openness may also vary in time as well as case by case.

The methods for managing stakeholder involvement should ideally be flexible enough to allow any level of openness in any dimension as needed. Since the common contemporary approaches to risk assessment have rather restrictive than open strategies to stakeholder involvement, in practice means that new methods should be developed with the aim of being able to allow and tolerate more openness.

In addition to the expected benefits in improving the outputs of risk assessments, openness in stakeholder involvement also brings about some practical challenges, which need to be addressed and managed. These are e.g. disputes rising from different perceptions and values among the participants and balancing openness and efficiency of the assessment process. Anyhow, the potential benefits of openness in improving the effectiveness of assessments are so substantial that it is worthwhile to take the pain of dealing with these challenges.

## **Techniques to organize stakeholder involvement**

There are several different practices for stakeholder involvement. For example, in the book *Understanding Risk* by National Research Council [20] common approaches to deliberation and public participation were listed as follows:

- Public hearings
- Citizen advisory committees and task forces
- Alternative dispute resolution (*mediation*)
- Citizens' juries and citizens' panels
- Surveys
- Focus groups
- Interactive technology-based approaches
- Combinations of deliberative methods

The list above is made with the idea of gathering contribution from public, i.e. laypeople, to decision making about risks. While some of the techniques are more deliberative in their nature, some are more intended for collecting public input without involving them in deliberations about the issues.

The use purpose of the abovementioned techniques can be also expanded to cover the collection of input from all kinds of wider groups, be they called public, stakeholders, decision-makers, specialists etc. In principle, the techniques are also applicable whether they are used as means for direct contribution during the risk assessment process or only before the assessment in issue framing phase or after the assessment in evaluating decision options. Therefore, the techniques listed above are merely examples of possible practical arrangements in organizing stakeholder involvement, it is a matter of openness in its different dimensions that is being applied in each case that ultimately makes the greatest difference.

Maybe the greatest changes in relation to the above techniques during the years since writing the book *Understanding risk* have taken place in the development of the *interactive technology-based approaches*, especially in the use of internet becoming a commonplace practice within many aspects of modern society. This brings about greater possibilities in organizing stakeholder involvement more openly and efficiently (see e.g. Pereira et al., 2006). The openness has been raised as a central issue in contemporary developments of improving the interfaces between science and society. In risk assessment this issue openness and its new possibilities by the aid of modern information technology is emphasized e.g. in the Open Risk Assessment (ORA) and Pyrkilo method development carried out by the National Public Health Institute of Finland (KTL) (see e.g. R80 Pyrkilo method article).

U.S. Environmental Protection Agency has collected experiences about and practices of public participation from their own work and published a Public Involvement Policy and a number of related documents (U.S. EPA 2003), which mainly address the practices of arranging public participation and stakeholder involvement using different techniques. The webpages on stakeholder involvement by U.S. EPA (<http://www.epa.gov/stakeholders/>) [21] also include other interesting information that can be useful as reference in the stakeholder involvement development.

Anyhow, disregarding the combination the chosen techniques, the most important things in relation to organizing stakeholder involvement is to identify and understand the purpose of stakeholder involvement in the particular assessment at hand and the role of the particular involvement events within the overall interaction between different contributors to the assessment. Reaching this naturally requires a clear understanding of the purpose and goals of the whole assessment and proper identification of the roles of the different contributors in relation to it. If these issues can be made clear, the right level of openness in its different dimensions can be identified for each assessment, and the right techniques and practices to carry out the stakeholder involvement can be realized.

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## Mass collaboration is a way to organise non-organised groups

**Mass collaboration** is a new kind of approach to carrying out risk assessments. It takes the assessment product, the description of a piece of reality, as the central object which a diverse

group of people contribute to and communicate by. In relation to the central object, the product, in principle everyone is seen as merely a contributor and no contributor has any more ownership of the product or a part of the product than anyone else. The product of the assessment is thus seen as a common property produced for a given, and preferably explicated, purpose.

## **Introduction**

Mass collaboration means more than just dividing tasks within a group into pieces that belong to someone. It is a way of working together on a shared set of tasks for a common goal. It makes use of the collective knowledge of groups and plurality of views in order to improve the output of the work. Its best properties can be seen in situations where there is a diverse (and maybe unknown) group of potential participants who possess different kinds of knowledge and represent a variety of value judgments about the issue that is being worked on.

Mass collaboration can be seen as a form of group communication which results are manifested and explicated in the product of the work. The product also serves as a platform or a medium for communication between the contributors. This means that the contributions to developing the product are messages that are sent by the contributors in form of manipulating the object that is being worked on and received by other contributors through observing the product. Through this communication by contribution the product thus develops into an explication of the shared understanding about the issue that is being worked on.

Mass collaboration can also be considered as a form of collective learning. The following example on collaborative design and some explanatory sentences about mass collaboration illustrate well the basic ideas underlying mass collaboration. The citation below has been copied from *collaborative learning-work* article in Wikipedia, the open encyclopedia in the web. Wikipedia itself is also an example of a system that builds on the principle of mass collaboration.

*For example, a work group engaging in the process of design would ideally need to pool their individual knowledge in order to create a new product. They will eventually want to create a shared meaning, which would allow them to take action together to carry out the design. Creation of shared knowledge structures involves symbolic interaction rather than manipulation of raw materials. Humans use their symbols to create, re-create, and share meaning and understanding, i.e. to develop new concepts. The use of symbols to create a shared knowledge structure is a primary focus of collaborative learning-work<sup>[22]</sup>.*

During the recent years mass collaboration has shown its effectiveness in many ways and is gaining popularity in many fields of business and science. The most recognized example is probably Wikipedia, which builds on complete openness and world-wide coverage, but the ideas of mass collaboration and wiki-type applications are also becoming more and more commonplace within smaller and possibly more closed communities, e.g. individual companies and research institutes. The principles of mass collaboration can be applied successfully for many different kinds of purposes, carrying out risk assessments is one.

## **Openness and collaboration**

Before moving on to consider the implications of mass collaboration in risk assessment, it is useful to discuss another concept, openness, which is very important to understand when thinking about mass collaboration. In principle the idea of collaboration builds on complete openness, but there might be practical reasons to limit openness e.g. in order to ensure the efficiency of the work process. It is also worth noticing that the openness here primarily means openness to directly contribute to the target of work, the product, not to the work process, which may be considered as an indirect way contribution to the product.

At least the following dimensions of openness can be identified:

- Openness of participation
- Openness of access
- Openness of influence
- Openness of temporal presence

Openness of **participation** refers to who, and on what basis, are invited or allowed to contribute to the work. Openness of **access** refers to what parts of the work are available to contribute to. Openness of **influence** refers to what extent may a particular contribution have influence on the target of work. Openness of **temporal presence** refers to the when is it possible to give ones contribution. The overall openness is a combination of all these dimensions.

The methods used for managing mass collaboration should ideally be flexible enough to allow the full range from complete closure to complete openness in all the dimensions of openness in order to adapt the work process to match all possible needs. The situations naturally vary case by case and the right form of working is ultimately defined based on the understanding about the use purpose of the product.

### **Mass collaboration in risk assessments**

The reasons behind applying mass collaboration in risk assessment are basically very practical: to improve the effectiveness of the output of an assessment and to improve the efficiency of the assessment process. Collection and synthesis of the knowledge and views of a diverse group of people tends to lead to better outputs than just relying on the knowledge and views of a single or few individuals. Also, inclusion of diverse groups to contribute to the work tends to increase the acceptability of the outputs and can help to improve the usability of the outputs. Even the efficiency of the work process can be enhanced by mass collaboration, although the effect of unsuccessful or badly managed collaboration can also turn out counterproductive in this sense.

A risk assessment can be considered as a good example of work which aims are clearly on creating shared understanding and where mass collaboration thus has great potential to be useful. In a simplified characterisation, a risk assessment should succeed in creating shared understanding between:

- The group of scientific experts on the issue
- The scientists and the decision-makers
- The scientists and the stakeholders (including public at large)
- *The decision-makers and the stakeholders*

The categorisation above is somewhat artificial, because in principle anyone belonging to any of the abovementioned categories could be a contributor to a risk assessment. Anyhow, in practice it is useful to recognize the different roles that different potential contributors may have in the overall societal decision making process and thus represent a particular interest and view to the risk assessment. The categorisations above are also inherently inter-related and have influence on one another. The last bullet, creating shared understanding between the decision-makers and the stakeholders can only be indirectly influenced by the risk assessment, the other can be addressed directly in the risk assessment process.

Applying the principle of mass collaboration in risk assessment means taking the output of the assessment work, the description of a piece of reality, as the central object of scrutiny. The description is the thing that is being worked on and which serves as the central point or a hub of communication between the participants. In principle all participants are seen as contributors to the product and the product is considered as an independent object. In other words it could be said that all contributors are *stakeholders* in relation to the assessment product. This also implies that no one, in principle, has any more ownership to the product or a part of the product than anyone else, the product becomes common property of all

contributors. Furthermore, if the participation is not limited, everyone becomes a potential contributor and the assessment product becomes more or less common property of the society as a whole.

The output of an assessment is thus an explication of the shared understanding of those who have contributed to the assessment. In a risk assessment the product is a compilation of information that attempts to describe a certain piece of reality as representation of the collective knowledge of the group of contributors about the assessed issue. The description develops iteratively through the contributions of the participants. The contributions are explicated messages that change the structure of the description and trigger other contributions by other participants. Ideally, the description is ready, when there are no more contributions and the quality of the description does not improve anymore. In practice, the assessment work can be declared done when no more big improvements take place and the quality of the description is perceived as sufficient. The assessment product is then ready to be used.

### **Facilitating mass collaboration**

To facilitate such synthesis of diverse knowledge and plurality of views, carrying out risk assessments needs some kind of a collaborative workspace which functions as the platform for mass collaboration. A collaborative workspace serves the purpose of providing e.g. the following functionalities:

- Facilitating communication between participants
- Facilitating documentation and representation
- Dealing with disputes
- Managing openness

In fact the collaborative workspace is the location of storing, manipulating and representing the target of work, the description of reality. It enables the participants to send their messages by making their contributions to the description and other participants to receive these messages. Enabling this communication through the target of work is the primary function that the assessment workspace needs to provide. In many cases, managing openness can also turn out crucial in practice. Providing tools to manipulate external data within the workspace in order to help the participants to create and support ones contributions may be convenient and efficient, but in principle secondary, for the assessment workspace.

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## Users included and excluded must be specified

In general terms, applying the new risk assessment method means managing the risk assessment process and producing the risk assessment outputs according to the method. By assisting this, the toolbox should be able to help the risk assessors to (see:General properties of good risk assessments for more detailed description of the properties mentioned below):

- Improve the quality of the contents of risk assessment outputs
- Improve the applicability of the risk assessment outputs
- improve the efficiency of the risk assessment processes



## Users and use purposes of the method

A spectrum of different potential users of the new risk assessment method can be described e.g. as:

- A Scientists, risk assessors in administration, or consultants working for administration on the European level.
- B Scientists, risk assessors in administration, or consultants working for administration on the national level.
- C Risk assessors in administration or consultants working for administration on the community level.
- D Authorities involved in managing risks but not actually qualified in making risk assessments (any level).
- E Political decision-makers (any level).
- F Representatives of the industry or business.
- G Representatives of NGOs.
- H Citizens directly affected by the risk assessment outcomes.
- I Anyone interested.

A spectrum of different kinds of use purposes by different users of the method can be described e.g. as in the table. Also tentative priorities have been given for the toolbox to facilitate different uses for different users (XXX = high importance, XX = moderate importance, X = potential importance, empty cell = no identified need or low importance).

	A	B	C	D	E	F	G	H	I
1 Managing an assessment	XXX	XXX	XXX	X					
2 Contributing to an assessment as a risk assessor	XXX	XXX	XXX	X					
3 Contributing to an assessment as a stakeholder	X	X	X	XX	XX	XXX	XXX	XXX	XXX
4 Contributing to an assessment as a decision maker				XXX	XXX				
5 Observing assessment-specific information	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
6 Observing general environmental health related information	XX	XX	XX	XXX	XX	XXX	XXX	XXX	XXX
7 Observing general risk assessment related information	XX	XX	XX	X	X	XX	XX	X	X
8 Producing general environmental health related information	XXX	XXX	XXX	X	X	XXX	XXX	XX	XX
9 Producing general risk assessment related information	XXX	XXX	XXX	X	X	XX	XX	X	X

## Don't hide disputes, resolve them

**Contributing to a discussion** presents rules of discussion engagement and discussion format, as well rules for editing discussions.

Your contribution in the form of remarks or argumentative criticism on the content of the wikipages is most welcome. It can change the outcome of the integrated risk assessment; it

will improve it and make the integrated risk assessment better understandable for decision makers and other stakeholders. The discussions will show the reasoning behind our work; it will indicate the objective and normative aspects in the risk assessment. In this way, decision makers and stakeholders in general can judge themselves whether they agree on our normative weighting. In order to obtain an orderly discussion it is appreciated if you follow the discussion rules and apply the discussion format.

### Discussion rules

1. Freedom of opinion. Everyone has the right to criticise or comment on the *content* of the wikipages.
2. State your critique with supporting arguments or your comment or remarks under the tab *discussion* **D** and sign it.
3. Comments, remarks, statements and argumentation must relate to the topic of the wikipage.
4. Only statements made and arguments given can be attacked.
5. Comments, remarks, statements and argumentation can NOT be redundant. They cannot be repeated.
6. You are supposed to be committed to your statements, that is:
  - a) if someone doubts on your statement (↔), you must explain it (edit or defend ↩).
  - b) if someone attacks your statement (↔), you must defend it (↩).
  - c) if someone doubts on your argument (↔), you should explain it (edit or defend ↩).
  - d) if someone attacks your argument (↔), you should defend it (↩).

### Discussion format

**BASIC DISCUSSION FORMAT:** For discussing, the discussion format (Blue **D** in the toolbar on the *edit* tab) should be used. This is how the discussion format appears:

<p><b>Dispute:</b> Add topic of discussion: This is either</p> <ul style="list-style-type: none"> <li>■ a single statement made in the wikipage text upon which someone cast doubt, or</li> <li>■ a statement made in the wikipage text and an opposing statement (thesis and anti-thesis)</li> </ul> <p><b>Outcome:</b> Under discussion (to be changed when a conclusion is found)</p>
<p><b>Argumentation:</b></p> <p>Add argumentation using attack-, defend- and comment buttons in the toolbar. Please be to the point and re-read your contribution first, before you store it.</p> <p>--#(number x): The blue horizontal line represents the comment button. It yields this blue layout, which is used for <b>comments</b> and <b>remarks</b>.</p> <p>↩#(number x): This green arrow represents a <b>defending argument</b>.</p> <p>↔#(number x): This red arrow represents an <b>offending argument</b>.</p>

Furthermore:

- If you agree with an argument made by others, you can place your signature (in the toolbar) under the argument.
- Arguments may be edited or restructured. However, if there are signatures of other people, only minor edits are allowed without their explicit acceptance.
- If agreement is reached, i.e. the dispute is settled or resolved, the result can be stated at **outcome**.

**N.B.** In order to contribute to the discussion you should be logged in. If you have not yet a user account, you can make one.

---

**ARGUMENTATION TYPE INDICATION:** It is recommended that you indicate your argument type, so that readers (decision makers) can see at once whether the argument is **theoretical** (T), **ethical** (E) or **practical** (P). Theoretical arguments are arguments that can be falsified (even after discussion closure). Ethical arguments are arguments based on ethics. Practical arguments are situation specific arguments. Notation examples:

←#(7 E): This is an example of the notation of an offending ethical argument.

←#(8 T): This is an example of the notation of a defending theoretical argument.

**ARGUMENTATION STRUCTURE:** If you use **coordinative arguments** \*, it is recommended that you use this notation:

←#(3 P): (3.1) We have no capacity for further research. **AND** (3.2.) There is no budget to outsource research.

If you use **subordinative argumentation** \*\*, it is recommended that you use this notation:

←#(4 P): We have no time for further research on this topic.

←#(5 P): *Because* there is other research to be done.

←#(6 P): *Because* the results of that research have to be included into the report.

The purpose of the numbers is to make it easier to refer to a specific argument. The numbers are simply running numbers and they do not show a position in the argumentation thread. If you add an argument between the two other ones, the arguments do not show up in numerical order. This is OK. However with coordinative arguments, sub-numbering is used because only the arguments together make a whole rational argument. Alone these arguments would not hold against rational criticism.

\*Coordinative argumentation is using complementing arguments, that are mutual dependent for the defense of/attack on the statement.

\*\* Subordinative argumentation is using arguments to support arguments.

### Editing discussions

- In principle everyone can edit a discussion.
- If you have initiated a discussion, it is expected that you also take care of the discussion editing.

- It is polite to inform the other discussion participants about changes (by placing a notification on their user page).

#### Rules for editing discussions

1. Only minor changes can be made to arguments with signatures of other people. However, you can suggest improvements and ask the persons who signed the original argument if they agree.
2. Valid arguments come first ( ~~←#~~ or ←# ), invalidated arguments at the end ( ←# or ←# ) of the discussion. However, the hierarchy (threads) of argumentation must be maintained.
3. You cannot simply remove arguments that are irrelevant within their context. This is what you can do instead:
  - a) You can attack the argument with a relevance argument. If you are right, your argument will invalidate the original one.
  - b) You can cut and paste the argument into a relevant discussion. Please, write a comment on the original argument location describing what was moved, why the argument was moved (you must be able to show the arguments irrelevance), and to where it was moved (add a link to the new page).

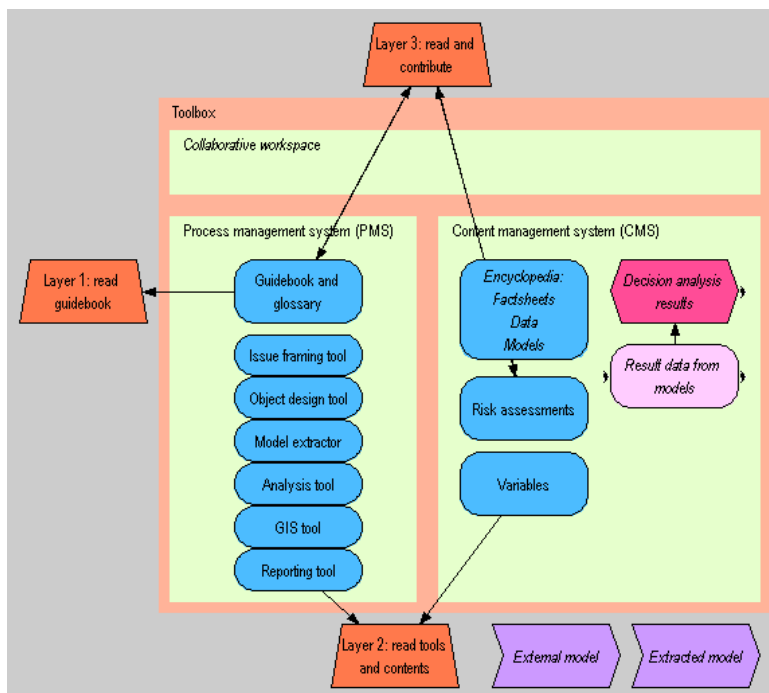
#### Related pages

- Argumentation Analysis

# There are tools available to help with open risk assessments

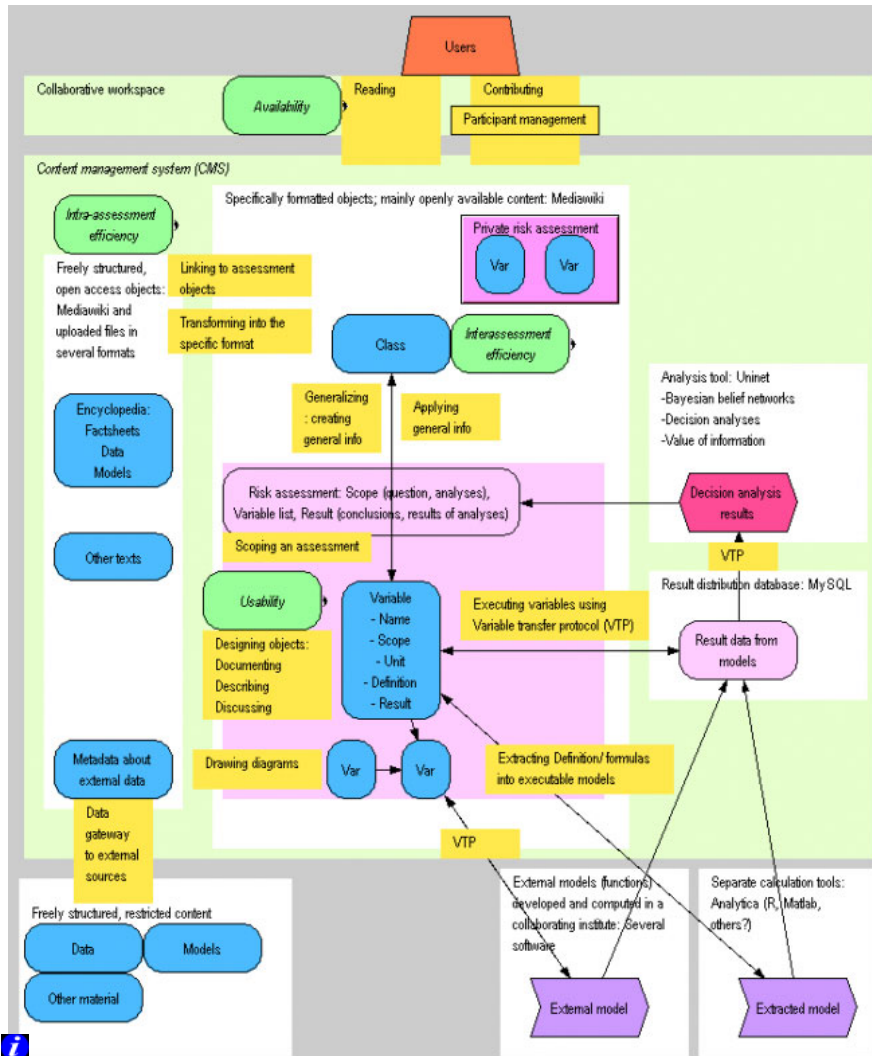
Open risk assessments are complex things to accomplish. Even a single-user work on risk assessments is complex. When a non-restricted group of people is allowed to participate, there are specific technical problems to manage the process, not to mention the contents. Therefore, several tools have been developed to facilitate open risk assessments. Especially Intarese project has been very active in this area. In 2007, these tools have started to take shape, but a lot of functionalities still don't exist. Therefore, the following description is somewhat theoretical, with little practical experience on the importance or the applicability of the tools.

The figure below presents an overview of the toolbox contents, according to the plans in the Intarese project. Collaborative workspace is an interface between the user and the integrated resource platform. The platform consists of two parts: the process management system and the content management system. **The process management system** gives guidance for the work and offers tools to make risk assessments, collect information, and manage the contents. **The content management system** contains substantive information and data about environmental health issues and risks. The products of risk assessments (assessment reports and variables) are located here.



The figure below presents an overview of the contents in the content management system. The content is divided into freely structured and specifically structured content (see below for more detailed description). Information flow is shown as arrows (not all arrows shown for

clarity). Processes for handling the information are shown as yellow boxes. Green nodes refer to the properties of good risk assessments that are expected to be achieved by using a particular functionality in the toolbox.



## Collaborative workspace is the interface for participation

**Collaborative workspace** is virtual working platform that allows open groups to participate in risk assessments. It is an interface for the users to access the toolbox contents, make their contributions to the assessment and communicate between each other. It also provides tools to organize and manage the user contributions.

In fact the collaborative workspace is the virtual location of storing, manipulating and representing information. It enables the participants to communicate between each other in the form of making their contributions to the contents of the toolbox. Enabling this communication through contribution is the primary function that the collaborative workspace provides. Enabling this also includes managing openness, both according to individual users and user groups or according to locations within the information structure of the content. Furthermore, the collaborative workspace provides the users access to the tools that they can use for making their contributions. Basically the idea behind the workspace is that everything can be searched for, found, saved, exchanged and discussed about in one place. In other words: The workspace functions as the "glue" between all parts of the assessment, helping the assessors to keep it together and in order, as well as enhancing both efficiency and effectiveness of the risk assessments.

### **Functionalities of the collaborative workspace**

In order to be functional, the collaborative workspace should provide the users with:

- access to browse, search, read and use the information contents of the toolbox, both within the process management system (PMS) and the content management system (CMS)
- access to use the tools within the PMS
- possibility to manipulate the information content, both within the PMS and the CMS

In practice, in order to make the above mentioned functionalities manageable the collaborative workspace also must enable:

- division of information content into individually manipulable pieces
- version and history control in the individual pieces of information
- management of openness, both according to users and according to content
- management of simultaneous use of tools and manipulation of content

### **Suggestions of techniques to get started**

- Collaborative workspace should be performed using **Mediawiki**, because that is the most common software for collaborative work, it is an open source software, and there is an active development going on.

## **Guidebooks tells how to do a risk assessment**

**Guidebook on risk assessment** is an electronic information center about making risk assessments according to the new risk assessment method. It describes each phase of the work, each method used, and each tool available to help in this work. It has open access and it is not necessary to login in order to reach this information. Material is mainly texts about methods and theories. There will be a short summary text about the issue that the user is facing and why it is important, linking to more detailed texts about the methods. These detailed texts will be complemented with short fact-sheets about the methods, with relevant links to the supporting resources in the **Integrated resource platform**. Depending on the specific phase/methods, these different types of texts will be more or less important/extensive.

### **Guidebook in the issue framing phase**

In the issue framing phases, the guidebook will provide access to methods and guidelines dealing with the 'why' question ("*Why are we doing this assessment? What would be the output in order to answer this question?*") and the 'what' question ("*What are we looking at and including in our assessment in order to answer our 'why' question?*") Methods that are

currently being developed in SP1 and that relate to this phase include

- Purpose and properties of good risk assessments
- Issue framing
- Scenario definition
- Full chain approach and causality
- Indicator selection and specification
- Variable definition and structure
- Addressing uncertainty in a risk assessment
- Including stakeholders in a risk assessment
- Reporting and logging your assessment

Each of these layers will include links to relevant pages in the Integrated resource platform and the Collaborative workspace as well as links to related information in this layer.

### **Guidebook in the design and execution phases**

In the design and execution phases, the guidebook will provide information on the "how" question (*"How can we estimate the variables included in our assessment?"*). Methods that are currently being developed in SP1 and that relate to this phase include:

- Source to exposure and exposure to effects
  - Source to exposure models
  - Intake fraction models
  - Models for source attribution of exposure
  - Exposure-response assessment
  - Use of both epidemiological and toxicological evidence in the exposure-response assessment
  - Combined exposures
- Aggregated Impact measures/ cross-cutting issues
  - Principles of monetary valuation and CBA
  - DALYs and burden of disease measures
  - Risk perception and MAU-analysis
  - Combining value judgments with descriptions of physical phenomena
  - Equity issues
- Research methods
  - Systematic review / Meta analysis (frequentist' meta-analysis, Bayesian meta-analysis, meta-regression)
  - Expert panel / elicitation
  - Multiple-bias modelling
  - Bayesian methods
  - GIS methods
  - Collective structured learning
  - Mass collaboration (including stakeholder involvement)
  - Dealing with disputes
- Uncertainty
  - Uncertainty analysis & Knowledge quality assessment
  - Characterizing uncertainty in the exposure-response assessment phase more systematically (e.g. see tables in WP1.3 protocol)
  - Value of information



Each of these layers will include links to relevant pages in layer 2 and 3, as well as links to related information in this layer.

### Guidebook in the reporting phase

In the reporting phase, the guidebook will provide information about final reporting, communicating and closing of the assessment. Methods that are currently being developed in SP1 and that relate to this phase include:

- Reporting results to policy makers and other stakeholders
- Graphical presentation of results, including GIS
- Communicating uncertainty
- Evaluating the risk assessment process

## Integrated resource platform contains environmental health information

The **Integrated resource platform** is a system containing tools and data that support the new risk assessment methodology. It will allow users to find data and tools of interest for their own risk assessments. In the Integrated resource platform, users can consult these data or tools (for example to check the coherence of their own data) and possibly use them (alone or with their own set of data) in the collaborative workspace to run a simulation. The pages of the Integrated resource platform will be linked to the pages in the Guidebook for which they have relevance. Furthermore, there will be a keyword system based on databases and tools. Resources will be classified by thematics corresponding exactly to the relevant phases of the integrated assessment methodology described by SP1. These thematics will be linked to the Guidebook. In each thematics, search will be possible using keywords. The result of each search will give access 1) to factsheets and 2) to links to external resources (for data) and/or internal resources (for tools : calculators etc.).

Primarisk is an example of an existing integrated resource platform.

**Table. Different parts of the Integrated resource platform according to their openness and structure.**

Type of content	Freely structured	Standard variable structure
<b>Public domain, open access</b>	<ul style="list-style-type: none"> <li>■ Guidebook on risk assessment               <ul style="list-style-type: none"> <li>■ Glossary</li> </ul> </li> <li>■ Encyclopedia on environmental health</li> </ul>	<ul style="list-style-type: none"> <li>■ Open Risk Assessments               <ul style="list-style-type: none"> <li>■ Variables</li> </ul> </li> <li>■ Result database</li> <li>■ Extracted models</li> </ul>
<b>Restricted or copyrighted</b>	Data gateway (metadata about external sources))	<ul style="list-style-type: none"> <li>■ Private risk assessments</li> <li>■ External models</li> </ul>

### Encyclopedia is the first place to search for information

**Encyclopedia on environmental health** is a part of the integrated resource platform that contains environmental health information and data. Thus, the main difference to the guidebook is that the guidebook contains information about making risk assessments, while

the encyclopedia contains information about the risks and other environmental health issues. The content is freely structured, i.e. it is not formally structured according to the method as variables or risk assessments, and it is openly available to all kinds of users. The encyclopedia may contain general texts, fact sheets, data (e.g. emission data), and models. If data described in the Data gateway (see below) becomes openly available, it can be copied to the Encyclopedia. Whereas the contents of the risk assessment guidebook are related to risk assessment methods and are mainly of interest to the risk assessment professionals, the contents of the encyclopedia may be of interest to a wider group of users, such as e.g. decision-makers, NGOs, industry or public at large. **D**

## Data gateway tells about data outside the toolbox

**Data gateway** is a part of the toolbox. It contains metadata about data and models that are not within the toolbox itself. They can be reached via links in the gateway, or, if they are not freely available, the gateway contains information about how they can be accessed.

Data resources have to be specifically identified based on SP2 outputs, listed by thematics (SP1) and connected to the relevant phase of the integrated assessment process when completed.

### Data

This section contains fact sheets and links to external data sources. For example, thematics for data and types of data resources associated could be:

- Epidemiology: national mortality data, morbidity, health survey... (WP 2.3?)
  - Biomonitoring data(bases) (WP 2.2?)
  - Population data (IC?)
- Toxicology: Toxnet, IRIS, atsd, WHO, ECB, RIVM, Health Canada... (Example of a Data Fact Sheet for toxicological data)
  - Toxicological models (INERIS)
- Physico-chemical properties: HSDB...
- Exposure:
  - Source-to-exposure models (INERIS)
- Characterisation of the environment:
  - Emission data (in air, soil, water, food...): available measures (EPER...), guidelines (IPPC...) (USTUTT)
  - Environmental data: concentrations in air, soil, water, food...: measures available, air quality guidelines, water quality guidelines... (WP 2.1?)
  - Meteorological data
  - Corine Land Cover...
- Characterization of the population:
  - Census data
  - Exposure factors: expofacts, EFH...
  - Biological data: biomarkers, biomonitoring surveys (CDC, GerIV...)
- Data fusion methods (CERTH?)
  - Use of (measurement) data for evaluation
  - Guidelines how to use data

This list is given as an example: it is not exhaustive neither it reflects specifically the current state of the art of the on going process in SP1 and SP2.

For each thematics there will be a possibility to access factsheets describing the metadata of the dataset and links to external databases. For example, a search in "toxicology" will give access to factsheets concerning the different kinds of toxicological data available (TDI, RfC,

UR, BMD...) and links to databases where these data are available (RIVM, EPA...). Most specific search will also be possible directly by keywords (Unit Risk...).

One can discuss the level of aggregation of the data described in one factsheet: continuing on the above example, would it be RfC only or all kind of toxicological data concerning threshold effects through inhalation exposure ? SP2 working groups could answer this question. Links will be provided to single databases (IRIS, ATSDR...) but also to web portal (Toxnet...)

As a result, a Template for data factsheet is proposed with an example. It will be provided to SP2 working groups. They will have the opportunity to react on it and to fill in the required information. They will also have to provide the corresponding keywords.

## Models

- Fact sheets and links
  - Source-to-exposure models Example of a Technical Fact Sheet for CHIMERE | Template of a Technical Fact Sheet | Template of a Multimedia Model Factsheet
  - Toxicological models Example of a Technical Fact Sheet for PBPK dioxin

## Suggested technical solutions

The gateway contains mainly text and hyper-links to external sources, maybe also some pre-formatted fact sheet-like pages. The possible software that could be used to operationalize the gateway in the toolbox are listed below. **D**

- Mediawiki: It has text edit and hyper-link functionalities, as well as search. It is easy to connect to other parts of the toolbox.
- Other platforms can easily be developed, but then the seamless connections to the collaborative workspace are lost.
- A user friendly and usable appearance of the system/platform is fundamental

## Open risk assessments are the core of the machine

The open risk assessments produce the core of content in the content management system (CMS). Typically the information flow in the content management system comes in a freely structured form from external sources through the data gateway and into the encyclopedia. This freely structured content is then synthesized as components of open risk assessment products. The open risk assessment products are formalized descriptions of reality as assessment-, variable- and class-level objects, which can be further manipulated within the information structure. The products of open risk assessment processes are also set openly available for others to use and develop.

The differences between open risk assessments and private risk assessments is that in private risk assessments both the participation in the process is limited, and the products of private risk assessments are not set freely available for others. Restrictions of access (either to process or products) are not necessarily complete either/or questions. It is possible for example to restrict access only to some parts of the products due to e.g. secrecy or sensitivity of certain variables.

## Result database stores variable results

**Result database** is a storage and retrieval system for variable results. It is basically an SQL database with the following functionalities:

1. Storage of results of variables with uncertainties when necessary, and as multidimensional arrays when necessary. **D**

2. Automatic retrieval of results when called from the collaborative workspace or other platforms.
3. Description and handling of the dimensions that the variables may take.
4. Storage and retrieval system for items that are needed to calculate the results of variables.
5. A platform for performing computer runs to update the results of variables.
6. Follow-up of the linkages between variables, the data about a particular variable, and the computing formula of the variable, in respect to their impact on the variable result.
7. Follow-up of the age and validity of the content based on the previous point.
8. A platform for planning computer runs based on the update need, CPU demand, and CPU availability.

### ***Functionalities of the result database***

#### **Storage and retrieval of results of variables**

The most important functionality is to store and retrieve the results of variables. Because variables may take very different forms (from a single value such as natural constant to an uncertain spatio-temporal concentration field over the whole Europe), the database must be very flexible. The basic solution is described in the variable page, and it is only briefly summarised here. The result is described as

$$P(R | x_1, x_2, \dots)$$

where  $P(R)$  is the probability distribution of the result and  $x_1$  and  $x_2$  are defining locations where a particular  $P(R)$  applies. A *dimension* means a property along which there are multiple locations and the result of the variable may have different values when the location changes. In this case,  $x_1$  and  $x_2$  are dimensions, and particular values of  $x_1$  and  $x_2$  are locations. A variable can have zero, one, or more dimensions. Even if a dimension is continuous, it is usually operationalised in practice as a list of discrete locations. Such a list is called an *index*, and each location is called a *row* of the index. In the general information structure of the new risk assessment method, dimensions are Classes with a special purpose. An index can be thought of as a variable that inherits its plausible range from a dimension (class).

Uncertainty about the true value of the variable is operationalised as a random sample from the probability distribution, in such a way that the samples are located along an index *Sample*, which is a list of integers 1,2,3...n, where n=number of samples.

The dimensions of a variable are determined by the parent variables (by inheritance) and the formula used to calculate the result. Thus, there is not a place where the dimensions of a particular variable are explicitly asked for. In addition, the indices (as operationalisations of dimensions) are NOT properties of variables but of risk assessments. This may sound unintuitive, but the reasoning is that indices are just practical ways to handle dimensions, and these practical needs may change from one assessment to another.

The tables **Variable** and **Result** contain the result data. In addition, **Location**, **Dimension**, **Index**, and **Rows** contain data about the dimensions and indices used. These tables together offer the functionalities of data storage and retrieval, and handling of multidimensionality and uncertainty.

#### **Calculation of the updated results**

The result of a variable can be calculated when four things are known:

1. The list of upstream variables (parents) (Definition/causality attribute),
2. The results of the parent variables,

3. The data used to derive the result (Definition/data attribute), and
4. The formula used to calculate the result based on the items above (Definition/formula attribute).

The three sub-attributes of the Definition are represented by three tables in the result database: **Causality**, **Formula**, and **Data**. In addition, the results of the parents can be obtained from the Result table. The variable transfer protocol is used to extract these data from the result database, send them to an external software such as R to calculate the result, and store the calculated result into the Result table of the database. The technical solutions to do this in practice have to be developed.

When a variable result is calculated, the computing software must know, which indices must be used with which variables. This can be automatically resolved using the following reasoning algorithm.

- Make a list of all unfinished risk assessments.
- Make a list of all indices in these risk assessments.
- Compile all indices of a particular dimension into one large "super-index" with all the locations.
- Use these "super-indices" in the calculations.
- Apply a particular "super-index" for a particular variable, if that variable has the dimension in question.

A wild use of occasional indices is discouraged, because they cause heavy computing needs with little benefit. Therefore, there should be a "standard risk assessment" that is constantly kept unfinished. It would then contain recommended indices for all major dimensions. This way, at least the standard indices are always used in computations, and the need for users to develop their own indices is smaller.

When the new results are stored in the database, the old results of the variables are deleted. The different versions of the variable results are NOT permanently stored anywhere. However, when a risk assessment report is created using the reporting tool, the result distributions used for that report are stored, together with the definitions and other data about all variables. Thus, a full copy of everything that relates to a particular assessment can be downloaded and stored outside the result database.

### **Follow-up of validity**

The result of a variable is valid since its update until something that affects its content (i.e., the four things listed above) changes. Therefore, there must be a system that follows what things these are for a particular variable, and whether they have changed since the last calculation of the variable result. When the data in Causality, Formula, and Data tables is combined with the data of the dates when the parent variables were run, it can be automatically concluded whether the variable is valid or not. If the variable is older than its determinants, there is a need to recalculate the result. This cannot be done fully automatically, because some variables are probably being actively edited, and this would create a constant need to update everything downstream. In addition, some complex variables may take even weeks to compute.

Therefore, there should be a planning system for result updates. This can easily be done by adding tables **Run** and **Run\_list** to the database. These tables contain information about the runs that have been performed or are being planned to be performed. The user can add variables to and delete them from the lists of planned runs. The needs for updating can be combined into practical collections of variables, given their connections, computer time needed, and computer time available. Then, when the task has been defined and the resources are available, a computer run can automatically be performed.

## Suggested techniques to get started

### MySQL:

The current idea is to describe the variables in Mediawiki, which is a text-based software. It would therefore become very difficult to operate these functionalities from there. Instead, if we store the data into the most convenient way, it can be effectively utilised. The most convenient way is to use an SQL database, which is the standard for large databanks. Among all SQL software, MySQL is the best due to several reasons:

- It is freely available open access software.
- It is easy to use.
- It has powerful functionalities.

To make this work out, we need a **variable transfer protocol** so that the result of a variable can be retrieved either automatically by a calculating software, or manually by the user who wants to explore the result. Fancy presenting software can be built on top of the database, so that the user does not see huge lists of numbers, but nice distributions instead. The development of this software is, again, technically straightforward, because:

- It is only communicating with the MySQL database, except some launch codes must be placed in other parts of the toolbox. Thus, the development can easily be decentralized.
- Something applicable probably exists in the open code world.
- It is not needed in the early life stages of the toolbox.

### *A suggested table and column structure for the database*

Variable
Information about variable attributes and validity
Columns <ul style="list-style-type: none"><li>■ Var_id* (identifier of the variable)</li><li>■ Var_name (variable name as in Mediawiki)</li><li>■ Var_scope (variable scope as in Mediawiki)</li><li>■ Var_unit (variable unit as in Mediawiki)</li><li>■ Validity_date (the date when the variable last was valid [1.1.2100 if it is currently valid])</li><li>■ Run_id (the run that produced the current results of the variable)</li><li>■ Run_time (CPU time that was needed for this variable during the last run)</li></ul>

Result
All results are stored in this table. Each value of a result of a variable has an own row.
Columns <ul style="list-style-type: none"><li>■ Result_id* (identifier of the row in this table)</li><li>■ Var_id (identifier of the variable)</li><li>■ Result (the actual value of the variable)</li><li>■ Sample (the row in the uncertainty index <i>Sample</i>. Use 0, if the result is deterministic.)</li></ul>

Location
The location of the result along a particular dimension.
Columns <ul style="list-style-type: none"> <li>■ Result_id*</li> <li>■ Dim_id*</li> <li>■ Location</li> </ul>

Dimension
Information about dimensions
Columns <ul style="list-style-type: none"> <li>■ Dim_id* (Dimension identifier)</li> <li>■ Dim_name (Dimension name)</li> <li>■ Dim_scope (Dimension scope)</li> <li>■ Dim_unit (Dimension unit)</li> <li>■ Dim_definition (Dimension definition)</li> <li>■ Dim_result: (Dimension result: the range of plausible values, such as "non-negative real number", "positive integer", or an exhaustive list of labels)</li> </ul>

Index
Information about indices
Columns <ul style="list-style-type: none"> <li>■ Ind_id* (index identifier)</li> <li>■ Ind_name (index name)</li> <li>■ Dim_id (dimension identifier)</li> </ul>

Rows
Information about rows of indices
Columns <ul style="list-style-type: none"> <li>■ Ind_id* (index identifier)</li> <li>■ Row_number* (the number of this row in the index)</li> <li>■ Location (the location along the dimension of this row and index)</li> </ul>

Risk_assessment
Attributes of a risk assessment
Columns <ul style="list-style-type: none"> <li>■ RA_id* (risk assessment identifier)</li> <li>■ RA_name</li> <li>■ RA_scope</li> <li>■ RA_started (date when the risk assessment was started)</li> <li>■ RA_finished (date when the risk assessment was finished)</li> </ul>

RA_vars
Defines the variables used in a risk assessment
Columns <ul style="list-style-type: none"> <li>■ RA_id* (risk assessment identifier)</li> <li>■ Var_id* (variable identifier)</li> </ul>

RA_indices
Defines the indices used in a risk assessment
Columns <ul style="list-style-type: none"> <li>■ RA_id* (risk assessment identifier)</li> <li>■ Ind_id* (index identifier)</li> </ul>

<b>Causality</b>
Defines the parents in the causal chain
Columns <ul style="list-style-type: none"> <li>■ Var_id*</li> <li>■ Causality_date (date when the parent list was last changed)</li> <li>■ Parent_id* (var_id of a parent variable)</li> </ul>

<b>Formula</b>
Defines the formulas of the variables
Columns <ul style="list-style-type: none"> <li>■ Var_id*</li> <li>■ Formula_date (date when the formula was last changed)</li> <li>■ Software* (name of the software able to run the formula)</li> <li>■ Formula (software code)</li> </ul>

<b>Data</b>
Defines the data of the variables
Columns <ul style="list-style-type: none"> <li>■ Var_id*</li> <li>■ Data_date (date when the data was last changed)</li> <li>■ URL* (location of the data file)</li> </ul>

<b>Run</b>
Information about the computer runs
Columns <ul style="list-style-type: none"> <li>■ Run_id* (the identifier of the computer run)</li> <li>■ Run_date (when the run was actually performed successfully)</li> <li>■ Run_who (who performed/will perform the run)</li> <li>■ Run_method (what method was/will be used in the run)</li> <li>■ Planned_run_date (the estimated date for the run)</li> </ul>

<b>Run_list</b>
List of variables in a run
Columns <ul style="list-style-type: none"> <li>■ Run_id* (the identifier of the computer run)</li> <li>■ Run_order* (the order in which the variables will be computed)</li> <li>■ Var_id (the identifier of the variable)</li> </ul>

\* This column or these columns together uniquely identify the row in the table

### External models run outside the toolbox but feed back to it

**External model** is a calculating piece of computer code that can be executed from within the toolbox, but it is physically outside the toolbox and it is maintained by a third party (not the user of the external model or the toolbox owner). This approach is utilised when 1) the model is unpractically large to be included in the toolbox, such as atmospheric dispersion models; or 2) the source code of the model is not freely available. The model looks like a function in the toolbox with the general format



```
Variable = function(input parameter 1, input parameter 2,...),
```

where function is the external model and the input parameters are input values that are needed to run the model. The model is executed and the results retrieved using the variable transfer protocol.

### Possible technical solutions

External models are flexible in the sense that there is no need to restrict ourselves to a single software. However, this is only possible when:

- The software is able to take the data for the parameters (usually upstream variable results) from the result database, and
- The software is able to place the result of the variable into the result database.

However, parts of this information flow can, at least in the preliminary phase, be done manually.

Possible software that may have the required functionalities:

- Analytica (<http://www.lumina.com>) , a Monte Carlo simulation program with graphical interface.
- R (<http://www.r-project.org/>) , an open access statistical software
- Unicorn ([http://dutiosc.twi.tudelft.nl/~risk/index.php?option=com\\_content&task=view&id=23&Itemid=23](http://dutiosc.twi.tudelft.nl/~risk/index.php?option=com_content&task=view&id=23&Itemid=23)), the "Uncertainty analysis with Correlations" (UNICORN) software tool, implementing staff research work on dependence modelling for high dimensional distributions.
- Many others if a module is built in the software to communicate using the variable transfer protocol.

### Extracted models are automatically extracted from the toolbox contents

**Extracted model** is a computing model that is created by extracting code out of a set of variables within the integrated resource platform. The code is an operationalisation of the definition of the variable. The code is located in the Definition/Formula attribute within an appropriate tag. For example, Analytica code is between `<anacode>place code here</anacode>` tags; R code is between `<rcode>place code here</rcode>` tags. When the code is compiled, it creates a fully functional model that can be run.

### Possible technical solutions

Extracted models are flexible in the sense that there is no need to restrict ourselves to a single software. Any object-oriented programming code can be attached to a group of variables, and those variables can be calculated using the particular software independently of the other variables and their calculation software. One variable can even contain several codes for different software, although this is not recommended due to possible updating problems. However, this is only possible when:

- The calculation software used utilises object-oriented programming,
- The software is able to take the data for the input variables (the most upstream variables that cannot be calculated inside the extracted model) from the result database.

However, parts of this information flow can, at least in the preliminary phase, be done

manually.

Possible software that may have the required functionalities:

- Analytica (<http://www.lumina.com>) , a Monte Carlo simulation program with graphical interface.
- R (<http://www.r-project.org/>) , an open access statistical software
- Unicorn ([http://dutiosc.twi.tudelft.nl/~risk/index.php?option=com\\_content&task=view&id=23&Itemid=](http://dutiosc.twi.tudelft.nl/~risk/index.php?option=com_content&task=view&id=23&Itemid=) the "Uncertainty analysis with Correlations" (UNICORN) software tool, implementing staff research work on dependence modelling for high dimensional distributions.

**Model extractor** is a tool that extracts the computer code out of the variable definition/formula attributes and compiles a self-sustained model file from them. The model can then be run by an external software, and the results can be uploaded to the result database.

- Works only for simple, exemplary assessments
- For all variables models are needed
- The causality is represented in a variable via the attribute *formula*: a complex model with 1000s of lines of code working in timesteps and on different scales cannot be integrated into a variable -> e.g. dispersion models, usually Eulerian models, cannot be integrated into a model extractor; for these, external models are used by applying the variable transfer protocol.

## Tools for doing risk assessments

### Issue framing tool gives guidance in the beginning

**Issue framing tool** is for scoping objects and drawing diagrams. The following functionalities could be provided.

1. **Scoping** is basically about describing the purpose, scope, boundaries, participants, and other general information about a risk assessment or variable. The tool should have functionalities for issue framing: defining a) the purpose, b) expected users, c) main questions, and d) boundaries of the assessment. Technically this is rather straightforward task: the endpoint is basically text. Methodological and practical help texts guide the user through the process, helping him in filling in the attributes.
2. **Templates for variables** are either existing variables or general properties, called classes. There should be some practical hierarchy for these objects so that the user can quickly browse through the existing objects and identify potentially useful ones for his assessment. The suggested hierarchy is based on the full chain approach following the causal chain of pollution from release to health impact and valuation.
3. **Drawing causal diagrams** is about making graphs with nodes (variables) and arrows (causal links) with some explanatory text. These diagrams form the basis for the modelling of the risk assessment. The diagram should consist of linked variables (one variable visualized in the form of a box) that visualize the causal chain and not just a flow chart. **Diagram tool** is a graphical tool. The tool helps the user to clarify the aims, the key components and the structure of the assessment. Secondly, it provides guidance to identify all necessary parts needed so that the user does not forget an important part of the assessment. Therefore the basic idea behind the diagram tool is to help structure the important parts of the assessment according to their causal relations. One box (or variable) in the diagram should be linked to one web page that describes

that specific variable and how it is connected in the causal chain. There should not only be one linked page but the whole assessment and all the belonging functionalities will be implemented - and held together by the diagram. Standard boxes/variables for typical elements in an assessment should be provided.

- The diagram tool helps the user to define his assessment and shows the key elements and main links by providing generic templates or examples of an assessment. The most generic template is a generic version of the causal chain. Following a hierarchical structure the tool helps the user to define each part of the causal chain in more detail (e.g. the part *emissions* can be broken down to *NO<sub>x</sub>-emissions of passenger cars*. The part of the causal chain are represented using **generic variables**. These are represented by boxes and linked by arrows representing the relationship between the generic variables.
4. **Deriving causal diagrams.** When a causal network has been described with definition attributes, causal diagrams can be created automatically from this information, if the list of variables is given. This list is an essential part of each risk assessment. Thus, a diagram can be automatically created for each well-defined assessment.

### Suggested techniques to get started

The main challenge with issue framing is that the user is guided through the whole assessment. He must not forget important steps and variables. If he wants to start with e.g. "traffic" he should be advised that he needs to take into account "air pollution", "noise" and maybe other impacts. Or another example: If the user wants to look at the health effects of secondary particles he is advised which health effects (and maybe default exposure-response-relationships) he should take into account. Or if he looks at a certain kind of cancer then he needs to be advised which stressors/pollutants cause this cancer.

Technically, we plan to provide a questions-and-answer-guidance to realise this part of the issue framing.

1. Scoping the objects:
  - Mediawiki: Guidance documents are written as wiki pages. Each risk assessment and variable is one wiki page. Templates for risk assessments and variables can be inserted on a page with a single click on a button.
  - Other techniques:
2. Templates for variables:
  - Mediawiki: Existing variables are pages in the Variable namespace. They are categorized according to the full chain approach, and possibly with other hierarchies. Classes are pages in the Category namespace. The page contains a description of the general property they possess, and also a list of all variables that have this property. If a variable belongs to a class, it may directly inherit information from the class.
  - Other techniques:
3. Drawing causal diagrams:
  - Analytica: Diagrams for a risk assessment can be created with Analytica as model files and uploaded to Mediawiki. Screen captures can be made and uploaded as well. Both kinds of files may be linked to the risk assessment page. The Analytica model files can later be used for developing the model further.
  - Other drawing software: The same procedure as with Analytica applies to any drawing software, except that further modelling work is not possible.
  - It would be possible to develop an add-on on top of Mediawiki that creates Analytica files with diagram information (not actual computing code). Analytica files are basically XML files with information about the objects of a graph, and their

sizes, colours, and locations. Technically this would be a piece of php that enables drag and drop of certain types of objects. These graph files could be created in Mediawiki using the add-on, and the files could be later used for model development. This idea should be suggested to Lumina (<http://www.lumina.com>) , the company developing Analytica. They might (hopefully) see this as an opportunity to widen their market share.

4. Deriving causal diagrams: This functionality would be nice, but probably it is not important with the first assessments and can be developed later.
  - Possible techniques: Not thought through. Ready-made solutions don't exist.

## Object design tool helps to fill in the contents

**Object design tool** is for describing the variables and risk assessments in detail. The contents of the objects (from technical perspective) are described below.

1. The descriptions of the attributes as text, tables, figures, and hyperlinks. Some large tables or data files may be included. Some of the text may be computer code to be used in a software outside the collaborative workspace. Strict version control is needed for the whole content management of the objects.
2. The discussions about the content of attributes. Discussions are basically hierarchically structured (threaded) pieces of argumentation, which are in one of five different states (attack, defence, comment, invalid attack, invalid defence). The state may change depending on the context of an argument. When the state of an argument has been changed, the change may have a cascade effect on the states of the other arguments in the thread; this process could in principle be performed automatically.

## Suggested techniques to get started

1. Descriptions of attributes:
  - Mediawiki: Object attributes are described as parts of the wiki page where the object is. Guidance on how to fill in the substance can be given in the Guidebook (open in a separate window).
  - Other alternatives: Plone, TYPO3, from the scratch
2. Discussions:
  - Mediawiki: Discussions are described in the Talk page of the object. Templates are used to reflect the state. Hierarchical structure is created by using the formatting codes of Mediawiki.
  - Other alternatives: Plone, TYPO3, from the scratch, using ready made discussion forums (e.g. PhpMyForum, phpBB, MyBB, ....)

## Analysis tool performs assessment-level analyses

**Analysis tool** is for analysing assessment-specific analyses such as policy comparisons, value-of-information, sensitivity analyses and others. The scope of these analyses is assessment-specific, and it goes beyond a single variable. Basically, the analysis tool performs operations on the data in the result database, extracting and comparing results and answering questions based on these.

### Functionalities

Analysis tool is statistical software that is able to do Bayesian inference and updating, among other things. It can compare result distributions of two or more variables, and calculate joint distributions and conditional distributions. The description of an analysis (including the actual computer code) is located in the *scope/analyses* attribute of the risk assessment product to

which it belongs. The result of the analysis is stored in the *result/results* attribute

### Possible technical solutions

- UNINET (<http://coh.ewi.tudelft.nl/request.php?2>) is a program developed by the Technical University of Delft (<http://dutiosc.twi.tudelft.nl/~risk/>) for analysing Bayesian belief networks (BBNs).
- R (<http://www.r-project.org/>) , an open access statistical software

### Reporting tool produces reports for the end-user

**Reporting tool** is a tool for reporting intermediate and finalised descriptions of variables and risk assessments. It automatically collects information relevant for a risk assessment from the integrated resource platform into a report. The user may choose the level of details in the report. The possible items in the report are the following:

1. Name of the risk assessment
2. Scope: Purpose, Boundaries, Scenarios, Optimizing, Analyses, Intended users, Participants (min required, max allowed)
3. Variables (set of variables included): Decision variables, Outcomes of interest (=indicators), Other variables
4. Results of indicator variables, other selected variables, assessment-specific analyses
5. Conclusions on indicators given scope
6. Summary

### Suggested techniques to get started

The materials to be reported are 1) risk assessment pages (including scope, conclusions, and summary), 2) variable pages, 3) variable results from result distribution database, 4) derived causal diagrams based on the list of variables included in the assessment and the variable definitions. Reporting risk assessment and variable pages is a pretty straightforward task. Results require some kind of query-and-show functionality from the database; this must be developed. The scoping diagram tool has the plan for derived causal diagrams, but it must be developed.

### The tools communicate using the Variable transfer protocol

**Variable transfer protocol** (VTP) is a protocol for automatically exchanging information about variable contents between computers and launching operations based on that information. The basic idea of VTP is to decentralize the (heavy) tasks needed in the full integrated risk assessment toolbox.

### Uses of VTP

- Variables should have a standard structure
  - Variables could be used across assessments
- Variable results should be calculated using the general format: Result = function(parameters)  
  
where the parameters may be data or results of other variables. Function may be a simple or complex model.
- If the parameter structure is fixed for a given function,
  - development of the function (model),

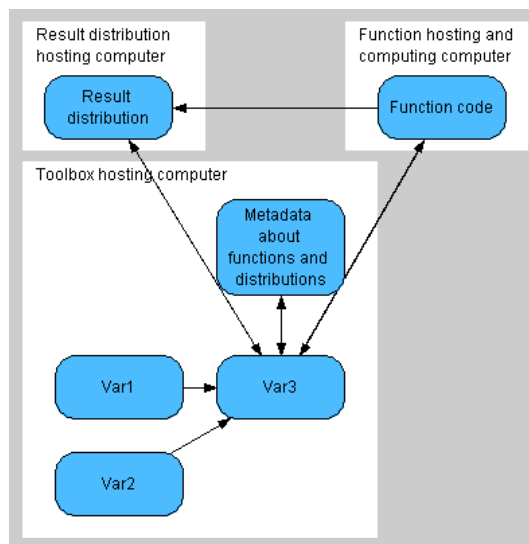
- development of the parameter values, and
- the actual computing can be done separately

→ The pieces can be connected and the result retrieved using VTP  
 → The toolbox work can be effectively decentralized

### Basic transfers of VTP

The basic transfer actions include the following (for each request, there is naturally a response).

1. Request for a result distribution of a variable from a result database.
2. Request for computing the result distribution of a variable based on the defined function and parameters.
3. Uploading the requested result distribution to a result database.
4. Request for the contact information for the computer hosting a function.
5. Request for the computing code of a function from the hosting computer.
6. Request for the exact location of a result distribution in a database in a hosting computer.



# Open access data fuels open risk assessments

**Openness of information** is a crucial thing in improving the efficiency of risk assessment work. A large part of the costs of making a risk assessment arises from collecting basic information. There are large quantities of data available, but extracting the right information is expensive due to several reasons: it takes time to go through publication databases and find relevant articles; the data is usually not in a directly usable format, but it needs organising and synthesising; the source of information is copyrighted, and it cannot be used as such without an explicit permission from the copyright owner, usually the journal. To decrease the costs of a risk assessment, relevant information should be systematically collected into a repository that is in public domain, i.e. the contents are freely usable by anyone. Risk assessors and researchers should be encouraged to provide the information they have collected for their own assessments. Such a repository would benefit other assessors and the society at large. The extra work needed from information providers should be acknowledged as work for general good.

In the new risk assessment, the system is designed in a way that increases the availability of information. This is done in three steps, which are:

1. collecting information about data sources to the **data gateway**,
2. collecting information about the substance itself to the **encyclopedia**, and
3. organising the information into the structured form as variables in **open risk assessments**.

**Data gateway** contains meta-data, i.e. information about existing data. All data owners are encouraged to provide information about their data, and also those who are aware of a piece of data should place a short description in the data gateway. The threshold for providing meta-data to the gateway should be kept as low as possible. Even very limited information is often useful, as a critical thing in making a risk assessment may be that some certain information sources are not identified at all. This lack of information is very costly to the assessor, but providing that information is very cheap to someone who knows about the information source. This kind of meta-data is almost always open, and there is rarely any copyright issues related to it.

However, the meta-data alone is not enough for making a risk assessment. Actual data about the variables must be obtained. There are systematic information sources for some kinds of information, such as IRIS (<http://www.epa.gov/iris>), a database of human health effects that may result from exposure to various substances found in the environment. These sources are extremely valuable for the risk assessment work. Not all information has been collected and organised in such a systematic way. There are different kinds of information that is needed. Some kinds of information are described in the table below.

Kind of data	Examples	Common sources	Availability issues
General descriptions of phenomena and properties	Things that are basic knowledge for an expert: "why dioxins are harmful?"	Textbooks, reviews	Easily found with some effort
Established properties of e.g. chemicals or populations	Common and routinely used building blocks in risk assessments: octanol-water partition coefficients or population age structures	Existing databases	Easily found if data sources are known
Necessary but not established properties	Average concentrations of or exposures to a particular chemical in a particular area or population	Scientific articles	Hard work to go through literature. The author or journal has the copyright for republishing.
Detailed measurement data about properties	Data from studies on individual observation level	Usually not available or only at request*	The need to protect individual privacy limits the availability. Researchers often not willing to give their data.

\*Recently, there has been an increasing trend of publishing the data together with the article as supporting material, or providing the data to an open repository.

Efficiency of the risk assessment process improves if all the different kinds of information are easily available. The encyclopedia offers help in this and acts as a repository for data and more synthesised information. If the information is already easily accessible and openly usable, there is little point in copying it to the encyclopedia. It is not meant to be a repetition of IRIS or other existing databases. However, it should be noted that there is a large difference between "easily available" and "openly available". Even if anyone can buy a textbook about exposure assessment, not everyone does, although he/she would need that information to make state-of-the-art exposure estimates for a risk assessment. The result is a bunch of not-so-great exposure estimates.

Therefore, there is a high value for having an open information repository as the encyclopedia. It should be organised in a way that it is very easy to add information to and that the existing information can easily be found from and further organised. When someone has made the effort to find, collect, and organise information for his own assessment, it should be practically no additional work to upload that information to the encyclopedia for anyone to use. If this is successful, the work the risk assessors do for their own assessments benefits the whole risk assessment community and improves the efficiency of all assessments. This way of working has been proved efficient with Wikipedia.

However, as with Wikipedia, there is a special need to pay attention to copyright issues and ownership of the data. Although many things are available to read, they are not necessarily available to be copied and republished elsewhere. The data owner may set restrictions to the use of the data, which must not be violated. On the other hand, such open repository sends a message to copyright owners: there is a place for collaboration here, and if you are not willing to collaborate, the same data may be found from somewhere else.

Finally, the data that is in the encyclopedia must be structured to match the format of **open risk assessments**. When the data has already been collected and made openly available in the encyclopedia, this restructuring is merely a technical issue. However, it requires work and



is not free of cost. Therefore, it is likely that only a part of the data in the encyclopedia will be structured as variables and directly used in risk assessments. But again, since the system is openly available, when one assessor has done this work, the result is available to all. This is one of the ultimate objectives of the open risk assessment idea: as the work can be based more and more on existing work, new risk assessments can be performed with less resources. Or, on the other hand, with the same amount of resources, the risk assessments will become more comprehensive and cover better the needs of the decision-makers.

# Appendices

**Pyrkilo guide 2/Appendices** contains two pieces of additional material. The first one is a practical guide for stakeholder involvement. The second one is a practical guide for editing Mediawiki pages.

# Appendix 1: Practical guide on stakeholder involvement

The purpose of this Practical Guide on Stakeholder Involvement is to provide you some guidance on the management of stakeholder involvement. *A stakeholder is a person or organisation that has (may have) some interest in your project.* As you will notice, stakeholder management is all about common sense. The benefit of this guide lies in the explication of stakeholder management issues. By answering the lead questions, you will become aware of these issues. (An old version also exists in wiki.)

This guide consists of two parts. The first part deals with general issues in preparing for stakeholder involvement. Questions I till X guide you in selecting a suitable organisational form of stakeholder involvement in risk assessment. The second part (questions XI till XIV) focuses on stakeholder issues specific to stakeholder *participation*.

Lead Questions
<i>stakeholder involvement preparation</i>
I. Why should you involve stakeholders?
II. Who are the stakeholders?
III. How can stakeholders be of service in different phases/components of the integrated risk assessment?
IV. Who should we involve for sure?
V. Who should <i>not</i> be involved?
VI. What could each stakeholder expect from us?
VII. What are the barriers for stakeholder involvement?
VIII. How do we involve identified stakeholders, so that they can make their contributions?
IX. How do we provide unidentified stakeholders a possibility and opportunity to become involved?
X. How to inform stakeholders
<i>stakeholder participation issues</i>
XI. Who do you invite for face-to-face participation?
XII. How to facilitate trust building?
XIII. Do all stakeholders acknowledge each other's roles in the integrated risk assessment?
XIV. How to deal with conflict?

## PREPARING FOR STAKEHOLDER INVOLVEMENT

The following ten lead-questions direct you in selecting an organisational form for stakeholder involvement. This part addresses stakeholder identification, stakeholders' possible contributions to the risk assessment, barriers to involvement and other organisational issues in stakeholder involvement preparation.

## I. Why should you involve stakeholders?

*"History shows us that the common man is a better judge of his own needs in the long run than any cult of experts."*(L. Gulick, 1937)

**The question that precedes the practical issues of stakeholder involvement is: why should you involve stakeholders? The answer is reflected upon in all stakeholder involvement issues; it determines the openness of the integrated risk assessment, the organisation of stakeholder involvement, and the type of stakeholders you invite. It is therefore important that you make your reasons to involve stakeholders explicit.**

### Reasons for stakeholder involvement

Fiorino (1990) grouped the arguments for stakeholder involvement into three categories; he distinguished substantive, normative and instrumental arguments for stakeholder involvement.

Substantive arguments are practical arguments, such as: Non-experts see problems, issues, and solutions that experts miss (Isacson, 1986). More inclusive procedures enrich the generation of options and perspectives, and are therefore more responsive to the complexity, uncertainty and ambiguity of the risk phenomena (International Risk Governance Council 2006), and more intensive stakeholder processes tends to result in higher-quality decisions (Beierle, 2002).

*Stakeholder involvement because stakeholder involvement is the norm and is thus expected* is a normative argument. The instrumental argument states that stakeholder involvement may increase the acceptance and usability of the integrated risk assessment process and outcome (INTARESE, 2007b). To wit, stakeholder involvement can increase public trust in research and government institutions and possibly decrease conflict.

In addition to Fiorino's substantive, normative and instrumental arguments, a fourth group of stakeholder involvement reasons can be distinguished, namely ethical reasons. Stakeholder participation is a means to manage the legitimacy problem, which is caused by uncertainty about the evidence of harm. And owing to the Liberal foundation of the regulatory system, evidence of harm is key to justifying regulatory interventions (INTARESE, 2006). Another ethical reason to involve stakeholders is that government should obtain the consent of the governed (Stern & Fineberg, 1996).

## II. Who are the stakeholders?

*A stakeholder is a person or organisation that has (may have) some interest related to the issues of the risk assessment.*

**Stakeholder involvement starts with stakeholder identification and selection. A stakeholder is a person or organisation that has (may have) some interest (i.e. stake) related to the issues of the risk assessment. In practice, you can think of stakeholder groups in different ways:**

**TABLE A: Thinking of stakeholders in different ways**

<p>i. <i>You can identify stakeholders based on their relation to the risk.</i></p>	<p>ii. <i>You can identify stakeholders based on their roles in the risk assessment.</i></p>	<p>iii. <i>You can identify stakeholders based on the different perspectives they represent.</i></p>
<p>(Briggs &amp; Stern, <i>in press</i>)</p>		<p>(e.g. Hage &amp; Leroy 2007; Kloprogge &amp; Van der Sluijs 2006)</p>
<p>Think of:</p> <ul style="list-style-type: none"> <li>■ People and organisations who (possibly) create the risks (<b>risk generators</b>).</li> <li>■ People or organisations who transmit the risks to other persons and/or organisations (<b>risk purveyors</b>).</li> <li>■ People or organisations who are effected by the risks (<b>victims</b>).</li> <li>■ People or organisations who benefit from the risks (<b>risk beneficiaries</b>). For example, companies who financially gain from the risks, because the risk (negative externality) is not included in the price of their products.</li> <li>■ Agents that hold the formal responsibilities to anticipate, reduce or manage risks, for example emergency services, planners, and regulators.</li> <li>■ Agents that hold the formal responsibility to deal with the consequences of risks, for example health services, insurance companies, and employers.</li> <li>■ People, organisations and institutions that inform about the risks (<b>informants</b>), for example, the media, scientists and monitoring agencies.</li> </ul>	<p>Think of:</p> <ul style="list-style-type: none"> <li>■ People, organisations and institutions that initiate the integrated risk assessment (<b>initiators</b>), for example policy makers, ministry, parliament, experts, research institutes, universities, industry, etc.</li> <li>■ People and organisations who perform the dose-response assessment, the exposure assessment, and the risk characterisation (<b>assessment executors</b>).</li> <li>■ People and organisations who can provide data, specific information, inside information, critical views, etc. to the risk assessment (<b>input providers and issue-framers</b>), for example pressure groups, local residents, industry, research institutes, monitoring agencies, etc.</li> <li>■ People and organisations who can provide feed-back on the risk assessment issues, process and outcomes (<b>critics and users</b>), for example, exposed local residents, experts, policy makers, journalist, industry, etc.</li> <li>■ People and organisations who can facilitate the risk assessment by providing resources, such as money, researchers, laboratories, and meeting rooms and coffee (<b>facilitators</b>), for example research institutes, agencies, and governments.</li> <li>■ People and organisations who can obstruct the success of the risk assessment (<b>obstructors</b>).</li> </ul>	

**TABLE B: Tools for identifying stakeholders**

<i>Brainstorming</i>	<i>Mapping</i>	<i>Snowball method</i>	<i>Argumentation Analysis</i>
In a brainstorm session you try to answer the lead-question: who are the stakeholders in this risk assessment? All suggestions are written down. When no one can come up with unidentified stakeholders anymore, the list can be discussed.	With the mapping technique, stakeholders are allocated to a group, for example stakeholders are grouped per role or risk relation.	The snowball method is very useful to identify unrecognised stakeholders. You ask each stakeholder who they consider to be a stakeholder in integrated risk assessment. You continue doing this, until no new names pop up.	You can use the argumentation analysis, when you identify stakeholders based on the different perspectives. You list all possible perspectives on the issues of the integrated risk assessment and subsequently search for persons or organisational representatives who have such a view. It is helpful to scan the media or to use a top-down approach for perspectives on the issues of integrated risk assessment. With a top-down approach, you derive from story lines or general cultural theories the possible perspectives. (Kloprogge & Van der Sluijs, 2006)

It can be difficult to identify the interested and affected parties, when there is no clear picture of integrated risk assessment issues. The best solution to this problem is to identify representatives of the more general public and/or environmental or community groups. Do ask yourself, however: How representative are the stakeholder representatives?

### III. How can stakeholders be of service in the phases/components of the integrated risk assessment?

*Most likely, you want stakeholder input (e.g. their views, information, data, etc.) or their commitments. However, it could also be that you want stakeholder protection or money or you just want them to be satisfied and silent.*

Stakeholders can make different contributions in different phases/components of the integrated risk assessment. Their contributions are examples of substantive and instrumental reasons to involve stakeholders in integrated risk assessment. Identifying and articulating your *preliminary* expectations about their possible contributions (according to the phases/components of the integrated risk assessment) has several benefits. Firstly, your preliminary expectations help in planning stakeholder involvement in the phases/components of the integrated risk assessment. Secondly, they guide you in selecting the organisational forms of stakeholder involvement (see VIII). Thirdly, your expectations can lead you in selecting participants for in the integrated risk assessment process (see XI).

**TABLE C: Stakeholders' contributions**

<b>Stakeholders' contributions can be generalised in the following general categories:</b>
<ul style="list-style-type: none"> <li>■ framing input: perspectives, critics, and suggestions</li> <li>■ assessment input: knowledge, information, and data</li> <li>■ comments: critics and suggestions (during the process)</li> <li>■ feed-back: critics and suggestions (after the process)</li> </ul>

- |                                                                                                                                                                                         |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>■ facilitation: mediation skills, negotiation skills, meeting rooms, website maintenance, money, etc.</li> </ul>                                 |
| <ul style="list-style-type: none"> <li>■ obstruction (negative contribution): going to press - publishing critics without internal deliberation, refusal to co-operate, etc.</li> </ul> |

### **issue framing**

Stakeholder involvement in the issue framing serves to increase support and acceptance of the risk assessment process and outcomes. If stakeholders are involved in setting the purpose and scope of the integrated risk assessment, the integrated risk assessment's relevance, usability and acceptability increase. To wit, if the problem definition of the integrated risk assessment (purpose) fits in the stakeholders' problem perceptions, the stakeholders perceive the risk assessment as a relevant and useful contribution to the solution of the problem and recognise (accept) the policy measures. If you involve a plurality of perspectives (different problem perceptions), the public support for and acceptance of the integrated risk assessment process and outcome increases. In order to achieve this, a plurality of stakeholders should be able to provide framing input: to present their views and make comments.

Illustrative examples of addressing the wrong problem (and thus *not* receiving public support for and acceptance of the integrated risk assessment) are the Yucca Mountain ([http://en.wikipedia.org/wiki/Yucca\\_Mountain](http://en.wikipedia.org/wiki/Yucca_Mountain)) case and the Antwerp waste incinerator case. Stern & Fineberg (1996) describe the Yucca Mountain case; the assessment of nuclear waste storage risks did not address all issues, such as fairness of dumping nuclear waste in a region that does not have nuclear power plants and already hosts the national nuclear testing facility. (They scoped the problem too narrow.) Many people perceived the risk assessment irrelevant and misleading, because it addressed only part of the problem. Craye, Funtowicz & Van der Sluijs (2005) describe, in the Antwerp waste incinerator case, that residents did not accept the assessments of the waste incineration risks, partly because these assessments did not address their problems (wrong purpose).

### **indicator selection**

Stakeholder involvement in indicator selection serves to secure that the integrated risk assessment addresses all relevant issues (to the stakeholders). The selected set of indicators determine the applicability and relevance of the integrated risk assessment. To optimise the applicability and relevance, all issues relevant to the stakeholders should be addressed. In order to secure this, stakeholders should be able to provide input (knowledge, information and data) to and comment (critics and suggestions) on the indicator selection.

### **risk assessment**

Stakeholders can contribute to the risk assessment by providing input (insight knowledge, specific information, data, expertise, etc.). For example, industry and the medical community can facilitate fast data acquaintance, external experts secure the acceptance of the risk assessment in the scientific community, local residents or companies can help in identifying hazards, etc.

### **impact valuation & appraisal**

Stakeholder involvement is a necessity for common accepted impact valuation (and thus for a widely accepted risk assessment output). People are more likely to support a common (average) value judgement, if their personal judgement is weighted within this common value judgment. That is to say, exposed local residents and local companies should be asked how they value certain health, environmental and economic impacts. Afterall, they have to live with the consequences.

Stakeholder opinions can be used in appraising and formulating the measures to counter certain impacts of stressors. A diverse group of people thinking about how to best counter impacts has a higher potential to yield creative solutions than a congenial group.

**evaluation**

Stakeholders can provide useful feedback and tips for improvement, after the publication of the risk assessment results. Policy makers can provide feedback on the usability of the risk assessment output. Residents and companies can provide feedback on the consequences of the measures (which are based on the integrated risk assessment).

**IV. Who should we involve for sure?**

Particular stakeholders can play an important role in the integrated risk assessment process, because they have the ability to obstruct or accelerate the process, they hold valuable knowledge, information or data, or they can provide resources for facilitation. Based on your preliminary expectations about the stakeholders' contributions (see table C), you can list the stakeholders you should involve to benefit from their contributions.

**Try to collect a plurality of stakeholder views on the different integrated risk assessment issues. This increases the usability of the integrated risk assessment process and output, and the possibility of their acceptance.**

**TABLE D: Stakeholders who should be involved for sure**

<p>It depends on the type of integrated risk assessment, which stakeholders you should involve for sure. No conclusive general list can be given. The involvement of a particular stakeholder can be redundant in the first integrated risk assessment, but the same stakeholder can make a major contribution to the second integrated risk assessment. You, yourself, should consider which stakeholders to involve for sure. You can take the following stakeholder groups in consideration. (Note that this list is not exhaustive and important stakeholders could be missing.)</p>
<ul style="list-style-type: none"> <li>■ risk assessors</li> <li>■ policy makers (from the ministry, municipality, etc.)</li> <li>■ experts in the issues addressed in the integrated risk assessment</li> <li>■ non-governmental organisations (NGOs), such as environmental protection organisations</li> <li>■ local residents (representatives) or community (representatives)</li> <li>■ pressure groups</li> <li>■ industry (representatives)</li> <li>■ agriculture and fishery (representatives)</li> <li>■ commerce (representatives)</li> <li>■ educational institutions</li> <li>■ medical community</li> <li>■ employer and employee unions</li> <li>■ ...</li> </ul>



## V. Who should *not* be involved?

Perhaps this question strikes you as awkward, but it addresses the default assumptions of stakeholder involvement in risk assessment (assumptions that influence the openness of the integrated risk assessment). **The default assumption of this guide is that *in principle risk assessments are open*; anyone who wants to be involved should be allowed to be involved. This means that you must have good arguments to exclude any stakeholders from involvement.**

### Two opposing default assumptions on stakeholder involvement in integrated risk assessment

#### *The assumption of **Closed** integrated risk assessment*

The classical default assumption on stakeholder involvement is that there is in principle no need to open up (i.e. involve stakeholders in) the risk assessment. If stakeholders are involved in the risk assessment, their involvement is of a passive nature (i.e. stakeholders do not directly participate in the assessment) and the inclusion of their perspectives is based on a top-down approach (i.e. stakeholders do not articulate their own perspectives, but risk assessors derive theoretical stakeholder perspectives from the general classification of ideas) (e.g. Kloprogge & Van der Sluijs, 2006).

#### *The assumption of **Open** integrated risk assessment*

This default assumption on stakeholder involvement states that integrated risk assessment is open to anyone who wants to be involved. It made its debut in the nineties of the twentieth century together with the introduction of post-normal science. Stakeholder involvement springing from this default assumption is more active in nature and the inclusion of stakeholder perspectives in the integrated risk assessment is based on a bottom-up approach; stakeholders participate in the integrated risk assessment and articulate their own perspectives on the issues (e.g. Kloprogge & Van der Sluijs, 2006; Craye, Funtowicz & Van der Sluijs, 2005; Funtowicz & Ravetz, 1993; Ravetz, 1999; Van der Sluijs, 2002). }

## VI. What could each stakeholder expect from us?

At the start of a risk assessment process, stakeholders do often not know if they have an interest in the risk assessment, let alone that they would know precisely what they want from it. Stakeholders are not interested in involvement in the risk assessment, unless they see that their contribution has an influence on decision making. (e.g. Fraser, Dougill, *et al.*, 2006; Newig, 2007) Hence, stakeholders expect that they can influence decisions, if they take the effort of contributing to the risk assessment. Related to this expectation are other potential stakeholder expectations: Stakeholders could expect to maintain the status quo; they expect the risk assessment consequence not to touch their interest. Stakeholders could also expect to be actively involved in a particular matter. Stakeholders could want to be informed, so that they can react to any inconvenient developments. Stakeholders could expect to be heard, so that they can express their views. It is important to live up to stakeholders' expectations for successful stakeholder involvement. Therefore, **by answering the question *what does each stakeholder expect from us?* you identify, estimate and group stakeholders' expectations, which enables you to tailor the involvement organisation and facilitation** (see VIII).

## VII. What are the barriers for stakeholder involvement?

*"Research since the 1970's suggest that the tendency of non-state actors to participate - and thus to invest time and other resources - is primarily a function of the degree to which an actor perceives a problem to touch his own interests, combined with the degree of perceived*

chances to influence the output of the decision process'(J. Newig, 2007).

**Asking stakeholders what refrains them from being involved and/or considering the (possible) barriers for stakeholder involvement enables you to act upon it. You can endeavour to eliminate or lower the barriers that stakeholders encounter in their involvement. Discuss (organisational) solutions for the possible barriers in an internal meeting.**

**TABLE E: Barriers to stakeholder involvement**

<i>Barriers related to problem perception and power to influence</i>	<i>Barriers related to involvement facilitation</i>
The most difficult barriers to stakeholder involvement relate to the stakeholder's problem perception (context) and power to influence (Newig, 2007). These barriers are the most difficult to decrease, because perception is not easily changed.	Other barriers to stakeholder involvement relate to the disorganisation, a lack of proper involvement facilitation, or a lack of resources (U.S. EPA, 2001). Good involvement organisation and facilitation take these barriers away by taking them into account.
<p>For example, stakeholders do not wish to be involved, because:</p> <ul style="list-style-type: none"> <li>■ They perceive the problem (from which the risk assessment springs) as your problem and not theirs (and they are not willing to solve your problem).</li> <li>■ Stakeholders do not see the benefits of being involved.</li> <li>■ Stakeholders mistrust (semi)governmental organisations (And they think you are from a (semi)governmental organisation).</li> <li>■ Stakeholders believe that authorities do not take their concerns and opinions seriously (And they see you as authority representative).</li> </ul>	<p>For example, stakeholders involvement is distorted, because:</p> <ul style="list-style-type: none"> <li>■ Stakeholders are unaware of the risk assessment.</li> <li>■ Stakeholders do not have enough time.</li> <li>■ Information is inadequate: chaotic, too detailed, too broad, not to point, etc.</li> <li>■ The discussions are too technical for stakeholders to be understandable.</li> <li>■ Experts use too much jargon in the discussions (and there is nobody who translates this for non-jargon speakers).</li> </ul>

## **VIII. How do we involve identified stakeholders, so that they can make their contributions?**

There is no use of involving stakeholders, if stakeholders cannot make their contributions to the integrated risk assessment process and defend their interests. Stakeholders involvement should be organised in such a way that stakeholders can defend their interests and make their contribution (i.e. articulate their views, share their knowledge information and data, criticise, make suggestions, facilitate, etc.). Therefore also stakeholder involvement barriers should be taken into account in designing, organising and facilitating stakeholder involvement.

Mostert (2003) distinguishes six levels of stakeholder involvement with organisational forms. **Consider what would be the most suitable level and form of involvement for each identified stakeholder, taking into account the stakeholders' possible contributions (see table C), expectations, and barriers to involvement.**

**TABLE F: Organisational forms of stakeholder involvement**

Mostert's different levels of stakeholder involvement:	Different organisational forms of stakeholder involvement:
<p>level 1: <b>Stakeholders are informed</b></p>	<p>by means of:</p> <ul style="list-style-type: none"> <li>■ leaflets and brochures</li> <li>■ website and mailings</li> <li>■ press releases and press conferences</li> <li>■ briefings</li> <li>■ information centers</li> <li>■ ...</li> </ul>
<p>level 2: <b>Stakeholders are consulted</b> : Stakeholders are asked for their views.</p>	<p>by means of:</p> <ul style="list-style-type: none"> <li>■ questionnaire surveys</li> <li>■ telephone surveys</li> <li>■ interviews</li> <li>■ public hearings</li> <li>■ focus groups with: <ul style="list-style-type: none"> <li>■ story telling</li> <li>■ commenting</li> </ul> </li> <li>■ Delphi-method (<a href="http://en.wikipedia.org/wiki/Delphi_method">http://en.wikipedia.org/wiki/Delphi_method</a>)</li> <li>■ ...</li> </ul>
<p>level 3: <b>Stakeholders participate in discussions.</b></p>	<p>Discussions can be organised as:</p> <ul style="list-style-type: none"> <li>■ internet forum or wiki (suitable for mass collaboration) with: <ul style="list-style-type: none"> <li>■ argumentation method (see: Argumentation Analysis and Contributing to a discussion)</li> </ul> </li> <li>■ workshops with: <ul style="list-style-type: none"> <li>■ grid method</li> </ul> </li> <li>■ brainstorm sessions</li> <li>■ ...</li> </ul>
<p>level 4: <b>Stakeholders participate in designing.</b></p>	<p>Designing (models, causal chains, variables, solutions, etc.) can be organised as:</p> <ul style="list-style-type: none"> <li>■ a meeting with: <ul style="list-style-type: none"> <li>■ scenario-building method</li> <li>■ group-model-building method</li> <li>■ role playing and bricolage</li> <li>■ ...</li> </ul> </li> </ul>
<p>level 5 &amp; 6: <b>Stakeholders have a say in decision making.</b></p>	<p>Decision-making can be organised as:</p> <ul style="list-style-type: none"> <li>■ referendum</li> <li>■ voting of representatives</li> <li>■ negotiations for agreement</li> </ul>

## **IX. How do we provide unidentified stakeholders a possibility and opportunity to become involved?**

Also *unidentified* stakeholders should have the possibility and opportunity to become involved

in the integrated risk assessment. Unidentified stakeholders are often forgotten stakeholders. If they represent yet unrepresented perspectives, they might have good comments and raise issues that have been overlooked by the other stakeholders. Therefore you should provide them the possibility and opportunity to make these comments and raise these issues.

**TABLE G: Organisational forms for involving unidentified stakeholders**

<i>Levels of stakeholder involvement :</i>	<i>Organisational forms of stakeholder involvement :</i>
level 1: Stakeholders are informed.	<ul style="list-style-type: none"> <li>■ leaflets and brochures</li> <li>■ website</li> <li>■ press releases and press conferences</li> <li>■ information centers</li> <li>■ ...</li> </ul> <p><i>And if opted for a higher level of stakeholder involvement, you can draw their attention to the</i></p>
level 2: Stakeholders are consulted.	<ul style="list-style-type: none"> <li>■ questionnaires (available on the website, or at the information centers)</li> <li>■ public hearings (state time and location)</li> <li>■ ...</li> </ul>
level 3: Stakeholders participate in discussions.	<ul style="list-style-type: none"> <li>■ internet forum or wiki (suitable for mass collaboration) with: <ul style="list-style-type: none"> <li>■ argumentation method (see: Argumentation Analysis and Contributing to a discussion)</li> </ul> </li> </ul> <p><i>or inform them about the time and location of the</i></p> <ul style="list-style-type: none"> <li>■ workshops with: <ul style="list-style-type: none"> <li>■ grid method</li> </ul> </li> <li>■ brainstorm sessions</li> <li>■ ...</li> </ul>
level 4: Stakeholders participate in designing.	<ul style="list-style-type: none"> <li>■ meetings with: <ul style="list-style-type: none"> <li>■ scenario-building method</li> <li>■ group-model-building method</li> <li>■ role playing and bricolage</li> <li>■ ...</li> </ul> </li> </ul>
level 5 & 6: Stakeholders have a say in decision making.  (After notification of their existence)	not applicable

## X. How to inform stakeholders

*"Communicating such information that it is understandable to your stakeholders is an*

*important first (and ongoing) step in stakeholder engagement. All other activities, from consultation and informed participation to negotiation and resolution of grievance, will be more constructive if stakeholders (...) have accurate and timely information about the project, its (possible) impacts, and other aspects that may have an effect on them.* (International Finance Corporation 2007 p.27)

There is a whole range of possible media to inform stakeholders, e.g. leaflets, brochures, website, mailings, press releases and press conferences, briefings, information centers, etc. (See table F under level 1.)

**When you inform stakeholders there are some important things to think of:**

- Explain why you think that their (stakeholders') involvement is important.
- Explain what a risk assessment is, so that those stakeholders who have never heard of risk assessment understand it.
- Explain the purpose of the risk assessment. Why do policy makers need information about these (un)certain risks?

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## IMPORTANT ISSUES IN STAKEHOLDER PARTICIPATION

The more interactive form of stakeholder involvement in risk assessment is stakeholder *participation* (levels 2 - 4, see table F). This second part addresses stakeholder participation issues that you would not directly think of when organising stakeholder participation in the integrated risk assessment. Your attention is drawn to the importance of trust in a work-relationship, potential problems due to (role) conflict and ways to deal with conflict among participants.

### XI. Who do you invite for face-to-face participation?

In case you want stakeholder to participate in the integrated risk assessment on a *face-to-face basis*, you face a selection of participants. There are important things to think of, when selecting stakeholders for participation:

- The groups of participants should be a representative selection of the stakeholder perspectives.
- Consider the possible contributions of the stakeholders. ... Which contributions can best be made in a face-to-face meeting?
- Consider the communicative and social skills of the participants.

### XII. How to facilitate trust building?

*Trust is a crucial component of any stakeholder involvement initiative. Trust ensures an effective working relationship.* (U.S. EPA, 2001)

If people trust each other, they are more willing to collaborate (Huxham 1996; Lubell 2000; Pretty 1995). Trust and participants' trustworthiness are created, when stakeholders learn to know each other: what they do, how reliable and consistent they are, how they react, whom they represent, how they present themselves, etc. If people learn to know each other, they can assess the trustworthiness of others by estimating their integrity, benevolence and ability

to contribute. (Mayer, Davis & Schoorman, 1995) In addition, when stakeholders know each other, they are more willing to listen to each other (which is a requisite for agreement).

In case of face-to-face communication, a pre-meeting introduction activity (dinner, lunch or a social drink) is a perfect occasion for participants to learn to know each other and thus to build their trust. It is also the opportunity to enthuse stakeholders for involvement in the risk assessment and to verify your estimations about their expectations. "There is a reason that lobbyists and politicians do much work at receptions and lunches." (Innes & Booher 1999 p.19)

In case of non-face-to-face communication (questionnaire surveys, telephone surveys, brochures, internet fora, wikis, etc.) trust creation is more difficult, because of the remote relationship between participants. Building trust demands more time and is almost solely dependent on the participants honouring their promises and living up to the expectations of others, for example securing privacy or delivering qualitative work on time. (e.g. Aubert & Kelsey, 2003)

In any case, **you can facilitate trust building among participants by admonishing them to be integer and to account for other opinions** ([http://en.wikipedia.org/wiki/Wikipedia:Neutral\\_point\\_of\\_view](http://en.wikipedia.org/wiki/Wikipedia:Neutral_point_of_view) ) when working on the **integrated risk assessment**.

### **XIII. Do all stakeholders acknowledge each other's roles in the integrated risk assessment?**

It is important that all stakeholders accept each other's role in (the execution of ) the risk assessment (which includes also the role of the risk assessors). Without mutual recognition of each other's roles, conflicts which have a negative influence on the risk assessment quality may arise (De Dreu & Weingart 2003). If participants in the risk assessment do not recognise each other's roles, authorities, responsibilities and coordinative lines remain vague. Conflicts might arise continuously, delaying the project's progress, or worse, making collaboration impossible. Mediating between stakeholders to establish mutual recognition of roles is an important stakeholder management issue.

#### **The benefit of mass collaboration**

Mass collaboration reduces the problems springing from the default of mutual role recognition. If the integrated risk assessment is organised by the ideas of mass collaboration, discussions and parts of the assessment output production take place on internet fora or in wikis and participating stakeholders work together on a *shared set* of tasks (e.g. INTARESE 2007a). The stakeholder collective shares responsibilities, which implies the absence of coordinative lines. This semistructured anarchical organisation of the integrated risk assessment avoids the dilemma of role recognition.

### **XIV. How to deal with conflict?**

Bringing together different views is likely to generate conflict. Some conflicts must be settled in order to proceed in the integrated risk assessment process and yield effective risk assessment output. According to Rahim (1983, 1992) and Thomas & Kilmann (1974) disputes can be settled or resolved in five different ways. You can settle a dispute by avoidance (you ignore the dispute), accommodation (you subordinate your view/opinion to those of others), or by competition (you superordinate your view/opinion to those of others). Or you can resolve a dispute by means of compromise (you *combine* your view/opinion with those of others) or by means of collaboration (you and the others *integrate* your views/opinions in a common standpoint by means of argumentation)

Achieving a compromise among the participants who all hold different opinions is a tough job and requires political skills. Unfortunately no one-fits-all method for establishing agreement can be given. Questions that can be helpful in guiding you to establish a compromise are:

- Which standpoints can be grouped and/or combined?
- Which standpoints lead to the same conclusion/decision?
- Which disputes are relevant/crucial for the outcome?
- How can participants' objections be taken away?

### **Argumentation**

Disputes among participants can be settled in many ways, but only logic argumentation can truly resolve their disagreement (Van Eemeren, Grootendorst & Snoeck Henkemans, 2002). Participants should be encouraged to resolve their disputes by means of argumentation. In the argument, the disputants try to convince the opponents of their standpoint by expounding their reasoning and attacking the reasoning of their opponents. The explanation of reasoning shows the (underlying) cause of the dispute and (hopefully) converge the disputing parties' views to a common new view.

Argumentation is only useful for solving disputes, when the disputants are willing to give up their original standpoint and are not carried away by their emotions (i.e. they must be willing to listen to the opponents). Furthermore, simple discussion rules can guide an argumentation to resolve disputes.

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# Appendix 2: Practical guide to editing in Mediawiki

## Quick guide to Mediawiki editing

Editing help:

Description	What you type	What you get
<i>applies everywhere</i>		
Italic	<code>''italic text''</code>	<i>italic text</i>
Bold	<code>'''bold text'''</code>	<b>bold text</b>
Bold & italic	<code>''''bold &amp; italic text''''</code>	<b><i>bold &amp; italic text</i></b>
Line break	Line 1 Line 2	Line 1 Line 2
	Textline 1    Textline 2	Textline 1 Textline 2
<i>applies only in the beginning of new lines</i>		
Different level headings	<code>Notice! Level 1 is preserved for article title</code> <code>==Level 1==</code> <code>===Level 2===</code> <code>====Level 3====</code> <code>=====Level 4=====</code>	<b>Level 1</b> <b>Level 2</b> <b>Level 3</b> <b>Level 4</b>
Horizontal rule	<code>----</code>	<hr/>
Bullet list	<code>* one</code> <code>* two</code> <code>* three</code>	<ul style="list-style-type: none"> <li>■ one</li> <li>■ two</li> <li>■ three</li> </ul>
Numbered list	<code># one</code> <code># two</code> <code># three</code>	<ol style="list-style-type: none"> <li>1. one</li> <li>2. two</li> <li>3. three</li> </ol>
Definition list	<code>:Definition</code> <code>:item 1</code> <code>:item 2</code>	<p>Definition</p> <ul style="list-style-type: none"> <li>item 1</li> <li>item 2</li> </ul>

Preformatted text	a space at the beginning of the line creates preformatted text	<pre> a space at the beginning of the line creates preformatted text </pre>
-------------------	----------------------------------------------------------------	-----------------------------------------------------------------------------

## Large guide to Mediawiki editing

### Introduction

This is a user's guide for Intarese MediaWiki-pages. User's guide contains briefly basic information about using MediaWiki.

Feel free to test your skills in sandbox -page.

**Remember!** You cannot cause any permanent damage to articles because everything can be retrieved. So have fun editing and creating!

### Creating an account and logging in

It is recommended that you create an account before making any editing to MediaWiki-pages. This makes easier for others to see who is the creator or the editor of MediaWiki-pages. Please note, that you can read, edit and create wikipages without creating an account or logging in.

You can create an account by clicking login or create an account on the upper right corner. From there you can choose your **User name** and **password**. It is recommended to use your own name in the username (for example first name).

For more information about logging in and user accounts please see<sup>[1]</sup> ([http://meta.wikimedia.org/wiki/Help:Logging\\_in](http://meta.wikimedia.org/wiki/Help:Logging_in)).

### Editing

#### Starting a new page

There are few different ways to create new articles in MediaWiki.

#### Creating a new article through URL-method

Easy way to create a new article is to type the name of the article to adresbar (URL) after **index.php?title=**

For example **index.php?title=Name of your new article**

## Creating a new article through search-box-method

One method is to type the name of the article to **search** -box on the left and click **Go**-button. From there you can simply click the text which says **this exact title** and the editing window opens.

## Creating a new article through link-method

Other way to create a new article is to make a link from existing page to a new article. For example name of the new article, code: **[[name of the new article]]** . When you click this link it opens a new edit window for article named **name of the new article** . More information about linking later in the linking -section.

For more information about starting a new page please see<sup>[2]</sup> ([http://meta.wikimedia.org/wiki/Help:Starting\\_a\\_new\\_page](http://meta.wikimedia.org/wiki/Help:Starting_a_new_page)) .

## Naming a new article

You can name your articles quite freely. There are few basic guidelines which are good to keep in mind while naming articles:

- Use descriptive names
- Names can consist of several words
- Numbers and spaces are allowed
- Do not use special characters like # < > [ ] | { }
- Names are case-sensitive
  - mediaWiki is same as MediaWiki but not same as mediawiki
  - Capitalization matters after the first letter but not in the first letter

For more information about naming please see<sup>[3]</sup> ([http://meta.wikimedia.org/wiki/Help:Page\\_name](http://meta.wikimedia.org/wiki/Help:Page_name)) .

## Editing basics

### Start editing

To start editing simply click the **edit**-link on the upside of the page. This opens **edit**-page.

### Type your text

In the edit-page you can just type your text. It is also possible to copy-paste text from another source (for example Word) directly to WikiPage.

### Save your text

Click **save-page** to save your text. It is a good idea to click **show preview** before saving your work.

For more information about editing basics please see [4]  
([http://meta.wikimedia.org/wiki/Help:Editing#Editing\\_\\_basics](http://meta.wikimedia.org/wiki/Help:Editing#Editing__basics))

## Text formatting

### New lines

To start a new line you need to press **enter** twice. It is also possible to use html command **<BR>** to start a new line.

### Italic -text

What you type: You can "italicize text" by putting 2 apostrophes on each side.

What you get: You can *italicize text* by putting 2 apostrophes on each side.

### Bold -text

What you type: 3 apostrophes will ""bold the text"".

What you get: 3 apostrophes will **bold the text**.

### Bold & italic -text

What you type: 5 apostrophes will ""bold & italicize the text""

What you get: 5 apostrophes will ***bold & italicize the text***

### Centered text

You can center text placing it between **<center>** and **</center>**.

This is centered text

### Example code:

```
<center> This is centered text </center>
```

### Superscripts and subscripts

Superscripts are done placing text between **<sup>** and **</sup>**. Subscripts are done placing text between **<sub>** and **</sub>**.

X<sup>2</sup> and H<sub>2</sub>O

### Example code:

```
X<sup>2</sup> and H<sub>2</sub>O
```

### Indentation

You can indent lines with **:(colon)**. More colons mean deeper indentation.

One level indentation  
Two level indentation  
And so on

**Example code:**

```
[: One level indentation
[: Two level indentation
[:: And so on
```

## Lists

### Basic lists

Lists are done with **\*(star)** -signs in MediaWiki. Just put **\*** at the beginning of the new line. More stars mean deeper levels.

- 1 star
  - 2 stars
    - 3 stars

**Example code :**

```
! * 1 star
! ** 2 stars
! *** 3 stars
```

### Numbered lists

Numbered lists are done with **#**-signs. Just put one **#**-sign at the beginning of the everyline you want to be included in your numbered list. Numbers are generated automatically.

1. This is list item number 1
2. This is obviously list item number 2

**Example code :**

```
! # This is list item number 1
! # This is obviously list item number 2
```

You can also use different depths of numbered lines. For example:

1. First level
  1. Second level
  2. Second level
    1. Third level
2. Quite easy?

### Example code :

```
!# First level
!## Second level
!## Second level
!### Third level
!# Quite easy?
```

### Definition lists

Definition lists can be used for defining a word or a phrase for example. Colons (:) and semicolons (;) are used to create a definition list. See example:

Word or a phrase  
and the definition  
you can also add more than one definitions

### Example code :

```
!;Word or a phrase: and the definition
!; you can also add more than one definitions
```

### Mixed lists

It is possible to combine different lists (numbered and basic lists for example).

1. Numbered list
  - option 1
  - option 2
2. Second item in numbered list
  - Word  
and its definition

### Example code:

```
!# Numbered list
!#* option 1
!#* option 2
!# Second item in numbered list
!#*;Word: and its definition
```

### Sections

Creating sections is done with = -signs in MediaWiki.

### Example code:

```

== 1 Section ==
=== 1.1 Subsection ===
==== 1.1.1 Sub-subsection ====

```

So you just type your section name between = -signs. Number of = -signs defines the type of the section. Please note that the section numbers are not shown expect in the table of context. If you'd like to see sections numbers in the text you'll need to change your user preferences.

For more information about creating sections please see [5] (<http://meta.wikimedia.org/wiki/Help:Section>) .

## Tables

### Standard Wiki-tables

You can create tables in MediaWiki with standard **HTML**-code or you can use special **wikicode**. Latter method is described here. If you are interested in HTML -table syntax you can learn it from here (<http://www.w3.org/TR/html4/struct/tables.html>) .

There is basic example of a WikiTable:

The table's caption

Column heading 1	Column heading 2	Column heading 3
Row heading 1	Cell 2	Cell 3
Row heading A	Cell B	Cell C

### Example code:

```

{| border="1"
+ The table's caption
! Column heading 1 !! Column heading 2 !! Column heading 3
|-
! Row heading 1
| Cell 2 || Cell 3
|-
! Row heading A
| Cell B
| Cell C
|}

```

- Table code is encased with curly brackets and a pipe{| table code here |}.
- Border is optional (bigger the number, thicker the border)
- Table's caption is optional
- First column heading is marked with single ! and next column headings are separated with double !!
- Rows are separated with |-
- Single ! marks row headings
- Cells within the same row are separated with || or with a new line and a single bar |



For more information about creating tables, please see[6]  
([http://meta.wikimedia.org/wiki/Help:Table#Pipe\\_syntax\\_tutorial](http://meta.wikimedia.org/wiki/Help:Table#Pipe_syntax_tutorial)) .

### **Converting tables from Excel or Word**

Easiest way to convert tables from Excel or Word -files is to use converter which can be found from **Navigation** -bar on the left: Excel to WIKI  
(<http://www.pyrkilo.fi/converter/csv2wp.php>) .

#### **Instructions:**

1. select table you want to import to MediaWiki
2. copy table (CTRL+c)
3. paste table to converter (CTRL+v)
4. press Convert to MediaWiki -button
5. select output text
6. copy output text
7. paste copied text to your article!

### **Table of contents**

MediaWiki creates automatically table of contents if there is more than 3 headings (sections) in the article.

For more information about table of contents please see[7]  
([http://meta.wikimedia.org/wiki/Help:Section#Table\\_of\\_contents\\_.28TOC.29](http://meta.wikimedia.org/wiki/Help:Section#Table_of_contents_.28TOC.29))

### **Linking**

#### **Links to articles in the same MediaWiki-project**

Links to articles within the same MediaWiki-projects are done typing **[[Name of the article]]** .

For example a link to Agriculture-article

#### **Links to articles in different MediaWiki-projects**

It is possible to link articles between different MediaWikis easily without typing the whole URL. Following Wiki-projects are so far included:

- pyrkilo
- beneris
- erac
- intarese
- heande
- tyjak
- piltti

A link to article in different project is created by typing **[[project name: article name]]** .

For example a link to pyrkiilo-project article named Mental models in food risks is typed:

**[[pyrkilo: Mental models in food risks]]** .

It shows: pyrkiilo: Mental models in food risks. It is also possible to use piped links to name links differently.

### Links to other sections

You can make a link to another section in the same project typing **[[Name of article#Name of section]]**. For example Agriculture#Description\_of\_work

For more information about links please see [8] (<http://meta.wikimedia.org/wiki/Help:Link>) .

### Piped links

Piped links can be used to name links differently than the name of the page that it links. In piped links a | -sign is used for separating the real article name from custom label. For example a piped link to article named Agriculture **[[Agriculture| Piped link to Agriculture]]** . Shows Piped link to Agriculture instead of just Agriculture.

For more information about piped links please see [9] ([http://meta.wikimedia.org/wiki/Help:Piped\\_link](http://meta.wikimedia.org/wiki/Help:Piped_link))

### External links

External links are links that point outside MediaWiki-project.

You can easily create links to another internet-locations simply typing the address: for example <http://www.ktl.fi> <- please note that you don't necessarily need brackets in external links.

If you type **[<http://www.ktl.fi>]** the link address is not shown. For example [10] (<http://www.ktl.fi>)

You can name the link by typing **[<http://www.ktl.fi> Name of the link]** . For example KTL homepage (<http://www.ktl.fi>) .

**Note** that you do not have to use | -sign to separate link from the link name.

For more information about external links please see [11] ([http://meta.wikimedia.org/wiki/Help:URL#URLs\\_in\\_external\\_links](http://meta.wikimedia.org/wiki/Help:URL#URLs_in_external_links))

## Using Images and Files

Before images and other files can be used they need to be uploaded into MediaWiki system.

### Uploading

You need to be logged in before you can upload files. Uploading is done through Upload file -link which is in the **toolbox** -menu.

In **Upload file** -page you will see a **browse** -button. You can use button to select a file from your computer. You can name your file in **Destination filename** box (default is the original name). It is recommended to use quite short and descriptive file names because that way they are easier to use. You can also add some information about uploaded file to **Summary** -box.

For more information about uploading please see<sup>[12]</sup>  
([http://meta.wikimedia.org/wiki/Help:Images\\_and\\_other\\_uploaded\\_files#Uploading](http://meta.wikimedia.org/wiki/Help:Images_and_other_uploaded_files#Uploading)).

## Supported file -types

So far our MediaWiki-projects supports following filetypes:

- ana (Analytica)
- ppt (Microsoft PowerPoint)
- pps (Powerpoint Show)
- xls (Microsoft Excel)
- pdf (Adobe)
- doc (Microsoft Word)
- bmp (Bitmap -pictures)
- tif (Tagged Image File -pictures)
- png (Portable Network Graphics -pictures)
- gif (Graphics Interchange Format -pictures)
- jpg & jpeg (Stands for Joint Photographic Experts Group -pictures)
- ogg (Audio -files)

You cannot upload files that are different types as mentioned above.

## Adding images to articles

Images are added to articles using `[[Image:name of your picture]]` -code. Remember that pictures have to be uploaded before they can be used.

There's a example where name of the picture is **picture.GIF**:



Example code:

```
[[Image:picture.GIF]]
```

## Adding other files to articles

Other files than images can be attached to articles using `[[Media:filename]]` -code.

Examples:

This is a link to Media:Ytos28\_6.pdf. It is also possible use piped links like this. You can add xls -files or any other supported filetypes as well Media:Testixls.xls.

**Example code:**

```
-----  
This is a link to [[Media:Ytos28_6.pdf]]. It is also possible use piped links like  
You can add xls -files or any other supported filetypes as well [[Media:Testixls.x  
-----
```

## Useful links to Wikipedia help pages

- How to use refactoring
- How to archive argumentation. In pyrkiilo, permanent link method should be used; not the subpage method, although is more common in Wikipedia.
- How to resolve disputes
- Quick guide to editing