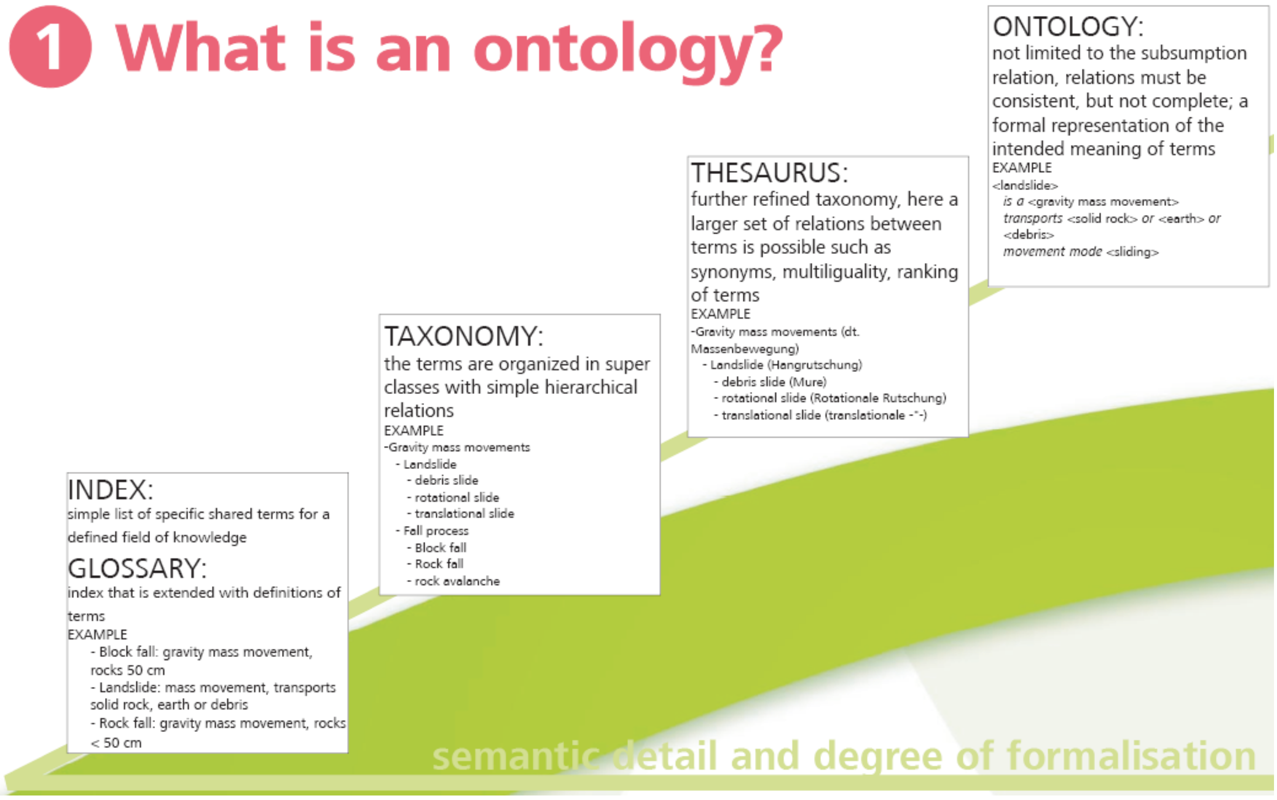
MONITOR – an ontological basis for risk management



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2 What ontologies can/not

Ontologies
+ provide an agreement on the meaning of terms
+ explain the meaning of a term
+ integrate all other forms of
+ strict formalization allows for additional automization, such as querying, consistency checking
- are not easy to generate

Document history

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INTRODUCTION

Within the scope of MONITOR a special working group was established on ontology, with the following base objectives in mind:

- the collection and definition of a common base vocabulary in the thematic fields of MONITOR
- the formalisation of these terms as an ontology
- the use of these terms in the formalisation of declarative knowledge (knowledge about facts)
- the integration of this formalised knowledge on monitoring methods and risk communication, in relation to identified situations
- the use of the resulting ontology as a knowledge base, providing access via web interfaces and querying capabilities

Problems

Agreement about language is the basis of any communication process. More specifically, this agreement is necessary about the meanings of terms used in communication. This meaning is commonly provided by defining the terms used in communication. But more often than not, at least parts of the terms used have not been defined sufficiently, resulting in misunderstandings: in other words, communication problems.

A few examples of definitions of "flood" can easily demonstrate this:

- (1) Temporary covering of land by water as a result of surface waters (still or flowing) escaping from their normal confines or as a result of heavy precipitation. (Munich Re 1997)
- (2) The temporary inundation of normally dry land areas resulting from the overflowing of the natural or artificial confines of a river or other body of water. Flood means a general and temporary condition of partial or complete inundation of normally dry land areas from: (A) The overflow of inland or tidal waters. (B) The unusual and rapid accumulation of runoff of surface water from any source. (EU-MEDIN)
- (3) (A) Rise, usually brief, in the water level in a stream to a peak from which the water level recedes at a slower rate. (B) Relatively high flow as measured by stage height of discharge. (C) Rising tide. (UNESCO; core glossary for hydrology)
- (4) Condition of surface water (river, lake, ocean), in which the water level or the discharge (or both) exceeds a certain (average or "normal" level). This does not necessarily result in flooding. (CEDIM; core glossary for experts in risk science)

Looking at these definitions of the term flood some questions arise:

- What is really meant when the term "flood" is used in communication?
- Is it necessary for successful communication to have (exactly one) common understanding of “flood” (which would result in one definition accepted and the others rejected)?
- How should a definition be designed in order to provide the basis for common understanding?

The problem situation can be explained more intuitively when presenting the different meanings in a graphical way. We assume as a starting point that a definition of a term should clearly describe the complete extension of the term. Then it would be sufficient to name all other terms which are “covered” by this term, in order to define the term (flood). The other terms used for defining flood in the definitions presented above – excluding terms related to tidal processes - are “temporary covering of land with water”, “temporary inundation of normally dry land”, “rise of water level to a peak”, “relatively high flow”, “condition … water level exceeds normal/average level”. These terms still are rather complex terms, so they can be further deconstructed into:

- Land
- Covered with water (= inundation)
- Normally dry
- Water level
- Peak (water level)
- Normal water level
- Water level exceeding normal water level

A first attempt for graphical representation shows only the terminological coverage of the deconstructed terms:

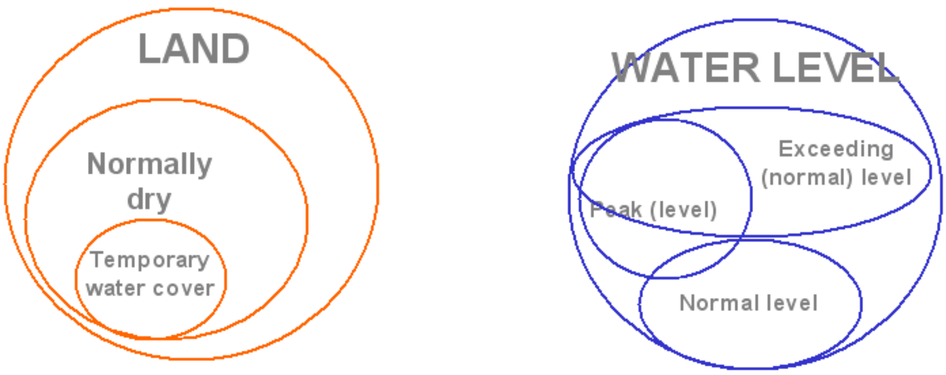


Figure 1: Some decomposed base terms used in the definitions of flood

Problem 1: Same term is used for different meanings ("extension"). Flood as temporary water cover of land vs. flood as some specific water level.

Problem 2: Same meaning is associated with different terms.

Problem 3: Terms are vaguely defined ("fuzzy"). Exceeding "normal" level depends on a clear definition of "normal", which is not easily provided.

Problem 4: A definition of terms can be self contradictory.

A first graphical analysis shows that there are two completely separated ways of defining "floods". On the left, the definitions which state that a flood is a (temporary) covering respective inundation of normally dry land. The definition is completely based on a hierarchy of "land", which can easily be classified without inherent contradictions: there are no intersections of terms used in the definitions.

In contrast to this, the definitions based on water level use terms which are intersecting, they are contradictory within themselves. "Normal water level" and "water level exceeding normal water level" can easily be told from each other, they do not intersect. The definition based on peak level on the other hand uses a term, which intersects with normal level as well with exceeding normal level (because a peak of water level can be well below normal water level).

Besides these obvious problems another problem can be a potential source of misunderstandings in communication. The base terms "normally dry land", "normal water level" and also "peak water level" seem to be ill defined. Many different interpretations are possible, since the term "normal" always requires at least an additional time scale for definition (which is not given in the definitions above). In addition the superclass of flood remains ambiguous (what kind of thing is a flood?). Potential candidates include "covering", "inundation", "situation", "rise (to a peak"). Covering, inundation and rise are related to things that happen (occur) and could possibly be subsumed to a superclass "process", but situation is something like a snapshot of some entities.

Based on this graphical analysis the definitions above seem to cover three different meanings:

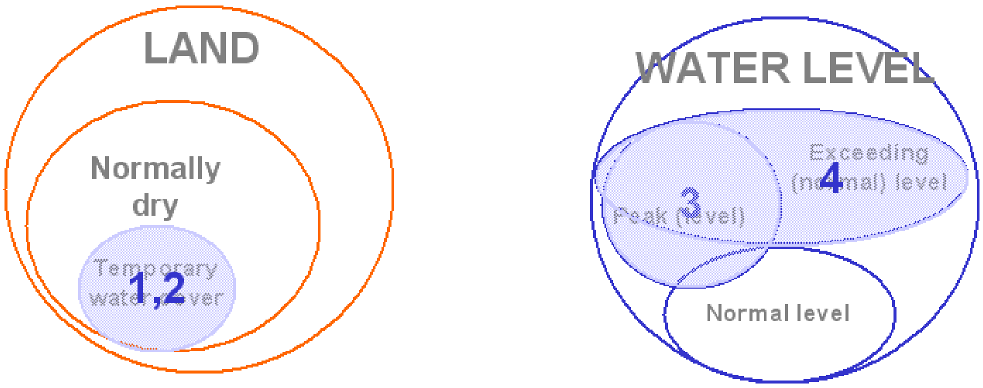


Figure 2: Flood definitions and their coverage of base terms ("extension")

The practical relevance of clear and concise definitions can be demonstrated when introducing a new term to be defined: debris flow.

With this term a process taking place in a torrent is described , where the water transports so much material that it becomes a mixture of earth, rock, wood and mud (SCHMIDT 2002, following BENDEL 1949). Due to its varying mixture of material and its varying percentage of water the classification of debris flows with a broader term becomes ambiguous, oscillating between floods and landslides.

The practical relevance of this issue can be demonstrated by the fact that standard insurances usually insure against landslides but exclude floods from insurance. Insurances subsume debris flows into the broader term flood, so that any damage resulting from a debris flow would not be covered by insurance. In this case a clear demarcation of terms becomes of direct practical importance, but in practice this demarcation is not easily reached. Definitions should thus also allow a differentiation between floods and debris flows in the field practice, not only a clear definition based on theoretical considerations (which could be difficult to implement in practical field work, often based on uncertain observations). In some cases this differentiation had to be proved with help of scientific expertise.

Definitions

The example above demonstrates the problem of contradictory definitions and the practical relevance of definitions. A definition of definition is still missing:

A definition declares the equivalence between some unknown term ("definiendum") and the defining known terms ("definiens"). With Aristotle a definition ("Realdefinition") can be given with genus proximum and differentia specifica (*Definitio fit per genus proximum et differentiam specificam).* A definition is thus based on classifying a term by its genus (species; type or category of this term) and then the distinction to other members of this class by declaring the distinctive properties.

This is the most widely accepted definition and also provides the starting point of discussion here. Special kinds of definitions are genetic definitions („How was it generated“) or final definitions („How to use“).

In order to be usable, definitions have to conform to some definition rules:

- Definitions should be adequate (by using exact and precise terms for the definiens; this means only well-defined terms should be used as definiens)
- No negative definitions should be given.
- Definitions should be non-circular (no tautologies)
- Definitions should be non-abundant (should have no redundancies, only essential properties)
- Definitions should be consistent (no internal contradiction)

Example debris flow – again:

Technical term	Example
Definiendum	Debris flow
Definiens	With this term a process in a torrent is meant, where the water transports so much material that it becomes a mixture of earth, rock, wood and mud.
Genus proximum (Superclass, Broader term)	Process (in a torrent)
Differentiam specificam (Restriction)	transports mixture (earth, rock, wood, mud)
Well-known terms	The following terms must be well-known (i.e. defined themselves previously) in order to make the definition understandable: Process, Torrent transport Earth, Rock, Wood, Mud

Table 1: Definition example in detail

In the example all criteria for a good definition seem to have been included. The definition seems to rely on (potentially) clearly defined terms and it is structurally correct, because it clearly distinguishes between a superclass and the special differences to other terms belonging to the same superclass. The definition includes no redundant information, is consistent in itself and thus seems to be adequate.

Note that this positive evaluation of a definition can be done only on a structural basis. Thematically there may still exist very good reasons to define debris flow in a completely different way. But the definition is obviously done in a formally correct way, and this is exactly what can be enforced with the help of an ontology.

Knowledge

Knowledge can be divided into declarative knowledge, which is knowledge about facts, and procedural knowledge, which is knowledge about rules.

Knowledge can be expressed with sentences and it can be passed on, in written or oral form. It can clearly be told from beliefs, because it has been socially selected and evaluated. So knowledge can be defined as true and well-founded beliefs (see e.g. DETEL 2007).

Well defined terms provide the basis for a well grounded knowledge base. These terms are used in knowledge about facts as well as in procedural knowledge.

Declarative knowledge includes single facts as well as relationships. A single fact would be “rainfall of 10mm was measured at station X on day Y” or “on day Y rainfall at station X was higher than average”. Adding relationships to that, general knowledge can be added, like causation, part-of information, generation and constitution. The process of rainfall could thus be linked to its generating causes or to related techniques of measurement. With the help of relationships general facts can be formulated.

Each single piece of declarative knowledge is a proposition about a state-of-affair (in German: “Aussage über einen Sachverhalt”) and relates well-known terms to each other. In contrast to terms, which are neither true nor false, all propositions have a logical value: true or false.

Knowledge can only be passed on and made understandable if both terms and relations used are well defined in advance. This means that between producer and user of knowledge a common understanding of these basic components of knowledge must be available.

Procedural knowledge defines rules, how to accomplish some goal. So it includes a definition of situations as well as the methods to accomplish some goal within that defined situation. In addition to that, with the help of procedural knowledge, it is possible to build recommendations for actions for various types of situations. Procedural knowledge is practical knowledge (“Know-how”).

It is important to note that terms, propositions and situations (contexts) only exist on a conceptual level. They are concepts to deal with objects of the real world. As an important consequence, the conceptual and the real world SHALL not be mixed in propositions of any kind. This can be exemplified with the proposition that “nature takes care, that unadapted creatures become extinct”. Nature as a conceptual term is not able to act, thus this proposition is a violation of the rule defined above (see Handwörterbuch der Raumplanung 2005: Grundbausteine des Planungswissens).

MONITOR ontology goals

The main goal of the development of the MONITOR ontology can be seen in overcoming the problems mentioned above and building a reliable knowledge base for further work. Thus this ontology provides the means for managing knowledge needed for MONITOR and produced within MONITOR.

Knowledge management can be defined as the systematic collection and structuring of knowledge within a specified domain of knowledge with defined pragmatic objectives (uses) in mind.

The main advantages of using a common formalised knowledge base are:

- direct and easy access to knowledge (with clearly defined entry points);
- communication across the borders of different languages, disciplines and applications;
- the (partially automated) usage of knowledge, e.g. as DSS (Decision Support Systems), as knowledge services (as web services) or as simple querying and visualisation option for knowledge;
- availability ofdifferent views on knowledge contents (e.g. adapted to user groups, focussed on specific application areas or on specific vocabularies);

During the phase of definition of the ontology the main use will be as a „reference ontology". This reference ontology will function as a work and discussion basise for the ongoing work of project partners and experts integrated in project.

In a later phase the ontology can be used as an „application ontology". This will allow different applications and services to use the formalised knowledge of MONITOR directly and automatically. The resulting ontology can thus be viewed as common "background intelligence" for different applications.

METHODOLOGY

A wide variety of methodologies exists for the creation of terminology systems and their further use as exchangeable knowledge bases. Some of the best known and most widely used are:

- Glossary
- Taxonomy
- Thesaurus
- Ontology

A **glossary** is a list of terms in a particular domain of knowledge with the definitions for those terms. A glossary can thus be seen as a sorted list of {term, definition}. It is used

- at the end of a book and includes terms within that book which are either newly introduced or at least uncommon,
- in scientific reports, in order to clarify uncertain terms and/or make terms understandable to a broader audience,
- as a stand-alone dictionary of terms in a defined knowledge domain (glossary of „flood related terms" ...)

Advantages / disadvantages of a glossary:

\+ glossaries can provide a valuable starting point as an accepted vocabulary (esp. if defined by a larger community), by providing an intelligent choice of terms (and implicit: a choice of non-terms).

\+ glossaries can easily be generated (from a technical point of view) and exchanged.

\- glossaries do not relate terms to each other.

\- glossaries can not be consistency-checked (they can include inherent contradictory definitions).

\- glossaries can not be automatically processed.

A **taxonomy** is a controlled vocabulary whose terms are classified (by means of the superclass and subclass relationships). This procedure is further refined in a Thesaurus.

A **Thesaurus** is a controlled vocabulary, with terms related to each other by a set of pre-defined possible relations. The definition can be given in a scope note (which is not obligatory). The main relations of terms to each other are

- Definition of hierarchy of terms (BT: Broader Term NT: Narrower Term)
- Collection of synonyms
- Differentiation of best terms (PT: Preferred Terms)

Advantages / disadvantages of a glossary:

\+ relations between terms are defined which is an improvement compared to glossaries (subterms ...)

\+ standards and norms for definitions exist

\+ partial automatic processing possible (see e.g. Agrovoc, UDK)

\+ translation via multilingual Thesauri can be provided

\- narrow set of defined relations between terms

\- no consistency check possible

- limited automated processing

An **Ontology** is a formalised specification of a conceptualisation within a domain of knowledge (GRUBER 1995). That is, an ontology is a description (like a formal specification of a program) of the concepts and relationships that can exist for an agent or a community of agents. More specifically it has been defined by GUARINO (1998): An ontology is a logical theory accounting for the *intended meaning* of a formal vocabulary.

Ontologies in computer science are not concerned with questions of existence. They simply assists in specifying and clarifying the concepts employed in specific domains. It helps formalizing them within the framework of some formal theory with a well-understood logical (syntactic and semantic) structure.

An ontology is characterised by

- an application field (domain)
- a formal description of concepts, that are used in that domain (classes, concepts)
- a formal description of relations between these concepts (properties)
- restrictions and rules, which describe these relations precisely (restrictions)

Ontologies have often been used for the purpose of enabling knowledge sharing and reuse. Users of an ontology commit themselves to agree upon a vocabulary (i.e., ask queries and make assertions) in a way that is consistent (but not complete) with respect to the theory specified by an ontology. In short, a commitment to a common ontology is a guarantee of consistency, but not completeness, with respect to queries and assertions using the vocabulary defined in the ontology (GRUBER 1993).

In addition to that ontologies can be used for the discussion and explanation of the meaning of various expressions:

+ to *negotiate the meaning of expressions* between (human or artificial) agents belonging to different (possibly related) communities;
+ to *establish consensus* in a community that needs to adopt a new term; or simply
+ to *explain* the meaning of a term to somebody new to the community
+ in addition to that ontologies integrate all possible applications of glossaries, taxonomies and thesauri;
+ and strict formalisation opens additional application options , especially automatic consistency checks and automated help in building the classification (using “inference”machines);

- formalisation requires additional efforts and is a time consuming task, which requires some (formal) expert knowledge;

These main solutions can be illustrated with the following figure (adapted from METOKIS):

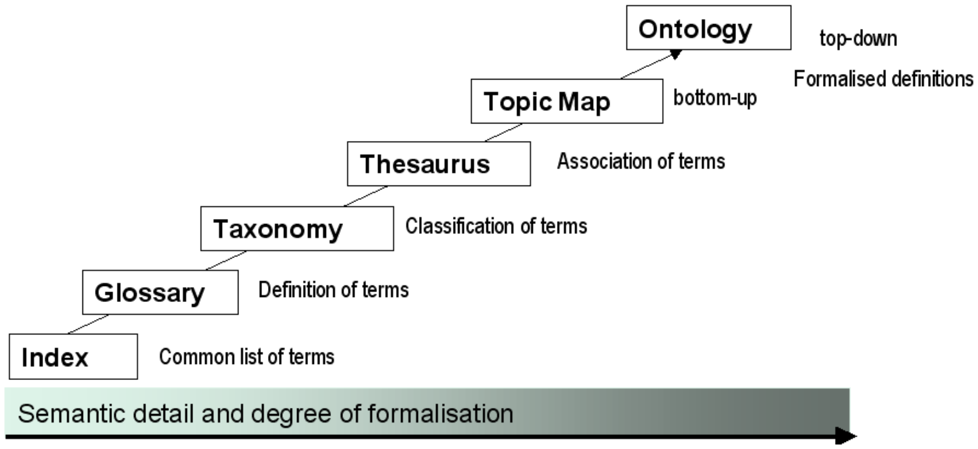


Figure 3: Methodologies for terminology formalisation

With this in mind the way forward was to choose an ontology as a basis, which can be seen to integrate different methods:

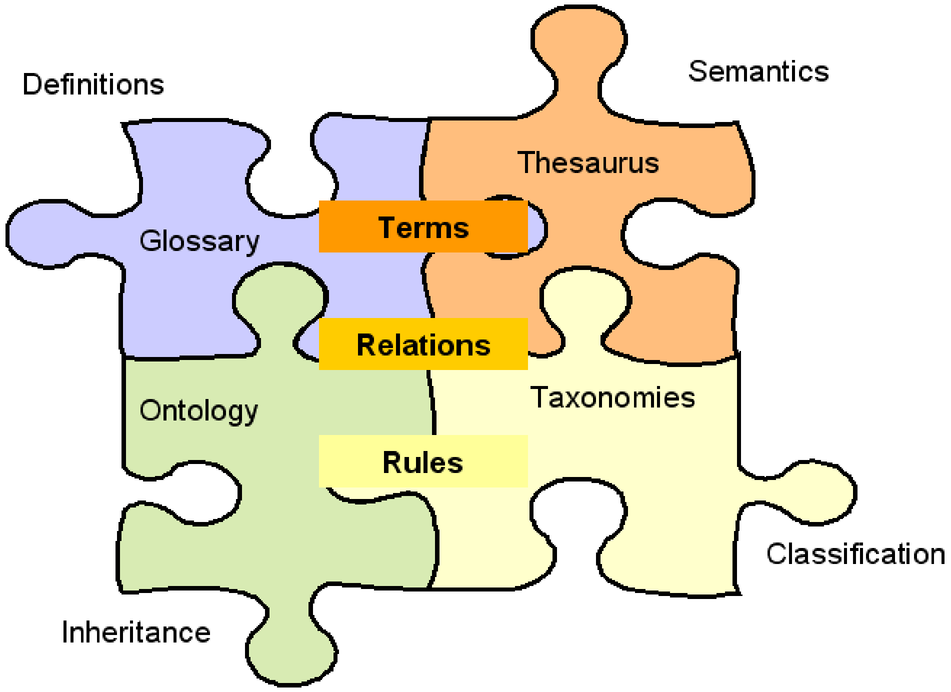


Figure 4: Fitting all the methods together

Each of these methods provides special advantages for the final result:

Method	Use in MONITOR ontology
Glossary	Selection of terms and verbal description. This usually includes a definition. → which terms are used ?
Taxonomy	Genus of term („Superclass“) for hierarchies of terms. → how are terms hierarchically related ?

Thesaurus	Defined relations between terms. Provides means of translation of terms and declaration of preferred (or not to be used) terms. → multilingualism, preferred terms
Ontology	Differentia specifica for a full formalisation of definitions. → full formalisation, automatic consistency checks

Table 2: Methodologies used for MONITOR ontology

With the help of MONITOR ontology the following objectives shall be supported:

- Provide a semantic road map to individual fields and the relationships among the fields.
- Improve communication generally.
- Provide the conceptual basis for the design of good research and implementation.
- Provide classification for action.
- Provide a tool for searching, particularly knowledge-based support for end-user searching.
- Provide tools for indexing.
- Facilitate the combination of multiple databases or allow unified access to multiple databases.
- Support document processing after retrieval
- Support meaningful, well-structured display of information

GUIDE TO MONITOR ONTOLOGY

Creation

The current first version of the MONITOR ontology was developed in a series of meetings by a dedicated ontology working group. Members of this working group are from project partners LP, P2, P3, P4, P5, P6 and P7. Four meetings with members from all these partners and additional multilateral meetings have been held.

A glossary of important terms was built, which developed rapidly into a collection of 400+ terms. The analysis of these terms clearly showed that many of the definitions – often published by renowned institutions – were mutually incompatible and sometimes even in itself inconsistent. The initial intention of finding one ("the best") definition for each term from an authoritative institution thus proved to be impossible.

Inconsistency problems in definitions occurred most often and pronouncedly were definitions included terms also in use in everyday language (which is true for almost all basic risk terms!) and/or where terms of very general concepts are used. Examples of these base terms are "process", "event", "method", "feature", "task" or "situation". They are mostly taken for granted in domain vocabularies and thus are not explicitly defined and are often used in very heterogeneous manner. Terminology systems which are based on inconsistently defined base terms will consequently be inconsistent themselves.

For this reason, a consistent upper level terminological base was required. A systematic approach needs clear definitions of these base terms as a starting point. MONITOR makes use of a well established "top-level" ontology for this end. This top-level ontology, providing formalised definitions of all general terms, is DOLCE (Descriptive Ontology for Linguistic and Cognitive Engineering). It was developed in the FP6 research project Wonderweb (http://wonderweb.semanticweb.org/) and has been further refined and used since then. It also provided the starting point for DIS-ALP ontology, so that DIS-ALP ontology and MONITOR ontology can easily be integrated.

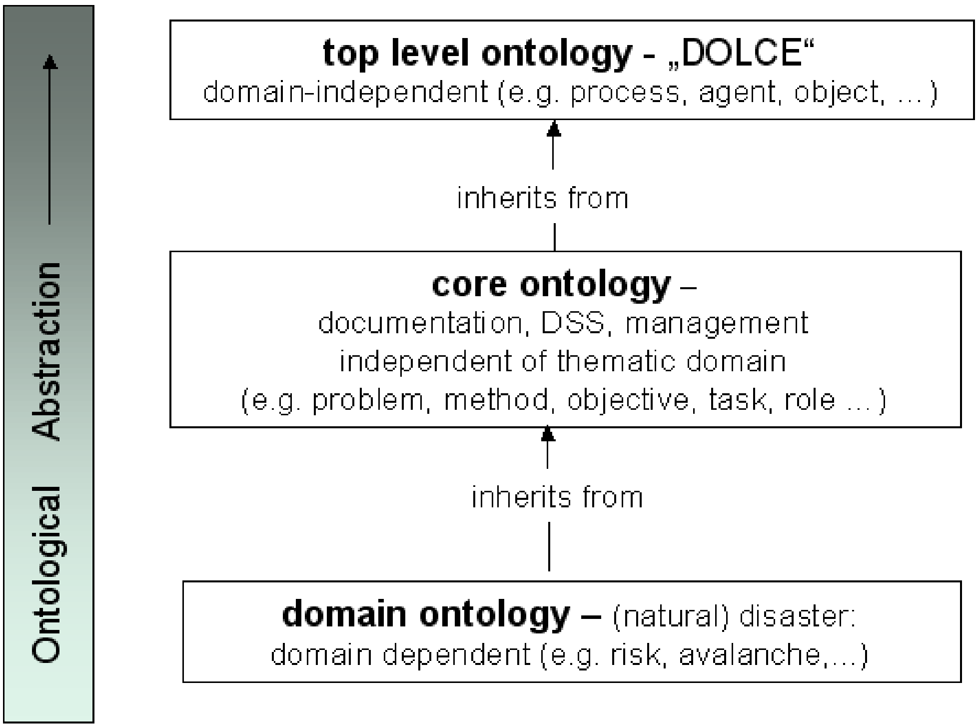


Figure 5: Modularisation of ontologies

With these basic assumptions, the definition of the ontology involved the following steps which were carried out by members of the ontology working group:

- Identify important term (concept)
- Identify superclass of term out of DOLCE terminology
- Define formal relations to other terms (restrictions) based on DOLCE basic relations
- Define LABEL and COMMENT(s) of term from literature

The steps described above clearly show that our definitions have to be built on well-known and well-defined objects, creating new objects from them. Only when defined in such a formal way the resulting object (concept, class) is labelled and commented. The label – what would be the "term" itself in the view of a user of MONITOR ontology – is thus not the starting point, but rather something ascribed to a well-defined concept.

This is one of the reasons why we did not consider language analysis (e.g. an etymological approach) to be valid for construction of the formal properties of a term. It can only help to ascribe labels to these terms (in order to make them more easily and intuitively communicable to users of the ontology).

The MONITOR ontology itself is being developed in a modular way, so that detailed special domain definitions can build on basic upper level definitions. This is illustrated in the following graphic:

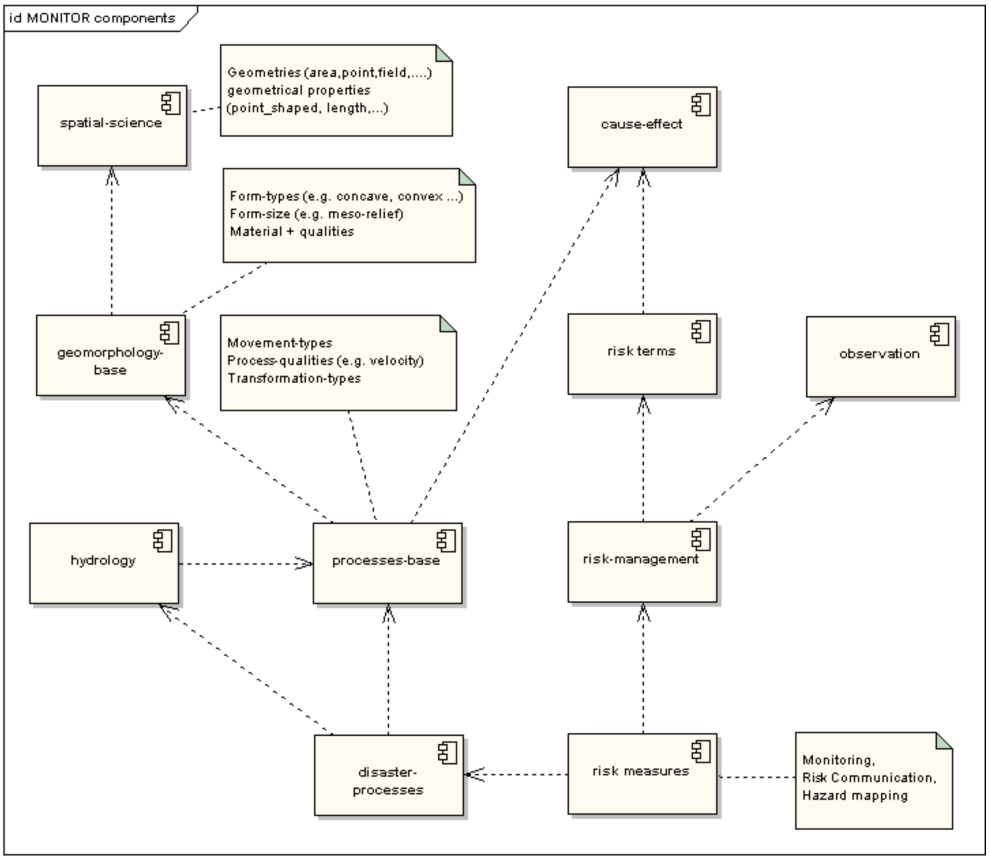


Figure 6: Basic modules of MONITOR ontology

Interpretation and top terms

The MONITOR ontology was developed as a series of UML[1] style graphics, representing definitions as terms with their relations to other terms. The colours of terms were chosen for representing specific DOLCE

[1] UML (Unified Modelling Language) is used as a standard in formal software and system definition. See www.uml.org for details.

superclasses, which gives a clear orientation within the graphic and allows minimizing the number of IS A relationships at the same time.

The UML notation provides representation possibilities for all important components of an ontology: terms, relations and special relations (like IS A). In addition, special components like “disjoint” or logical conditions can be modelled with little additional effort.

For an interpretation, an idea of some basic DOLCE concepts is necessary. The most important are listed here with a short explanation and their relations to each other[2]. The base classes are endurants, perdurants and quality.

In DOLCE endurants are defined as entities that are in time, while lacking temporal parts (so to speak, all their parts flow with them in time). They are independent essential wholes and exist continuously (endurants have also been named “continuants”). Examples of endurants are physical objects, social objects or amount-of-matter (e.g. “clay”, “water”).

Perdurants, on the contrary, are entities that happen in time, and can have temporal parts (all their parts are fixed in time). Perdurants have also been named occurants (in German: “Vorgänge”). Examples of perdurants are climbing a mountain, a smile, an avalanche or a project meeting.

Qualities are the basic entities which can be perceived or measured (like shapes, colours, sizes, sounds, smells, as well as weights, lengths, electrical charges). Qualities inhere to entities.

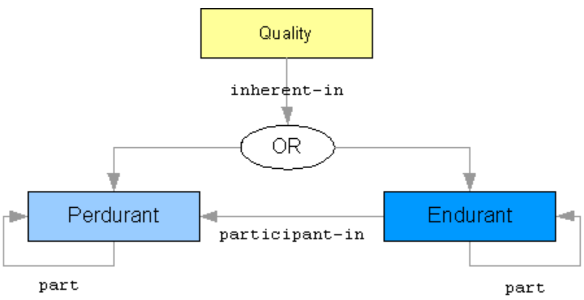


Figure 7: Basic categories and their relations in DOLCE

Category (Symbol color)	**Definition / Description**
	Endurants
Physical object	Physical objects are endurants with unity. Differently from aggregates, (most) physical objects change some of their parts while keeping their identity; they can have therefore temporary parts.
Feature	Features are parasitic objects, that exist insofar their host exists. Typical examples of features are caves, holes, bumps, boundaries, or spots of

[2] The explanations in this table are taken from DOLCE version DLP 397. They are partially re-formulated to improve ease of understanding.

	colour.
Amount-of-matter	Amounts of matter are endurants with no unity (according to Gangemi et al 2001 none of them is an essential whole). Amounts of matter – ‚stuff' referred to by mass nouns like ‚gold', ‚iron', ‚wood', ‚sand', ‚meat', etc. – are mereologically invariant, in the sense that they change their identity when they change some parts.
Non-physical objects	
Mental object	Mental objects are dependent on agents which are assumed to be intentional (in the wider sense of conceiving some description). AKA „internal description".
Social object	A catch-all class for entities from the social world. It includes agentive and non-agentive socially-constructed objects: descriptions, concepts, figures, collections, information objects. It could be equivalent to ‚non-physical object', but we leave the possibility open of ‚private' non-physical objects.
Agent	Intentional social object ...
Situation	A situation is a social object, which is the setting for at least one entity (e.g. contexts, episodes, states of affairs, structures, configurations, legal cases, etc.). A perdurant is usually the only mandatory constituent of a setting. Two descriptions of a same situation are possible; otherwise we would result in a solipsistic ontology. The time and space (and possibly other qualities) of a situation are the time and space of the perdurants in the setting.
Description	A description is a social object which represents a conceptualization (e.g. a mental object or state), hence it is generically dependent on some agent and communicable. Descriptions define or use concepts or figures, are expressed by an information object and can be satisfied by situations.
Goal	A goal is the description of an impact (of an activity) which an agent desires to achieve.[3] The direct impact desired can related to a change of certain qualities (which is discussed below with the term "quality"). A goal is different from an objective, because the second one is independent from the cognitive state of a particular physical agent. In practice, an agent (physical or social) may aim at realizing an objective even though the realizing situation conflicts with a goal-situation of the same agent. In ‚private' plans of a physical agent, realizing situations usually coincide with goal-situations. Different cases occur with plans endorsed by social agents like organizations, institutions, etc., which are more clearly aimed at realizing objectives.
Method	A description that contains a specification to do, realize, behave, etc. Subclasses are plan, technique, practice, project, etc.
Plan	A plan is a method for executing or performing a procedure or a stage of a procedure. A plan must use both at least one role played by an agent, and at least one task. Finally, a plan has a goal as proper part, and can also have regulations and other descriptions as proper parts.
Information object	Information objects are social objects. They are realized by some entity.

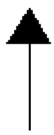
[3] This definition differs in emphasis from DOLCE but rather follows BOESCH (1991, p. 45), in order to allow a better integration with action theory (and thus practicability).

	They are ordered (expressed according to) by some system for information encoding. Consequently, they are dependent from an encoding as well as from a concrete realization. They can express a description (the ontological equivalent of a meaning/conceptualization), can be about any entity, and can be interpreted by an agent. From a communication perspective, an information object can play the role of „message“. From a semiotic perspective, it plays the role of „expression“.
(social) Concept	AKA C-Description. A non-physical object that is defined by a description s, and whose function is classifying entities from a ground ontology in order to build situations that can satisfy s.
Role	Also known as ‚functional role’. A concept that classifies (in particular, it is ‚played by’) endurants, as used in some description. Roles are the descriptive counterpart of endurants, and, as endurants participate in perdurants, they usually have courses as modal targets.
Course	A concept that classifies (in particular, it ‚sequences’) perdurants (processes, events, or states), as a component of some description. Courses are the descriptive counterpart of perdurants, and, since perdurants have endurants as participants, they are usually the function of some role.
Parameter	A concept that classifies (in particular, it is ‚valued by’) regions, as defined by some description. Parameters are the descriptive counterpart of regions, and, as regions represent the qualities of perdurants or endurants, they can be requisites for some role or course. A parameter has at least one region that is a value for it.
Perdurants	
Event	A perdurant (occurances, happenings) which has an inherent end and which (can) have parts of a different class of perdurants. Events usually cause impacts (changes).
Accomplishment	Event, which has a duration in time. Examples are a rock concert, an avalanche or a project meeting, climbing Großglockner mountain.
Achievement	Atomic event (point in time). Examples are finding (something) or reaching Großglockner summit.
Impact	Achievement, which exemplifies a change.
Process	A perdurant, which has a duration in time but has no (pre-defined inherent) end. It could continue to happen endlessly. A process is interval-based, meaning that only for some time interval it has parts of the same class. In the DIN xxx norm a process has been defined more detailed as a perdurant, which transports or transforms physical objects, amount-of-matter or information. This definition can provide a valuable starting point for considerations of natural or technical hazards.
Action	A process that exemplifies the intentionality of an agent.
Activity	An activity is an action that is generically constantly dependent on a (at least partly) shared plan adopted by participants. This condition implies that an action must be sequenced by a task. Intuitively, activities are complex actions that are at least partly conventionally planned.

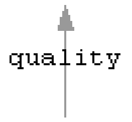
State	A perdurant, which has no (pre-defined, inherent) end and which is not interval-based. All its time intervals are of the same class. Examples are sitting or having black hair.
Qualities	
Quality	Qualities can be seen as the basic entities we can perceive or measure: shapes, colors, sizes, sounds, smells, as well as weights, lengths, electrical charges. Qualities inhere to entities: every entity (including qualities themselves) comes with certain qualities, which exist as long as the entity exists. For practical reasons qualities can be further differentiated by their scale: ▪ Nominal (categorical scale) ▪ Ordinal (categorical scale) ▪ Interval (metric scale) ▪ Ratio (metric scale) Goals are always related to qualities. The possible types of goals can be classified according to the scale of qualities. So on a nominal scale the goals of change (from one category to another category) and conservation (staying the same category) can be distinguished. On an ordinal scale in addition the goal of improving (from one category to another category, which is classified as "superior") can be introduced. On the metric scales the goals of increase and decrease can be defined. These goals can be defined in more detail by an absolute change (increase, decrease) or alternatively by a target threshold, which should be exceeded or stay/get below. The goal of stabilisation is the metric analogy to conservation. Ratio scale in addition allows defining goals like doubling (due to the absolute scale of measurement). These goal categories change, increase, conservation, decrease, improvement and stabilisation can all be regarded as subcategories of impact.
Region	Regions define the possible values a quality can adopt (value domain). The region for quality color is a color space, the region for a quality location can be defined as some spatial reference system and the region for a temporal quality can be defined by some temporal reference system (like the Gregorian calendar).

Table 3 : Basic terms (classes) as defined in DOLCE

Concerning the most relevant relations between terms (classes) in detail the following notation was used (illustrated with examples):

Relation Name[4]	Symbol (Relation category)	Explanation
IS A (← subclass-of)		The IS A relation describes a relation of a subclass to its superclass. This is the most basic relationship, because it implies that the subclass inherits all definitions from its superclass. It is the only relationship used in a taxonomy.

[4] In brackets the name of the inverse relation is given (if applicable).

Any other relation		Describes a (non IS A) relationship between classes (terms). The name of the relationship is indicated on the arrow.
part (← part-of)	Mereology	The most generic part relation: reflexive, asymmetric, and transitive.
proper-part (← proper-part-of)	Mereology	The proper part relation: irreflexive, antisymmetric, and transitive.
generically-dependent-on (← generic-dependent)	Dependence	X is generically-dependent-on Y if whenever Y is present X will also be present. In other words: the generation of X depends on the presence of Y.
generic-constituent (←generic-constituent-of)	Constitution	Y constitutes X if Y would be part of X destruction. Constituents are not properly classified as parts, although this kinship can be intuitive for common sense. Example of specific constant constituents are the entities constituting a setting (a situation), while the entities constituting a collection are examples of generic constant constituents.
has-quality (← inherent-in)	Inherence	The immediate relation holding for qualities and entities. A quality is inherent-in some particular. E.g. Color (a quality) is inherent-in a physical object (each physical object has-quality color).
participant (← participant-in)	Participation	The immediate relation holding between endurants and perdurants (e.g. in 'the car is running'). Participation can be constant (in all parts of the perdurant, e.g. in 'the car is running'), or temporary (in only some parts, e.g. in 'I'm electing the president'). A 'functional' participant is specialized for those forms of participation that depend on the nature of participants, processes, or on the intentionality of agentive participants. Traditional 'thematic role' should be mapped to functional participation.
functional-participant (←functional-participant-in)	Participation	This relation constrains participation within the scope of a description: a perdurant is participated by an object according to a description and its components.
use-of (← used-in)	Participation	A functional participation between an action and an endurant that supports the goals of a performer. It catches the everyday language notion of being exploited during an action by someone/something that initiates or leads it.
product (← product-of)	Participation	A functional participation that assumes a meet relation between an activity and the life of an endurant. Unfortunately, such a notion can't be formalized in general, because it is sensible to the particular project that drives the action.
references (← referenced-by)	References	A relation holding between non-physical objects and entities whatsoever (thus including non-physical objects themselves). An intuition for the references relation could be that a non-physical object adds 'information' to an entity. In fact, non-physical objects depend on a communication setting. In most cases, this is the characteristic relation that provides a unity criterion to objects, events, etc. For example, cars are

		objects and not mere aggregates because there is a project, a design, a social value, a functional structure, a personal emotional structure, etc. attached to them. This attachment can be represented by means of 'non-physical objects' that 'reference' cars. The most obvious application is for situations, which do not exist without a description, although they still are extensional entities: a situation without a part is no more the same situation, but a situation is not a mere aggregate, since it has references to a description as its unity criterion. Adding information to an entity can also be thought as an intentional solution to a holistic stance. Defenders of this view - within different frameworks - are Kant, Brentano, Husserl, Gestalt psychologists, Merleau-Ponty ... References is distinguished according to the kinds of non-physical objects and referenced ground entities: referencing between descriptions and situations is called 'SATISFIED-BY', while referencing between description components and situation components is called 'CLASSIFIES'. 'SETTING-FOR' is a referencing relation between situation and the entities in its setting (it was formerly a constitution relation, but since situation appear to be social objects from the DOLCE viewpoint, the constitution solution is no more applicable). 'EXPRESSES' is bound to information objects and the meaning (description of a representation or conceptualization) in which they are involved. 'REALIZED-BY' is bound to information objects and physical representations that are used to communicate them, etc. 'ABOUT' is bound to information objects and entities whatsoever (aboutness of intentionality).
classifies (← classified-by)	References	A.K.A. 'selects'. The referencing relation between concepts defined by descriptions, and constituents of situations. It can be understood as a reification of a 'satisfiability' relation holding between elements of theories and elements of models. It has a time index, but this should not be intended as a partial compresence ???, since the time only refers to a part of the classified particular life or extension.
value-for (← valued-by)	References	The "selected by" relations holding between regions and parameters. At least one region is supposed to be a value for a parameter.
sequences (← sequenced-by)	References	This is the immediate relation between courses and perdurants. A course can be either atomic, being a simple 'perdurant role', or it can be complex, thus creating an abstract ordering over a temporal or causal sequence of processes or actions. The ontology of plans develops in detail intentional complex courses.
played-by (← plays)	References	This is the immediate relation between roles and endurants. A role classifies the position (function, use, relevance …) of an endurant within a context (description). Roles can be ordered, interdependent, at different layers.
setting-for (← setting)	References	The relation between a situation and the entities that are referenced by it. At least some of, or all such entities must be classified by concepts defined by the description that the situation is supposed to satisfy.

has-in-scope (← in-scope-of)	References	When there is an 'epistemological layering', i.e. a description d involves another description d' (one of the roles in d classifies d'), a situation that satisfies d', will be in the scope of d as well. For example, a judgment procedure will have a legal case in its scope, but being a legal case depends on satisfying some legal description not identical to that procedure. Another example: a plan assessment is a technique to evaluate a plan execution, and the assessment 'has in scope' the plan execution.
satisfies (← satisfied-by)	References	A situation satisfies a description.
about	References	An information object is about some entity, which it describes.
causes (← caused-by)		A perdurant A causes another perdurant B (to happen). This is usually related to a temporal precedence of A to B and a common (temporal) border. A causal relationship is usually defined by experience, which gives evidence that B usually follows after A, given certain defined conditions.

Table 4: Basic relations from DOLCE

MONITOR ONTOLOGY

Basic risk terms

As MONITOR is a project that is dedicated to risk management (as defined in CADSES programme as Measure 4.2 "Promoting risk management and prevention of disasters") the terms used centre around "risk". For this reason, the first step in ontology definition was the selection and formalisation of risk related base terms. The result turned out to be a rather complex pattern of terms interconnected by a high number of relations, which is why the graphical definition of these basic terms is shown here step-by-step, starting with the basic concepts and progressing towards more detailed views.

For the definition of the base terms we take as our guiding principle that general terms should also be generally defined, which means that these definitions can be applied to a broad range of applications. So when talking about hazards we do not (explicitly or – even worse – implicitly) restrict ourselves to natural hazards or risk to flood risk. Counterexamples to this can be found e.g. in the glossary of FloodRisk. We think that those general terms should be defined in such a (consistent) way that they can be applied to risk management in different fields like natural disasters as well as in medicine or insurance. For more specific (restricted) definitions we propose to use combined terms (like "flood risk" or "natural hazard").

Only qualities can be observed

A distinction between "real world" phenomena and social concepts serves as basis for structuring the terms. The "real world" consists of all (actual or possible) objects and events, but can not be directly represented and observed. Any observation of objects and events of the real world is directed towards the (observable) qualities of these objects and events.

Real world: basic cycle

Starting point for terminology development is the basic interrelation between the environment and events changing the environment:

The environment (as a term subsuming natural, built and social environment) consists of endurants. These endurants participate in events – the location of these events is thus indirectly the same as the location of the participating objects.

This relation of participating in events (which actually means a spatio-temporal co-location) can be labelled "exposure", if an event is only a potential (possible) event.

Events are perdurants (occurrences) which happen within this environment and which "cause" impacts.

An impact "changes" (qualities of) the environment. A change of quality in this meaning may include substantial changes like generation and destruction of objects.

Real world

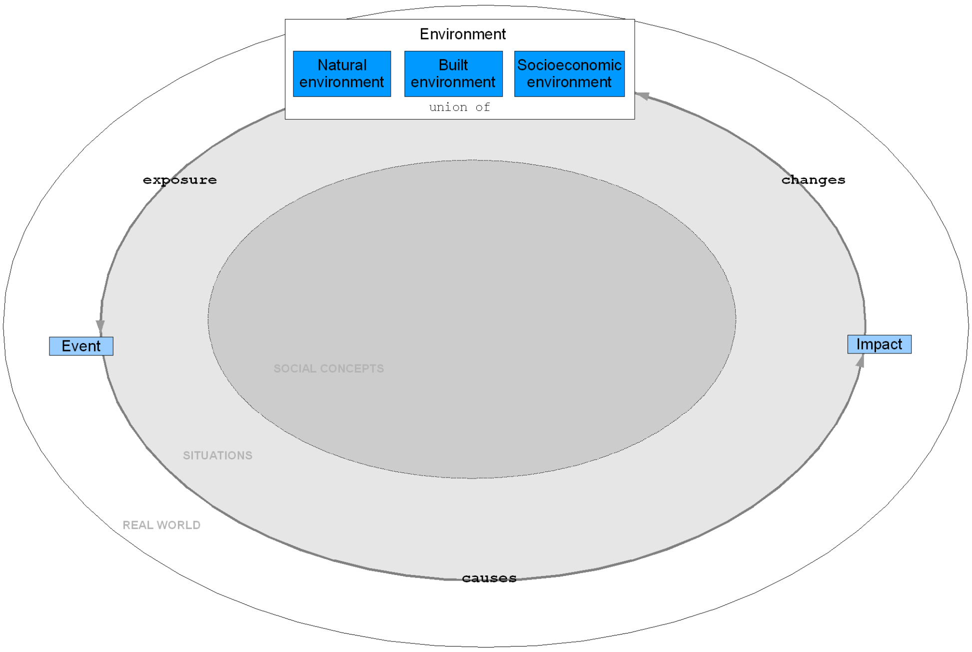


Figure 8: Basic cycle in the reak world

Social concepts: damage, hazard and endangered objects

The basic cycle as described above happens continuously in the real world and is itself not in the focus of interest. But social concepts classify objects and events of the real world; in this way they become of social interest.

Social concepts classify elements of the real world in order to make them communicable and knowledge interchangeable. Without social concepts no communication about objects and events is possible, because they provide the basis for exchange of information. But this classification is always depending on context as much as on the social collective, which finds agreement on a specific social concept. Social concepts can thus not be seen as constants, but rather as changing views of the world, depending on a common agreement of some social collective.

The starting point of any discussion on risk and hazard is the social concept of damage. Damage is the concept which classifies an impact (of some event) to have negative consequences.

Depending on damage a hazard can be defined as the social concept, which classifies an event as one (potentially) causing negative consequences (an impact which is socially classified as damage). This formal formulation corresponds with a more intuitive formulation: Hazard is an event, which causes damage. This includes both the actual event and the potential event.

Intuitive definitions

This intuitive definition comes much closer to everyday language and thus improves comprehensibility of definitions. Yet it still remains a formally correct definition if one allows defining a social concept and the term it classifies as equal (using this equalness like IS A). With this “language shortcut” definitions become more intuitive.

All objects which are within reach of an event classified as hazard can consequently be seen as endangered objects. This concept thus classifies objects of the (natural, built, socioeconomic) environment.

Damage is the central concept for all risk related propositions

This argumentation shows that without the concept of damage, concepts like hazard or endangered objects would not exist.

Social Concepts

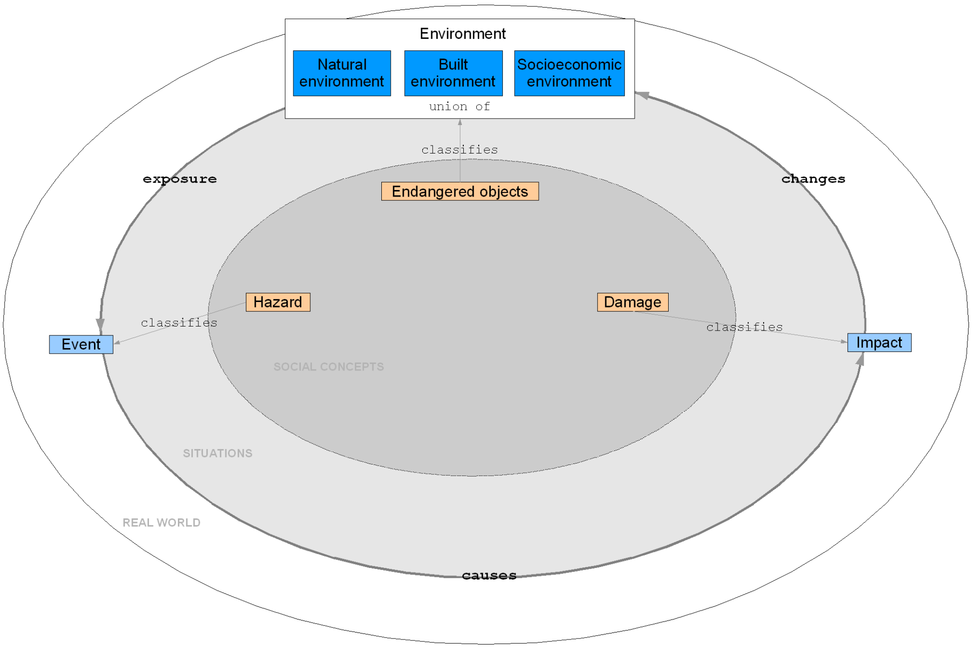
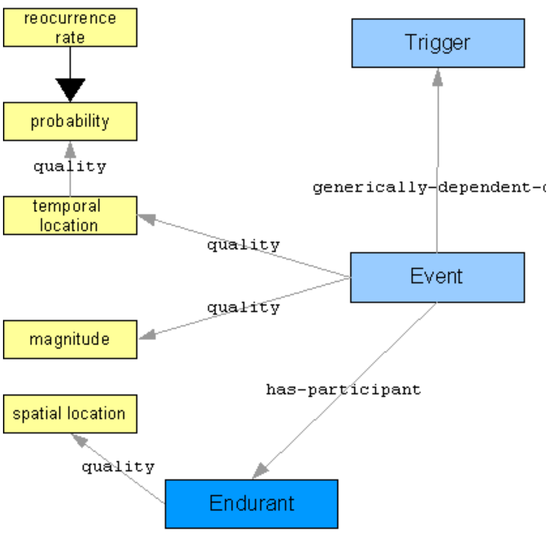


Figure 9: Basic social concepts for the real world

Qualities – basis for observation and evaluation

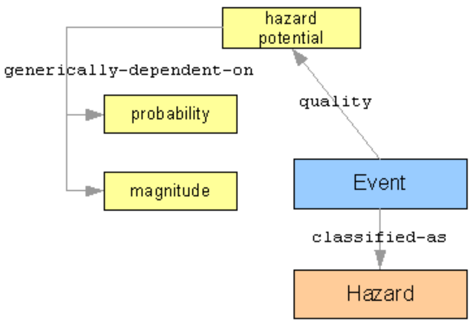
Physical and social objects as well as perdurants (“things which happen”) can never be directly observed. Observation and thus identification has to be directed towards the qualities of objects.

These qualities are often not part of the definition of these objects and perdurants but they play an important role in observation and in defining goal dimensions.



An event has a magnitude (sometimes also labelled “intensity”) and it has an indirect spatial location (via its participating endurants). An event and all its parts have a temporal location. This temporal location can have a probability as quality. A reoccurrence rate is a special form of probability.

In case of debris flow the participating endurant is debris (an amount-of-matter) and its location at different times of the flow determines the indirect location of the event.

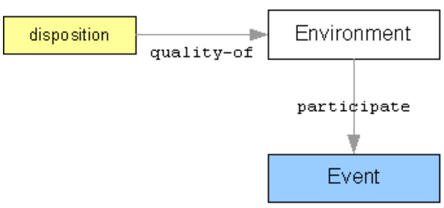


Using the defined qualities of events a definition of hazard potential can be given:

Hazard potential is the quality of a (potential) event, which is classified as hazard. It is generically-dependent-on the probability and the magnitude of the event.

Thus if both the probability and the magnitude of the (hazardous) event can be defined the hazard potential can also be defined.

Figure 10: Events and their qualities – defining hazard potential



Disposition is a quality of an endurant, which defines that given certain (possible) conditions it would likely participate in a defined event (see MEIXNER 2004, p. 79). Language denotes these qualities usually with the suffix "-able" (e.g. "inflammable"; in German "-bar" or "-lich").

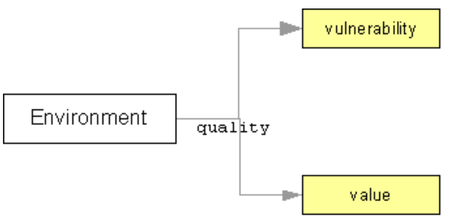
In case of debris flows disposition would be the quality of amount-of-matter (the debris) to participate (be transported) in a debris flow.

This definition is well conforming to one provided by KIENHOLZ (1998; cited in SCHMIDT 2002).

Disposition alone does not cause an event to happen. Disposition determines the base conditions, which together with a trigger cause an event to happen. In this respect the trigger is seen as the causal event, whereas the disposition can be seen as (necessary but not sufficient generale) conditions.

In the case of natural disasters, disposition is usually regarded as a quality of an area/region. This view can be seen as a shortcut to the full ontological correct view, because the disposition of some material to participate in a process is not completely defined in the material itself, but depends on conditions of the area it is situated.

Disposition is usually differentiated into static disposition (also called base disposition), which is regarded as time-invariant, and current disposition, which is the dynamic short-term view. The main factors of static disposition are invariant factors, like geological conditions or qualities of the terrain, whereas the dynamic conditions are mainly influenced by weather (and possibly other extreme events, like earthquakes and resulting tectonic changes).



Vulnerability, capacity and value are qualities of (objects of) the environment.

This formulation is somewhat difficult, because value is more a social concept than a direct quality of something and vulnerability is a complex quality.

Vulnerability – just as value – is here regarded as a subclass of quality, although there are many arguments for categorising these terms under social concepts. Here we consider vulnerability to be objectively definable (although difficult to operationalise) and value to have some measurable dimension. The social dimension of value we consider to be of the damage classification (of impact).

In the literature a vast number of definitions of vulnerability can be found. Terms that are usually found related to vulnerability include resilience, resistance or susceptibility. Most definitions remain vague to a large extent and usually can not be (directly) operationalised.

Vulnerability has been seen as the complement of capacity and“being vulnerable” as the complement of “secure” (WISNER et al. 2003[2]) Here capacity is regarded as the complement of vulnerability (because both capacity and vulnerability can be categorised as qualities of objects, whereas security rather refers to a situation). Thus the higher the capacity the lower the vulnerability (of an object). They are inversely related to each other.

WISNER et al. (2003[2]) have defined vulnerability as being dependent on

- the capacity to anticipate
- the capacity to cope with
- the capacity to resist and
- the capacity to recover from

an extreme event.

They confine their definition to persons or social groups (arguing that a building or a settlement’s location should rather be categorised as unsafe than as vulnerable). We consider vulnerability to be valid for a broader range of application, also referring to non-agentive physical objects. This allows us to use one term without having to distinguish between objects (natural object or social object or built object) were it is applied.

In environmental science (e.g. water management) vulnerability is usually classified into general conditions of vulnerability (called “intrinsic” vulnerability) and “specific” vulnerability, which describes vulnerability in relation to a certain type or magnitude of hazard. This provides a valuable enhancement, which can also be applied in disaster management and risk management.

A good practical definition of vulnerability can be read as follows:

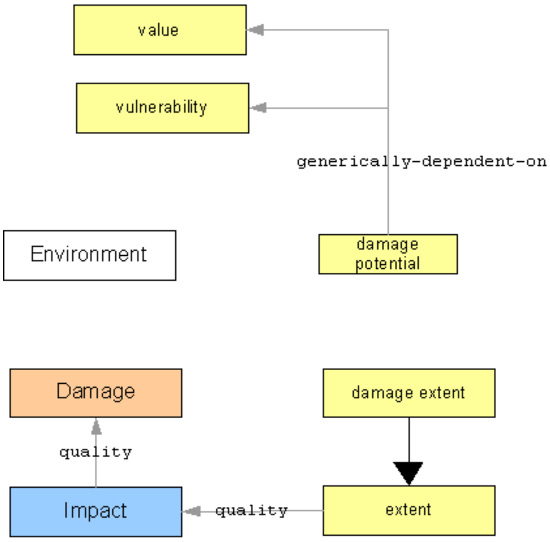
Vulnerability is the quality of (objects of) the environment, which determines damage, given a defined (hazardous) event.

As short (more intuitive) definition this can be formulated as:

Vulnerability is the quality of an object, which describes its probability of getting harmed in an event.

The factors, which determine vulnerability (such as anticipation capacity or recovery capacity, see above) are not part of the definition of vulnerability, but rather describe its components. Examining these components in every detail can easily result in making the term vulnerability itself become vague and fuzzy.

Capacity is defined here as the quality (of objects) of the environment, which describes the ability to cope with some process[5]. This is true to objects of the natural environment (e.g. "absorption capacity" of soil, resistance capacity of a house against an earthquake or the recovery capacity of people after a medical surgery).



Damage potential is a quality of the environment, which results from an event (of a defined size).

Damage potential is dependent on the value of objects affected and vulnerability of these objects.

Damage extent is an extent, which is the quality of an impactclassified as damage.

It is important to note that most of the qualities defined here are not static but rather time varying. This is true for disposition (as discussed above) but as well for probability of an event or for vulnerability.

Figure 11: Qualities of the environment and damages

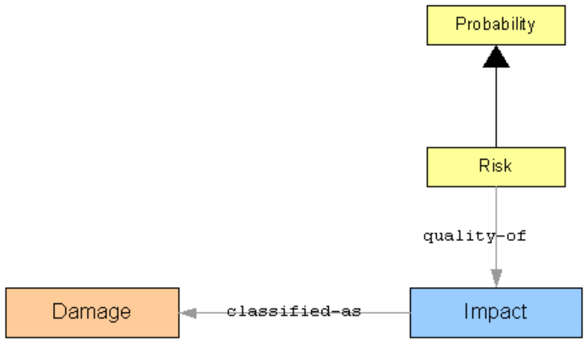
Risk and uncertainty

In the literature reviewed risk has been defined in a variety of ways and with very heterogeneous meanings. From a formal point of view parts of this definition problem can be attributed to a confusion of definitions ("necessary and sufficient") and the generation of the content of the term. This will be discussed in more detail below.

Here risk is seen as a quality (the probability) of an impact, which is classified as damage. In more casual language this would mean that risk is the probability that something (anything) negative will happen.

[5] In some glossaries capacity has been defined as a "strategy", which is in our view a clear mislabelling.

More specifically, risk can be defined as the probability that impact (classified as damage), which has an impact effect of a defined size.



RISK (wide) is the probability of an impact, which is classified as damage.

RISK (narrow) is the probability of an impact of defined extent, which is classified as damage.

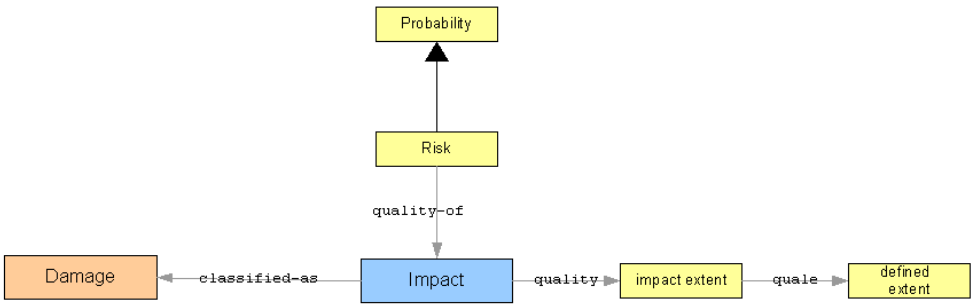


Figure 12: Definitions of risk (wide and narrow definitions)

In contrast to the definition of risk the generation of risk is dependent on the hazard potential and the damage potential. So whenever a hazard potential AND a damage potential are co-located (this relation is termed “exposure”) then a risk is there. These restrictions are not part of the definition but provide additional information (knowledge).

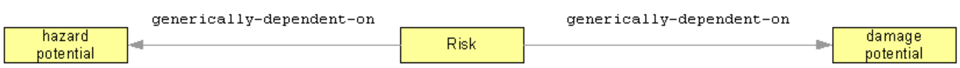


Figure 13: Risk generation

Uncertainty of risk depends on all parts of risk generation. It is thus inverse to the reliability of estimation of hazard potential as well as to the reliability of estimation of damage potential. Considering the definitions of hazard potential and damage potential, uncertainty[6] of risk relies on the reliability of magnitude and probability definition of an event (and the reliability of its spatial location) as well as on the reliability of vulnerability definition and calculation of value of endangered objects.

[6] In German uncertainty is best termed “Ungewissheit” and not “Unsicherheit” due to potential misunderstandings with “Unsicherheit” as insecure.

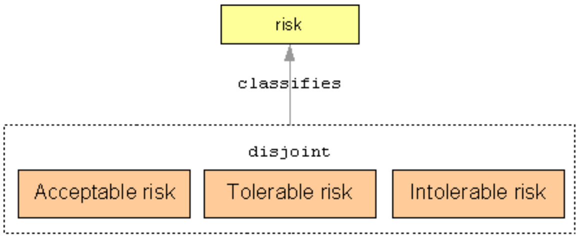
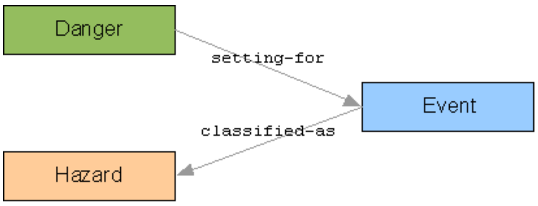


Figure 14: Uncertainty of risk

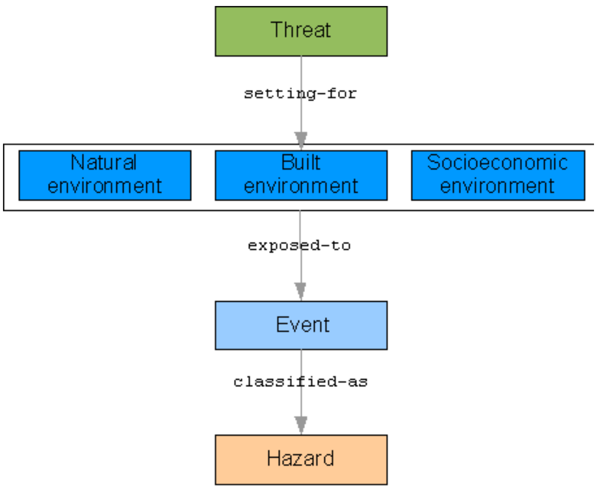
Risk management never deals with risk as such, but rather with socially classified risk (which in risk management is the result of risk evaluation as discussed below).

Basic risk related dituations

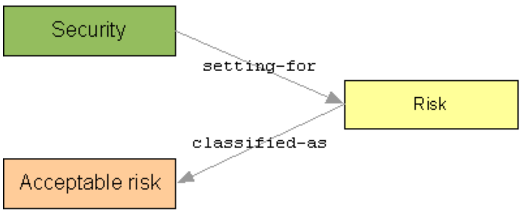
Situations define those social objects which are relevant for action. They describe a section of entities of the real world, which are (considered to be) action relevant and which are (at least partially) classified by social concepts. These entities provide the setting of a situation. In line with DOLCE we consider a perdurant to be the only mandatory entity of a situation.



Danger is a situation which is the setting for an event which is classified as hazard.



Threat is a situation which is the setting for elements of the environment which are exposed to an event classified as hazard.



Security is a situation, which is the setting for risk classified as acceptable.

A damage situation is a situation, which is setting for an impact, which is classified as damage.

An alarm situation is a situation, which is the setting for a risk, which is above a defined alarm threshold.

A disaster is a situation, which is the setting for a damage extent, which is above a defined disaster threshold.

Emergency is a situation, which is the setting for risk (classified to be above emergency threshold) or a damage extent, classified to be above disaster threshold.

Coping capacity below damage potential (of risk) or below damage extent.

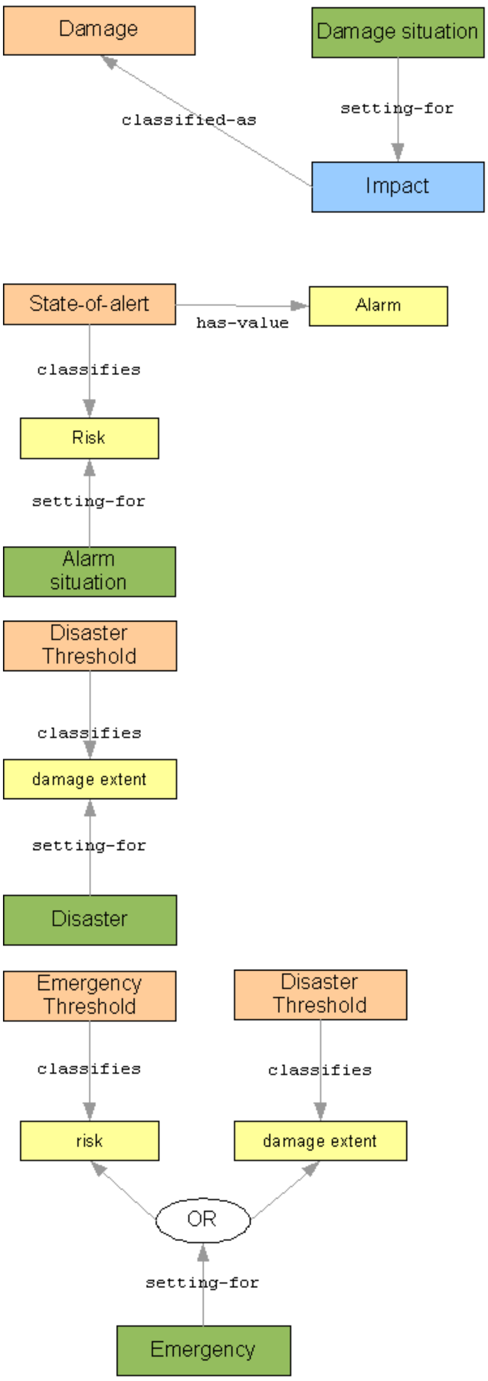


Figure 155: Relevant situations in risk management

Mental world

The mental world has not yet been intensively investigated within the scope of MONITOR. It can be seen as the view of the (qualities of the real) world which is filtered by the quality of sensors for collecting information about these qualities and by the available social concepts for classifying this (perceived, experienced) information.

Risk definition in practice – a discussion

Defining risk as probability of damage (as defined above) makes risk a rather analytical term, which is not directly usable in practice. It has been observed that economy, sociology and natural sciences all seem to apply different definitions of risk in their practical work. But yet the definition above seems to be the only one, which could serve as a smallest common denominator, despite being heavily discussed. We consider it therefore to be the only possibility to serve as an integrative concept for risk (as demanded by FUCHS and KEILER 2007) and will argue this on a broader basis in the following. It is a valuable starting point to depart from risk as probability of damage and then to further distinguish risk by the way it is calculated (the method of calculation).

This allows distinguishing the "objective" risk from the "constructed" risk. The "objective" risk is used by (natural) scientists. They calculate risk as the product of hazard potential and damage potential.

In contrast to this, the "constructed" risk is the result of risk perception, by calculating risk based on attributing very heterogeneous dimensions, such as experience, perceived controllability or social justice of the distribution of potential damages and potential gains.

When using the term risk in practice (i.e. in risk management) it makes sense to differentiate its usage by the terms it is considered to be distinct from. This distinction approach has been elaborated by WEICHHART (2007, in press) for a discussion of risk terminology. It allows to distinguish different notions of a term by contrasting it with its main distinctive (i.e. opposite) term, which is typical for the use in a certain application domain.

Chance	Probability of a positive impact of an event (as opposed to damage). Gain and loss as used mainly in economy.
Security	No exposure to hazards (no threat).
Danger	This has been propagated by the sociologist LUHMANN (1991, 1993), who distinguishes danger from risk by stating that danger exists independent of human action, whereas risk is always related (and depending on) human action. Risk is thus the result of a deliberate decision to take a risk. This seems to be very well in line with our decisions above, when focussing on exposure as a necessary condition for risk. It departs from our definition when taking into consideration unknown risks and risks, which are not deliberately taken (people who have no capacity of risk avoidance). The consequences of this can be exemplified with the example of hurricane Katrina (WEICHHART 2007, in press); some people deliberately stayed in the threatened area (thus taking the risk), while others had no choice (they thus were endangered and not at risk).

LUHMANN (1993) states that risk is socially constructed by ascribing it to dangers and thus not existing in real. So our modern society perceives much more risk than traditional societies, although traditional societies were much more (and more directly) exposed to “objective” hazards.

In our view a satisfying explanation to this contradiction cannot be found by a re-definition of risk, but rather by careful analysis of the definition of damage (which we considered above to be the central social concept in risk terminology). From this perspective the difference of modern and traditional societies as described above can then be explained by a difference in damage definition:

Events which cause negative consequences but happen regularly and/or cannot be actively avoided are not regard as damage but rather as a “normal” part of life (see the examples of “living with flooding” in Bangladesh, as cited in PLAPP 2003, p. 72). An impact is only classified as being a damage if it either departs from normality and/or could have been avoided, which is true for modern societies much more than for traditional societies. Our definition of damage can thus be enhanced as “an impact which is classified as negative in comparison to “normal” conditions of life”.

The relevance of this distinction in meaning of terms is made clear when using it in risk communication. PLAPP (2003) observed, that many test persons (of a risk related survey) argued that inundations were not to be classified as risk, but rather as hazards. This seems to be due to the fact that inundations were considered to be “uncontrollable” from a personal point of view – and thus were not seen as risk, defined from a constructivist perspective.

Analytical risk as defined above is defined for just one (type of) hazard and one magnitude (out of a multitude of possible magnitudes, which only differ in probability). But in practice risk management cannot rely on just one single risk formulation but has to deal with many different risks in parallel. These risks arise from different hazards (occurring to objects) and of different possible magnitudes. This is called “cumulative risk” and it is the risk which usually has to be dealt with in risk management. Difficulties in aggregating single analytical risks arise especially from the scale of analysis (time frame of probability calculation; different spatial coverage of different types and different magnitudes of hazards). The actual dimension of cumulative risk can only be derived by cumulating single analytically defined risk values.

From this formulation several steps for risk calculation can be logically derived

- hazard type(s) must be defined (“hazard identification”);
- an area of interest (delimiting the spatial scale) must be defined; this is usually done by competence areas (e.g. administrative

areas) or by hazard process delimitation (catchment areas). But these areas may be overlapping incongruently, showing discrepancies between administrative and process areas as well as between the process areas of different hazard types (and magnitudes !);

- magnitude of events and time frame of analysis must be defined; this needs to be done in one step, because magnitude changes with time frame. The time frame is usually set by some convention, like 30 and 100 yrs for flooding events or 450 yrs for earthquakes.

Risk management

Risk management is the (continuous, process-like) management which aims at reducing risk to a level, which can be classified as acceptable. The corresponding goal situation (which satisfies this goal of reducing in order to keep it below a certain level) is security. The goal 'risk reduction' is identical to the goal 'increase security' (yet we have defined security to be a situation – for such a formulation to be valid security would have to be a quality).

According to ISO norm (ISO 9000:2000), management in general comprises all coordinated activities for the guidance and control of an organisation. Hahn (1996) similarly defines it as planning, monitoring and controlling. Thus all of the subplans, strategies, measures and goals listed in this chapter belong to the overarching plan of risk management.

Risk management in particular comprises establishing the context – hazard identification – risk analysis –risk evaluation – risk treatment – evaluation of risk management. The main structures needed for risk management related terms are thus:

- subplans of risk management, which are sequenced, but need not follow this sequence by all means,
- phases of risk management and their corresponding situations,
- strategies and their related goals, which can be applied to all phases and subplans of risk management and
- concrete measures applicable in the defined situations.

Management and strategies

Some important basic terms which are related to this are management, strategy, guideline, method and tactics. Management in DOLCE terms would thus be a subclass of plan, inheriting the goal orientation and the use of roles (resources) for sequencing tasks.

A Plan is a description that describes a method for executing or performing a procedure or a stage of a procedure. A plan must use both, at least one role played by an agent, and at least one task. Finally, a plan has a goal as proper part, and can also have regulations and other descriptions as proper parts.

Risk management is a plan that has the goal to ofrisk reduction and that describes a method for its execution. The method is a sequence of steps which are subplans to risk management. These subplans have their own goals and goal situations but inherit the overall goal of risk reduction.

Figure 166: Risk management a subclass of plan

The difference between management and other subclasses of plan (like strategy, tactics or governance) can be defined according to their finality (event-like plans against process-like plans), according to their orientation in time (targeted towards current situations against long-term perspective) and according to their perspective towards external plans (taking into account external plans vs. ignoring external plans).

- Management is the non-final (process-like) plan, which is oriented towards the optimised use of scarce resources (as a sub-goal). It does not take into account external plans. It is iterative with no clear a priori sequencing of tasks.
- Strategy can thus be defined as the non-final (continuous) long-term plan, which takes into account external plans.

- Measure is the final (event-like) plan, which is oriented specifically at providing solutions for one known problem situation. Measures can be permanent even if the goal has been achieved.
- Project is the final (event-like) plan, which has, unlike a measure, a defined beginning and end, which is either defined by a temporal duration or by the achievement of the goal situation. This implies, ideally, the evaluation of the a priori defined goals. A project can include measures.

Concepts not used here, but important:

- Tactics is the non-final short-term plan, which takes into account external plans.
- Governance is the non-final (process-like) plan, which is oriented towards the optimised use of (state) authority as resource. This use has to conform to some rules of conduct (social norms). The term governance is seen here to be widely synonymous to policy (but with explicitly positive connotations).

Strategies are applied on how to deal with risk. They can be identified as follows:

- Risk avoidance
- Risk reduction
- Risk transfer
- Risk acceptance

Accepting these terms as strategies as defined above, it becomes clear that they are not related to one specific situation, but rather represent the long-term orientation of risk management. Once a specific situation (like danger, threat, alarm or disaster) has been identified, corresponding measures have to be taken. The decision of what measures will be taken is guided (but not pre-defined) by the strategies applied.

There is quite some confusion concerning disaster management and risk management cycles. Various forms of these have been developed and they seem to be mutually incompatible. But actually they can be seen as intertwining views, concentrating on different aspects of situations. Thus the disaster management cycle is applied in relation to a disaster event – this means that all phases are defined in relation to the disaster event. But in each (!) of these phases the steps of risk management are applied – so risk management can be seen as a cycle which has to be applied in every phase of the disaster management cycle – ranging from long-term (decades) decisions to short-term (seconds, minutes during a disaster) decisions. Taking this perspective the two different views are no longer competing but rather complementary.

Risk management is iterative but – in contrast to disaster management – not dependent on a disaster, but on the continuous plan to reduce risks. This theoretical view has to be contrasted with the practical experience that disasters are the main trigger for additional efforts in risk management and that risk management efforts significantly decrease with time distance to disasters. We consider this to be one of the main tasks of risk communication – to keep / raise risk awareness, depending on risk and not on actual disasters.

It is important to note that strategies, management and the other terms defined above are social objects. They are thus not directly observable, nor are their properties.

Problems and goals

Management has been defined as a plan and plans are always related to goals. Management thus cannot be seen independent of the goals, which are the basis of its right to exist. Goals have been defined here as impacts (on qualities) which are desired by some agent.

But the very existence of goals can have different reasons. BOESCH (1991, p. 52) has named three different ways of goal formation:

- by imitation (of a model, which is regarded as desirable),
- by centration or
- by construction (which needs a structured plan to achieve the goal).

In the case of (risk) management it seems to be clear that only the third variant for goal formation is relevant. But it still remains open what the driving forces behind goal formation are. In many projects this seems to be given by a problem to be solved.

A problem is a social description, which defines some perdurant to be a barrier to achieve a defined goal state. This means that some necessary steps to achieve this goal must have been defined before a problem can be identified as such. A problem is consequently dependent on a pre-existing plan.

In this view there cannot be any goals directed towards solving a problem without the existence of some more important goal, which is part of the plan (to which the problems function as a barrier). These goals can be called superordinate (or overarching) and thus define a goal hierarchy. Goals are always directed to qualities (of objects). In the case of risk management the relevant qualities have been defined in the chapter "basic risk terms".

Depending on the scale of qualities the corresponding basic types of goals can be defined (see also the discussion of “qualities” in chapter Interpretation and top terms):

Possible goals that correspond with qualitative qualities (categorical qualities) are modification and sustainment. Modification would mean to change the current status of a quality from one category to another, whereas sustain would mean to keep the status the same.

Ordinal qualities have the same related goal types and in addition the goal of improvement. An example would be the improvement of a risk situation classified as intolerable into one classified as tolerable (or even better, as acceptable).

Quantitative qualities have different types of goals related. Change of a quantitative quality can be pinned down to increase and decrease, whereas sustainment would equal to stabilising. Both increase and decrease can be further divided into a change above/below a certain defined threshold or a change by a defined quantity. These definitions are true for interval as well as for ratio scaled qualities. For ratio scaled qualities multiplication (e.g. “to double xxx”) and division are additional possible goal types.

Causality is directly related to goals. A goal can only be reached in a planned manner if causal relations between ones own activities (which are guided by a plan) and the changes they are likely to bring about are known. Causality in its simplest form is based on an empirically determined relationship between events and its impacts. [7]

General Method – subplans of risk management

In DOLCE a method is defined as a description that contains a specification to do, realize, behave, etc. Subclasses are plan, technique, practice, project, etc. Ontologically describing a universal method used by risk management is difficult since it largely depends on the field of application at hand and the type of risk under scrutiny. Although the basic sequences of the method do not vary that much (some take a shortcut while others insert intermediate steps) with the different approaches, the naming does vary considerably. This is true for the tasks themselves (e.g. analysis, estimation, assessment, evaluation are sometimes used almost interchangeably) as well as for the objects of the tasks (hazard analysis – risk analysis).

Therefore, some sequential steps were identified that are common to all (most) forms of risk management and which in a similar way were described by the Australian/New Zealand Standard on Risk Management (1999). These steps correspond well to the logically derived steps as described above (see chapter “risk definition in practice”).

[7] A more thorough discussion seems to be necessary.

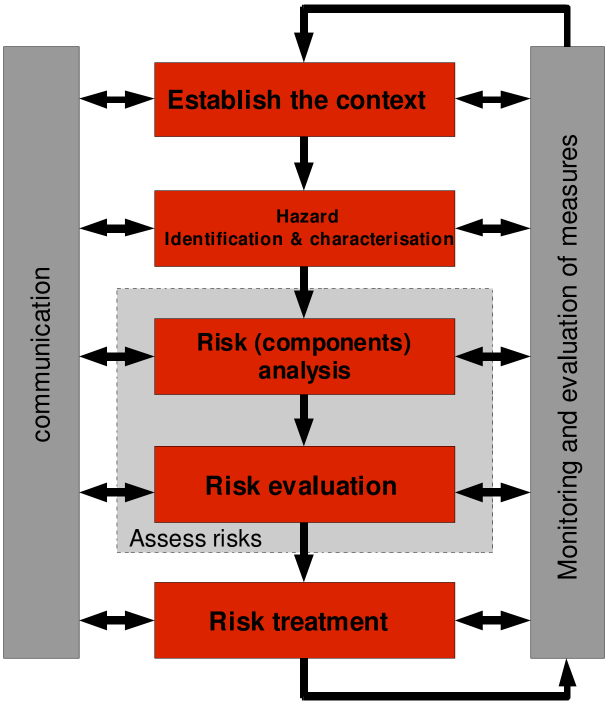
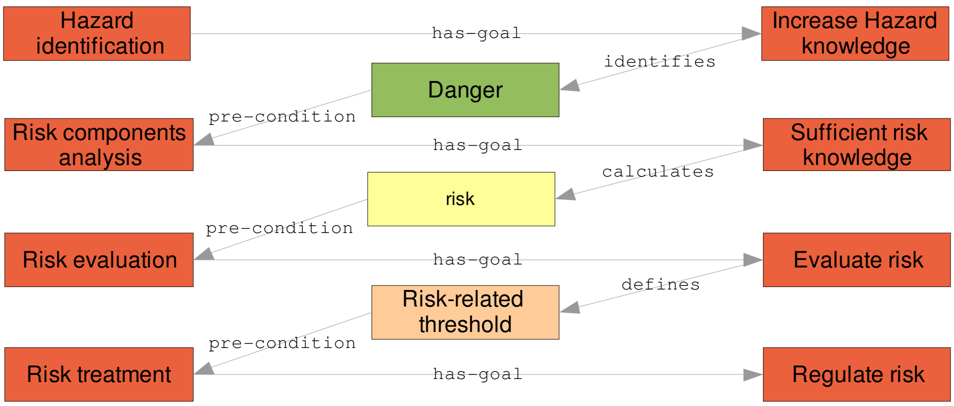


Figure 17: Risk management overview (source: Australien/New Zealand Standard on risk management (modified by authors))



Sequential subplans of risk management that have their own (intermediate) goals which serve as pre-condition for the next sequential subplan.

Figure 188: Sequential subplans of risk management

Establish context

Objective and spatial as well as temporal scale of risk definition must be established.

Identification & characterization

Often a distinction is made between hazard identification and risk identification. According to the definition of risk as generically dependent on a hazard potential, and a hazard as potentially having harmful effects, it can be stated that a hazard poses a risk. In practice they have to be kept apart.

A hazard can thus be any event potentially causing harm, whereas risk identification takes into account vulnerability and value of exposed objects as well.

Hazard identification is an important step in, e.g., hazard mapping and can become identical with risk identification. In the case of, e.g., a flood one and the same object in an area with HQ= 100 would be twice as much at risk in an area with HQ=50. Yet this is only the case under the assumption that no risk reducing measures have been taken and when risk identification focuses only on one particular hazard at a time. Risk identification can, however, combine different hazards.

In any case, the identification and characterization of the hazard is an important input in the analysis step. It is important to note that the observations that are required for the identification and hence the qualitative description do imply a first analysis as it is already information filtered (interpreted) by an expert with a trained eye.

The identification of risk is a step executed in differing degree of analysis involved. This task is sometime called characterization since the description of circumstances to identify the risk implies the collection of data which does also automatically characterize the type and magnitude of risk.

Analysis

As we stated before, in practice the identification and analysis task are not clearly separable. One possible and reasonable distinction could be the qualitative-descriptive character of the former against the quantitative-descriptive character of the latter. We consider it the process of “quantification of probabilities and expected consequences for identified risks” (xxx, see also OECD Glossary) without mingling it with different concepts as happens in numerous definitions.

As for the analysis, a distinction has to be made between different "dimensions of risk" which are analysed. Hazard analysis, vulnerability analysis, analysis of values at risk (sometimes also: exposure analysis) and the integration of these into risk analysis. The various labels of analysis correspond directly to the identified dimensions of risk generation (hazard magnitude/probability, vulnerability, value of objects and exposure as necessary pre-condition).

Hazard analysis is the (qualitative, semi-qualitative or quantitative) description of the probability of the event and its spatio-temporal location and magnitude. This involves estimation of parameter and interpretation (evaluation) of data. For natural hazards there exist basically two approaches to describe them: a phenomenological-descriptive approach and a process-oriented-descriptive approach (cf Gefahrenanalyse vs Prozessanalyse).

Hazard assessment in our understanding is not to be seen as equivalent to hazard analysis (unlike e.g. LOAT/MEIER 2003 who consider hazard analysis and hazard assessment to be synonymous).

Risk analysis is not focusing only on one hazard but can and usually has to (see cumulative risk) focus on a multitude of hazards. It is the task of combining all collected parameters in one analysis in order to (quantitatively) determine or estimate risk. It combines the parameters of all previous analysis steps into one (cumulative) risk value.

Evaluation

Evaluation was interpreted as a “component of risk assessment in which judgements are made about the significance and acceptability of risk”, which comes closest to our use of the concept ‘evaluation’. Attention has to be paid by German-speakers to the confusion between our understanding of ‘evaluation of risk’ as synonymously to the ‘interpretation of the outcome of risk analysis in terms of its personal or societal acceptability’ and the German ‘Evaluierung’ as the ‘evaluation of risk management measures in terms of their efficiency and goal-orientedness’.

This step involves the definition of acceptability, tolerability and intolerability of risk and possible outcomes are consequently:

- Risk is acceptable
- Risk is tolerable
- Risk is intolerable

According to the defined risk-related thresholds - the outcome which then directly influences decision-making and may lead to risk treatment. The definition of acceptable levels of risk are borne by a societies risk perception on one hand and by norms and regulations on the other hand.

Assessment

Risk assessment is one of the most heterogeneously used terms in risk management and often mingled with risk analysis and/or risk evaluation. Therefore we deliberately chose to use the term ‘evaluation’ and abstain from using assessment, in order to avoid confusion.

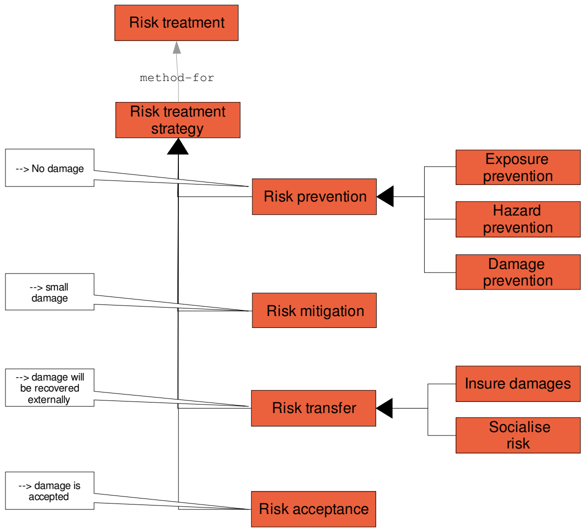
If used at all then we define the term in accordance with e.g. AN/ZNS 1999 as comprising both, analysis and evaluation. It is discussed in detail in the chapters of these terms. Hazard assessment thus covers hazard analysis AND hazard evaluation, whereas risk assessment covers risk analysis AND risk evaluation.

Risk treatment – strategies and measures

Risk treatment is directed at the outcome of the evaluation and the characteristics of risk determined in the identification and analysis step. It has the aim to modify the risk in order to reduce it to a level which is classified as acceptable.

For risk treatment strategies are applied which determine (possible) measures. Both strategies and measures have relations to goals and to the corresponding qualities they are targeted at. A strategy is usually not applied exclusively; instead it is mostly a set of strategies that comes into operation. No measures (Nullvariante) is also included as a possible alternative strategy, yet we do not consider it in our graph.

Note that risk reduction can be a strategy as well as a goal!



Risk treatment is the plan that subsumes different strategies (see management & strategies) which again have different measures as (final, event-like) plans which can be permanent or temporary.

Figure 199: Risk treatment and related strategies

Measures can be attached to these strategies and discussed in detail.

Not preferred terms:

This chapter introduces some terms which are often found in literature, but which are here not recommended for use. Main argument for discouraging their use is the differing meanings attached to these terms and the fact that they don't contribute substantial 'extra-knowledge' to the ontology. In the context of a thesaurus these terms would be named "not preferred terms". This label is used for all those terms which have better (understandable, unambiguous, accepted) alternatives.

However, it is important to clearly state that the MONITOR ontology does not intent to be a new 'school of thought' beside all the different 'schools of thought' that exist already in risk sciences. The ontology focuses on the concepts, on describing what there is and how things are related. Terms for our purpose are only 'labels' and can be replaced by other terms without problem. The important thing is what stands substantially behind a certain term, which is what the ontology tries to capture. Once this is agreed upon, then the naming is only 'convention'.

A typical example for a non preferred term is resilience, which has been defined in a variety of ways, e.g.:

Resilience: A protective strategy to build in defences to the whole system against the impact of the realisation of an unknown or highly uncertain risk. Instruments for resilience include strengthening the immune system, designing systems with flexible response options, improving emergency management etc.

Resilience can be covered with the term capacity or the subterms defined for it (see discussion above).Disaster management can be/is part of risk management. It inherits its goal 'risk reduction' but aims explicitly at damage reduction with preparedness as the goal situation. Disaster management has only two strategies: response and recovery. Contingency (emergency) and evacuation plans are typical examples of responses to disasters. The main difference between response and recovery is it temporal implication. Response (plans) come into force before (less often) and mainly during an event, while recovery (plans) less often during but mainly after the event. Both target at the increase of coping capacity and decrease of vulnerability.

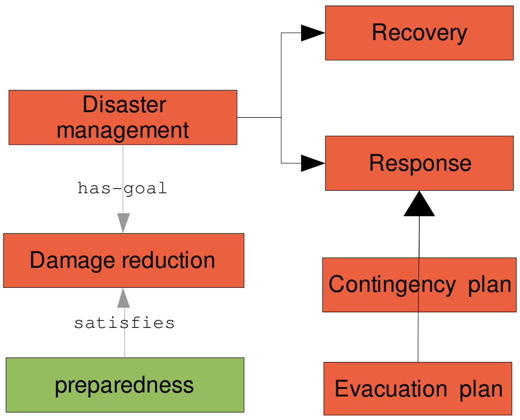


Figure 20: Disaster Management as a part of risk management

Risk perception as basis of risk communication

A clear view on risk perception is in our view the basis for any successfull risk communication. It has been defined as the everyday process of risk appraisal without making use of long-term records of events or exact calculation models (PLAPP 2003, p. 14). In this wider sense it does not only include cognition of risk but also evaluation. It thus directly corresponds – at least in its outcome! – to the steps of risk determination / risk appraisal on expert level described above. It thus involves the identification, analysis, assessment and evaluation of risk as well.

The distinction between everyday risk perception and between expert opinion is its everyday non-scientific methodology. Methods applied are rather heuristic methods than scientific analytical methods. A summary of the most prominent methods can be found in PLAPP (2003):

Heuristic	Description of effect
Availability	Events people know of are considered to be more probable than events which are cognitively not available.
Anchoring effect	The Probability of an event is adapted to available information and the perceived importance of this information.

Representativity	Judgement of all similar events are based on (very) small samples (e.g. few experiences). Single personal experiences and their qualities are considered to be more relevant than information, which is based on a large sample of data.
Avoidance of cognitive dissonances	Information, which contradicts estimated probability of events or experience based knowledge (which has become accepted facts) is being ignored or reduced in importance.
"Gambler's Fallacy"	For accidental events regularities are searched for / constructed, in order to reduce uncertainty (SLOVIC et al. 1974). Examples are card players rules: "After three times spades one diamonds comes", which is of course stochastically nonsense.
Habituation	The more continuous and uniform damages occur and the less probable disastrous effects are, the more average damages are being underestimated (RENN 1989).

Table 5: Heuristic methods and description of effects

Another differentiating aspect is that risk is determined and usually not analytically divided into its components. In addition the components of risk are usually not regarded as generating risk but rather as direct qualities of risk itself and the mixture of qualities perceived determines the evaluation of risk (in categories such as high or urgent). Ist kaum verständlich!! Sollte unbedingt umformuliert werden.!

PLAPP (2003) has prepared a list of perceived risk qualities, following RENN (1989) and TOBIN and MONTZ (1997):

Dealing with risk	Potential effects	Individual or social relation to hazard source
Personal controlling capabilities Security against fatal effects Impression of just distribution of benefits of risk Trust in public control and mastery of risks Perceived complexity of risk reduction	Potential of far reaching effects Immediate effects Size of effects Size of exposed group of persons Perception of reversibility of effects Effects for future generations	Habituation to hazard Degree of familiarity with hazard Ability to sense hazards Congruence between those who benefit and those who take risk Voluntarity of risk taking Degree of personal concern

Table 6: Perceived qualities of risk

From our point of viewthese risk qualities used in studies of risk perception can mostly be easily correlated to the "classical" risk generation components. Most components are related to (perceived) damage, to exposure and to capacities. But there are some additional components, which are not part of the classical risk generation components. This is especially the notion of "justness" (who benefits), habituation and familiarity with hazards, voluntarity of risk taking and the ability to sense hazards.

For risk communication this means to account for distortions in the perception of the classical risk components (by bringing scientific results into risk perception) as well as for the additional components.

Considering this discussion of risk perception, the concept of risk does thus not need to be re-defined (to a more “complex” social risk definition in comparison to the “simplistic” technical definition). It rather has to be accepted that risk generation differs widely between scientific and everyday approaches concerning methodology and especially weighing (aggregating) factors determining risk. Concerning aggregation some regularities of distortions have been found (PLAPP 2003,p. 28):

- Damage extent is more important in risk perception than the probability of an event.
- Risks resulting from natural hazards are estimated much lower than human-made risks (e.g. SLOVIC 1987). This is partially explained by the perceived smaller responsibility for natural events.

One important result of these psychometric studies was that these qualities are usually not considered to be qualities of risk, but rather are attributed directly to the sources of risk (the hazards). Consequently some empirical studies (PLAPP 2003, p. 87) had to replace the term risk in their questionnaires with the term threat (“Gefährdung”), because some respondents had considered risk to be inadequate when talking about earthquakes, floods or storms.

Applied ontology

Situations – the basis for application in practice (an example)

According to DOLCE a situation is a social object and has to satisfy a description. It has to be setting for at least one entity (in our case e.g. a natural disaster process). The time and space of a situation are the time and space of the perdurants in the setting (DOLCE 2008).

The main reason for defining situations is to identify the conditions for action. The link to actions is twofold:

- In a long-term view situations are continuously evaluated in order to identify which measures have to be taken in order to achieve existing goals (which depend on some long-term plan).
- In a short-term view situations are being identified in order to deduce which norms have to be applied and which immediate actions (measures) have to be taken.

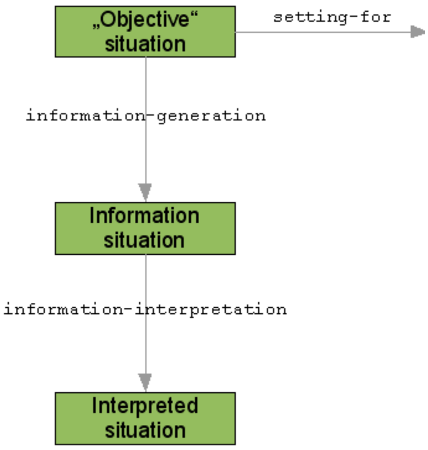
Situations provide the link for social regulations (norms) as well as for actions (measures). Situations are regulated by social norms.

When considering the action relevance of situations, any situation has to be seen in the context of the current plans of the agent(s) experiencing the situation. These plans define the goals to be achieved and situations define the action alternatives available to achieve these goals. The relation “action-alternative” provides the link from situations to measures to achieve the goals. Measures can thus be defined as plans which are directly linked to situations.

Situations thus provide the direct link to practical relevance of this ontology. The better a situation can be identified and defined the better relevant measures and actions can be taken.

The earliest formal notion of situation was introduced by BARWISE (1981) as a means of giving a more realistic formal semantics for speech acts than what was then available. In contrast to a “world” which determines the value of every proposition, a situation corresponds to the limited parts of reality we perceive, reason about, and live in. Furthermore, in situation semantics, basic properties, relations, events and even situations are reified (i.e., made concrete) as objects to be reasoned about (BARWISE 1989). Note that once a situation is made into a concrete object, various properties can be associated with the situation. While Barwise's situation semantics is only one of the many alternative semantic frameworks currently available, its basic themes have been incorporated into most others.

The action relevance of situations can be defined as follows:



The „objective“ situation is the situation which should be described. It can not be directly observed / measured. It is the target situation of observation. It is setting for all endurants and perdurants to be observed.

The information situation includes all the information available about the target situation (generated by observations).

The interpreted situation is based on interpretation (classifying elements we have information about) according to social concepts.

This is the situation definition which is the basis for action. It usually divergeseven stronger from the „objective situation“ than the information situation, because social concepts can not fully cover all types of relevant situations and are often not available (as knowledge) to those people judging a situation.

Figure 220: From objective to interpreted (= action relevant) situation

Other important terms related to monitoring are methods and plans. All of these related terms have a broad range of subterms, subject to detailed classification. This is especially true for the relevant methods and the situations, to whom they are applicable.

The basic terms of method, plan and situation are used according to their formal definitions in DOLCE, as described above. Here their main characteristics are briefly recapitulated:

A method is a description that contains a specification to do, realize, behave, etc. Subclasses are plan, technique, practice, project, etc.

A plan is a method for executing or performing a procedure or a stage of a procedure in order to achieve a defined goal (which is a proper part of the plan). A plan must use both at least one role played by an agent, and at least one task. Finally, a plan has a goal as proper part and can also have regulations and other descriptions as proper parts. A plan "has-in-scope" some situation.

A procedure is a method without an explicit goal.

Plans in the domain of monitoring in the context of hazards include disaster documentation plans, monitoring plans, assessment plans,...

Tasks are courses used to sequence activities or other controllable perdurants (some states, processes) within methods. They must be defined by a method, but can be “used” by other kinds of descriptions. Tasks can be complex and ordered according to an abstract succession relation. The can relate to ground activities or decision making down to specialised tasks dealing with typical flowchart content,… In principle, tasks could be transformed into explicit plans (DOLCE 2008).

Hazard processes - example of landslides

Knowledge about hazardous processes, especially about their existence/identification and their mechanisms, is the starting point of any risk management consideration. The terms processes and events in that context are often used in a very heterogenous way. The following short discussion is neccesary for the understanding of some base terms and is based on the results of DIS-ALP.

An event, which is classified as a hazard, can have damaging impact. Sometimes events are very complex and have other events as parts of them. The extreme weather event of September 2005 in Western Austria and Bavaria (BMLFUW 2006) can serve as an example. This extreme meteorological event had as parts several debris flows and floodings, which were all seperated in their location but connected to the meteorological event by a common causation.

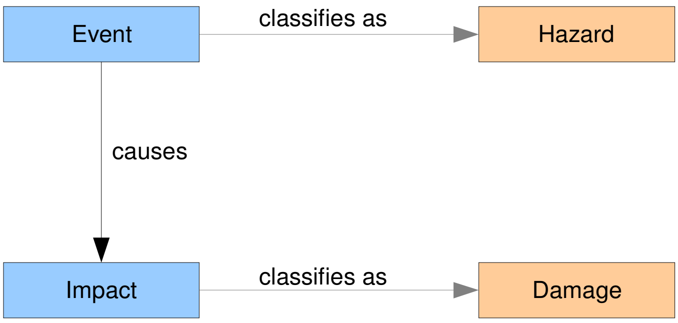


Figure 22: Hazard and impact

Processes are part of events and provide the mechanisms of how things happen. More specifically, they define HOW (type of transportation or transformation) WHAT is changed (in terms of location or some other quality). When talking about natural hazards the HOW usually defines the transport-mode and the WHAT defines what kind of material (“amount-of-matter”) is being transported. Process parts of an event can be related to each other causally within an event in a multitude of ways.

The differentiation of events and related processes can become vague when permanent processes are encountered, which continously evolve and where no clearly defined event can be distinguished. This can be the case with permanent landslides as well as with climate related processes (global warming, degradation).

In the discussion about (natural) hazards the term “phenomena” is encountered regularly. Usually no concrete definition is provided but rather vague descriptions like “characteristic of one or more feature types, the value for which must be estimated by application of some procedure in an observation” (in this sense e.g. in OGC “Observation and measurement”). Since there are varying definitions, which are partially also due to different usages of the term in english and other languages, it is proposed here not to introduce the term at all. The definition used in DOLCE is for example “A phenomenon is basically a process that does not include any intentional active participation.”, which would include natural processes as well not-intended economic processes (and others).

Instead it is proposed here to replace the use of this term with two clearly defined terms: feature and (observable) quality.

Features are defined in DOLCE as objects (endurants), which are parasitic in the sense that they cannot live without some host. Examples are holes, edges, surfaces or borders. The qualities of features, objects and processes/events are the entities to be observed.

Observable qualities are qualities of objects which can be sensed (and in some cases: measured).

Also important for the distinction of different processes is the endurant 'amount-of-matter', as amount-of-matter is the transported material of natural disaster processes. DOLCE defines amounts-of-matter as endurants with no unity ('stuffs' referred to by mass nouns like 'gold', 'iron', 'wood', 'sand', meat', etc.). Amounts of matter are mereologically invariant, in the sense that they change their identity when they change some parts (DOLCE 2008).

To illustrate the application of the ontology, the process of gravity mass movement has been chosen (for illustration see below). Gravity mass movements are distinguished from other natural disaster processes (avalanches, water-related-disaster-processes) primarily by the transported matter, which consists of mainly solid amount-of-matter. Secondary the gravity mass movement processes like: landslide or debris-slide, fall processes, subsidence or collapse, differ in their movement modes. A detailed distinction of the observable qualities of transported material and the transportation process (like size, volume, velocity,..) will lead to a clear definition of a particular disaster process.

Detailed information and the definition of each term used is provided and the formalised depiction of used disaster related terms and processes offers a standardised knowledge basis about hazardous processes. This supplies a starting point for any risk management considerations.

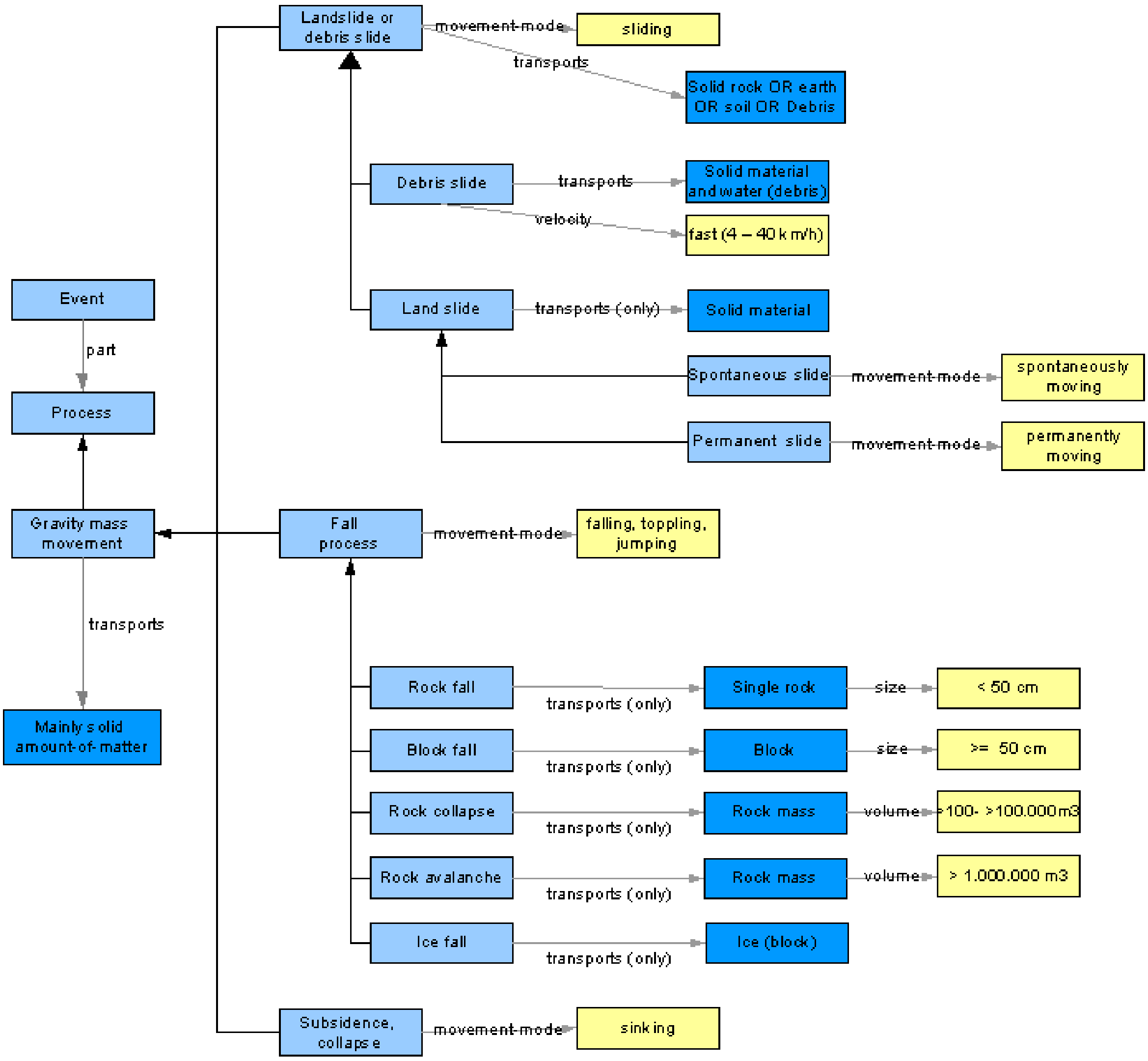


Figure 23: Mass movements as defined in DIS-ALP

Another possible depiction of hydraulic and gravity geological processes is offered by D. Tosoni and U. Sulzenbacher. Here the focus is on process-related dynamics and background mechanisms. In addition to the movement-type and the transported amount-of-matter, the scale of the process (large, medium, small) is considered as well as the evolution type (rapid evolution, slow evolution). The location of the process describes the affected area (surface, channel, slope,...). As both approaches are valid from different point of views, both are integrated in the ontology to allow for an analysis that includes different aspects and different problems.

With a complete and sufficient definition, classes like solid particle related processes, landslides etc. are recognised and ranked in the ontology as equivalent classes despite their different focus.

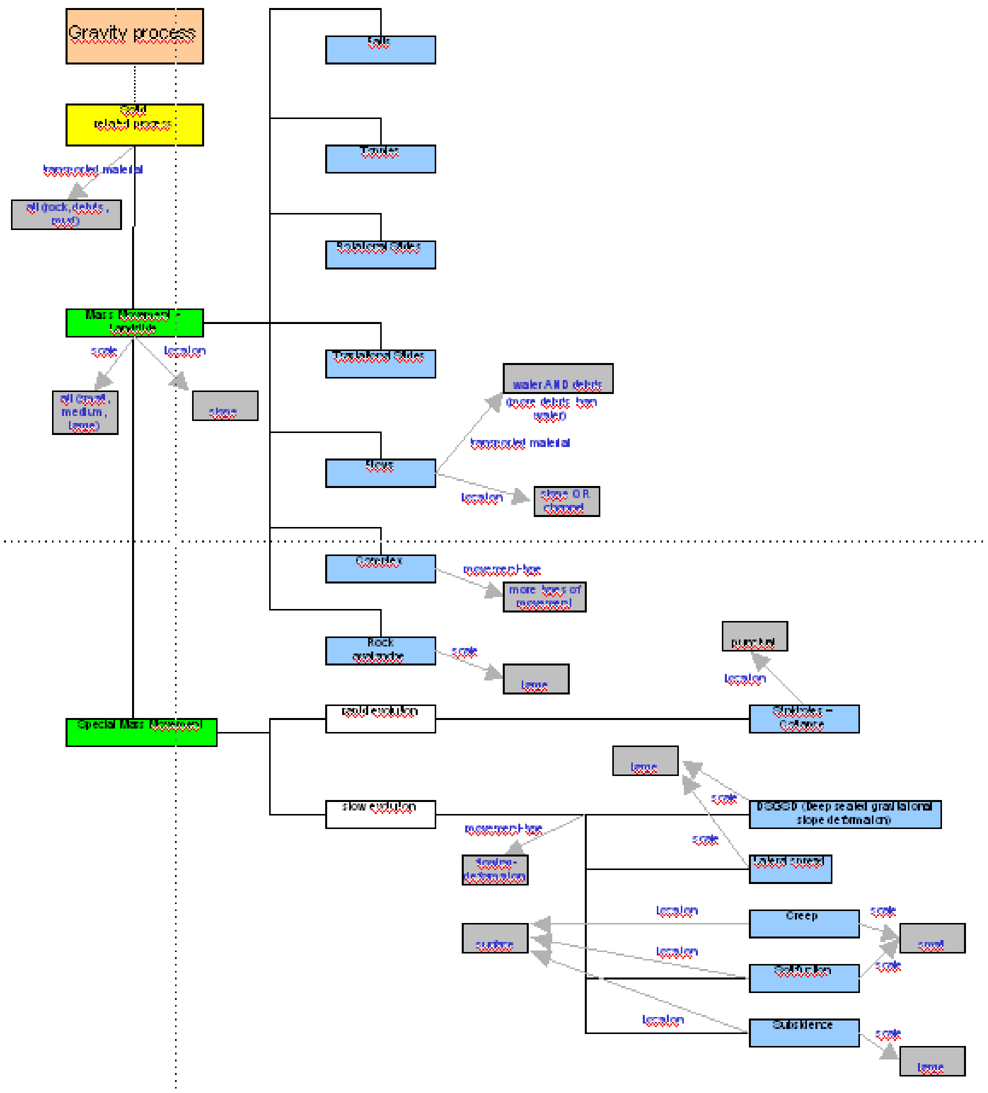


Figure24: Mass movements – alternative definitions

Observation methodology

Observations are the basis for collecting information in order to define situations as exactly as possible. The goal of any plan related to observation is to raise "situation awareness", i.e. to identify and assess a situation in relation to some superordinate plan. The discussion of observation related terms uses definitions of OGC (Open Geospatial Consortium) Sensor Web initiative and the proposals for DOLCE alignment of these terms by Florian PROBST (2007).

Observation can thus be defined as an accomplishment, which observes qualities (of the entities of interest) and which produces (has-effect) symbols, which approximate values of the qualities observed.

Symbols are information objects and play the role of a result defined by an observation plan.

An observation consists of (part) observation processes, in which sensors participate. A sensor is a physical object which measures physical qualities at a certain time. The functional relationship (between sensor and physical quality) is one of the functions defined for artifacts by GARBACZ (2006). It is a subrelation of senses (which is a subrelation of signals).

A sensor is operated according to a procedure (which is a kind of method) and is hosted by a station (often called "platform"). An example of the relationship between sensors (below: component), station and values produced relating to physical qualities to be observed, is shown graphically below:

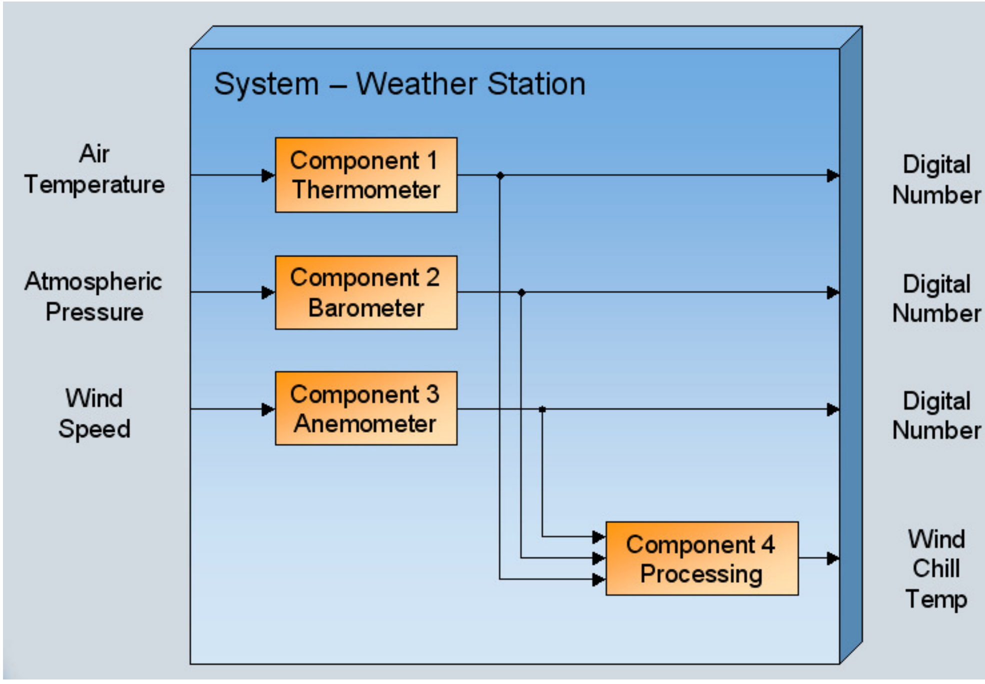


Figure25: Sensors, stations, qualities and values (example from SANY 2007)

A detailed account of observation terms defined above is given in the graphics below.

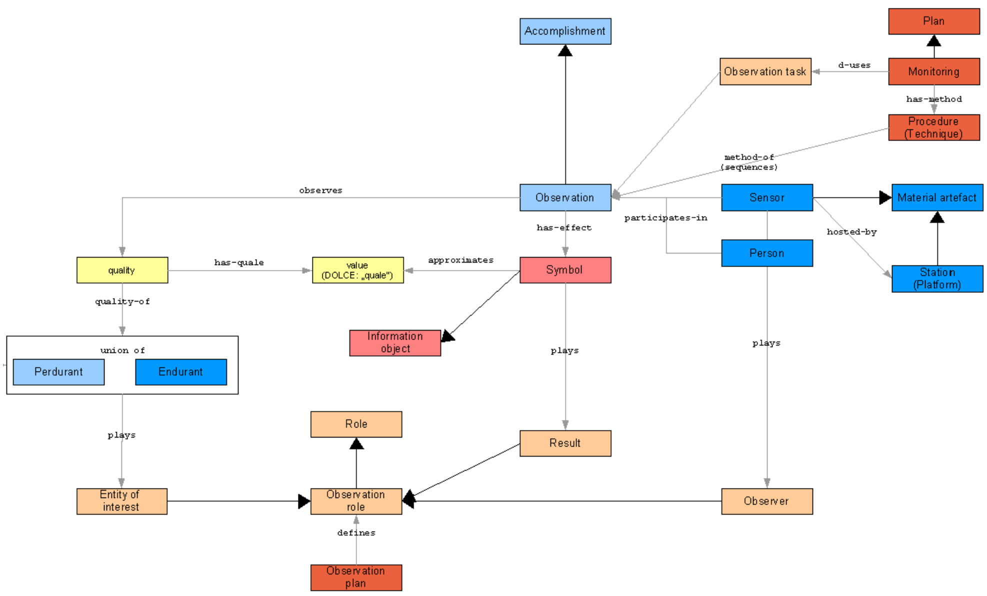


Figure26: Observation ontology (after PROBST 2007; slightly adapted)

When trying to recommend (monitoring) methods for some special situation it is necessary to discuss sensors and their characteristics in more detail:

A sensor measurement can be modeled as a process by which an input quality (phenomenon) is observed by the sensor at some discrete moment in time. Some measurement of that quality is then the output from the sensor. The values of the measurement are dependent on the sampling and response characteristic of that sensor, as well as on the sampling and detection methodologies. Often, either through hardware processing or subsequent processing in software, the raw observations are often processed to higher-level knowledge (see OGC (2006): Sensor Model Language).

An important distinction has to made between observations by sensors and observation by human observers:

As stated above a situation is mainly identified by the main (causal) perdurant which identifies it. An important conclusion from that is that any observation aims at identifying and describing (at least) this perdurant. But single values as a result of a sensor observation can not directly be related to a certain event. Therefore a post-processing of the resulting information (values) is necessary, as described above.

In contrast to the sensor observation, observations by humans are usually directly classified into events and processes. But human observers are weak in quantifying their observations, making sensor based observations a necessary complement.

High quality situation awareness thus depends on the fusion of several sensor values with human observations.

Typically, sensors fall into one of two basic types. In-situ sensors measure a physical quality within the area immediately surrounding the sensor, while remote sensors measure physical qualities at some distance from the sensor, generally by measuring radiation reflected or emitted from an observed object. To further characterise a sensor, its association with the platform has to be known as a reference frame. For example, to fully describe a wind profiler’s wind speed and direction measurements, the height of the sensor needs to be known as that sensor could be situated on the roof of a building, mounted to a 10-meter tower, or sitting at ground level (OGC (2006): Sensor Model Language; adapted).

Measures / Mobility	In-Situ	Remote
Fixed	Stationary O2 Probe	Doppler Radar station
Mobile	“Diving” Salinity probe	Airborne LIDAR

Table7: OGC (2006): Sensor Model Language. Relationship between sensor type and mobility.

The most important parameters to characterise sensors are listed below, together with a short description of their relevance:

WHAT is measured?

→ Quality measured (topographic information, chemical information regarding the measured material (based on characteristic absorption), surface roughness, moisture content, morphology and profile of area (laser scanning),…, Frequency, Response

HOW is it measured?

→ Calibration, Quality (spectral resolution of a sensor (how many channels available, which part of the electromagnetic spectrum is analysed))

WHERE is it measured?

→ Geometry, Spatial Response & Sampling (spatial resolution of a sensor: aerial remote sensing techniques: down to 1 cm, satellite remote sensing techniques: down to 0,61m (QUICKBIRD), laminar data is recorded which offers a practical outline of an area but the precise mapping of specific points is difficult)

WHEN is it measured?

→ Temporal Sampling (In case of historic events there is usually information to be found in a number of archives. In regard to current ongoing events aeroplanes can be equipped with sensors in a very short times and satellite sensors can be adjusted to a specific areas within 1-2 days.), Impulse Response

WHY is it measured?

→ Application, Further processing (e.g. SAR can be used in flooding areas, for generation of elevation models and detection of movements (subsidence, glaciers, mass movements,…).)

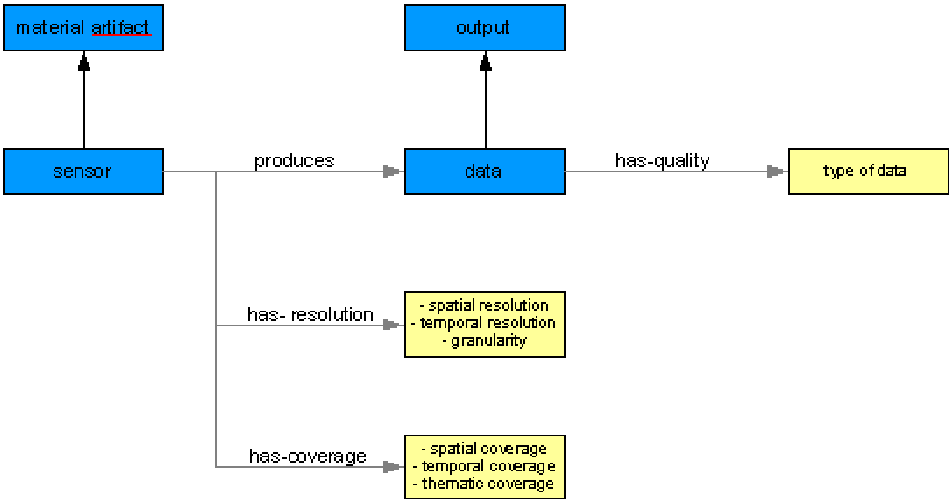


Figure 217: Qualities of sensors and sensor output

Synthetic Aperture Radar (SAR) as an example:

WHAT: Synthetic Aperture Radar (SAR) is very sensitive to electrical and physical properties, it will serve well to portray the morphology (surface roughness) and the moisture of the soil. SAR operates in a wavelength range of 0,8-100 cm, which allows an analysis of deeper layers as well.

HOW:

WHERE:

WHEN:

WHY: For use in flooding areas, for generation of elevation models and detection of movements (subsidence, glaciers, mass movements,…).

The table below provides examples for qualities, which can typically be measured by sensors. In the table these qualities are categorised into quality types. For alignment with DOLCE the headings should be read "quality type" (instead of "phenomena") and "qualities" (instead of "phenomena properties").

Phenomena	Phenomena Properties
Acoustic	Wave Amplitude, phase, polarization, Spectrum, Wave velocity
Electric	Charge, Current, Potential, Resistance, Conductivity, Capacitance, Inductance, Permittivity, Electrical Field Amplitude, Phase, Polarization, Spectrum
Magnetic	Magnetic Field, Amplitude, Phase, Polarization, Spectrum, Magnetic Flux, Permeability
Optical	Wave amplitude, phase, polarization, spectrum, Wave velocity, Refractive Index, Emissivity, Reflectivity, absorption
Mechanical	Position (linear, angular), Velocity, Acceleration, Force, Work, Power, Stress, Pressure, Strain, Mass, Density, Moment, Torque, Rate of mass transport (flow rate), Shape, Roughness, stiffness, Hardness
Thermal	Temperature, Heat, Flux, Specific Heat, Thermal conductivity, Enthalpy
Radiation	Type, Energy, Intensity
Biological	Biomass type, concentration, state
Chemical	Component identity, p-h, chemical potential, ionization rate, rate of reaction, molecular weight, concentration, state

Table 8: Example list of observable qualities (OGC 2006: Transducer ML)

The application areas of observations (with focus on sensor based observations) are widespread. For FP6 project OSIRIS some application areas have been identified within the disaster management cycle (shown below):

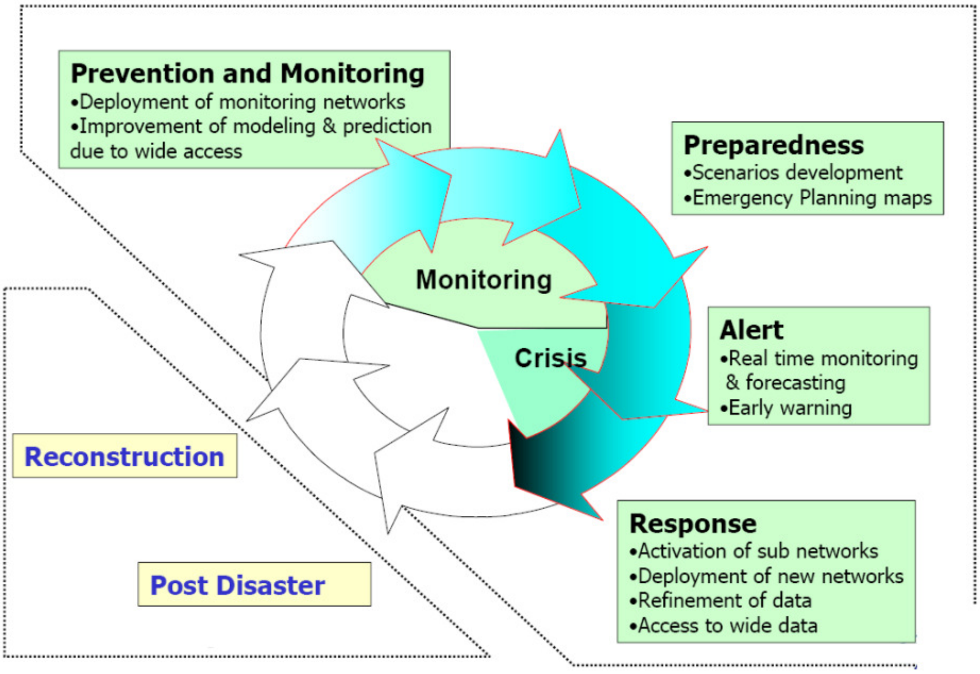


Figure 22: Usage potential of sensors within Disaster Management Cycle (FP6 project OSIRIS 2006)

We will focus on two areas to describe the application of this ontological background. These are disaster documentation and monitoring. These areas will be dicussed in more detail below.

Monitoring and monitoring situations

The project MONITOR received its name from its main focus – monitoring in the context of hazards. In MONITOR WP3 monitoring has been defined as “the process of checking, observing or keeping track of something, in a certain area, for a specific purpose and with defined criteria”.

This definition can easiliy be translated with the ontologically defined basic terms:

Monitoring is a plan, because it both defines tasks how to do something (defined criteria) and has a defined goal (specific purpose). It is a non-final (process like) plan with the goal of long-term information provision about a specific topic – the qualities of “something” (see also: Handwörterbuch der Raumplanung 2004).

The goal of information provision can be translated into MONITOR ontology as availability of information about certain relevant measurable qualities above a defined minimum or aspired level.

Within MONITOR project the following parameters have been identified as necessary basis for classifying situations in order to define appropriate monitoring methods:

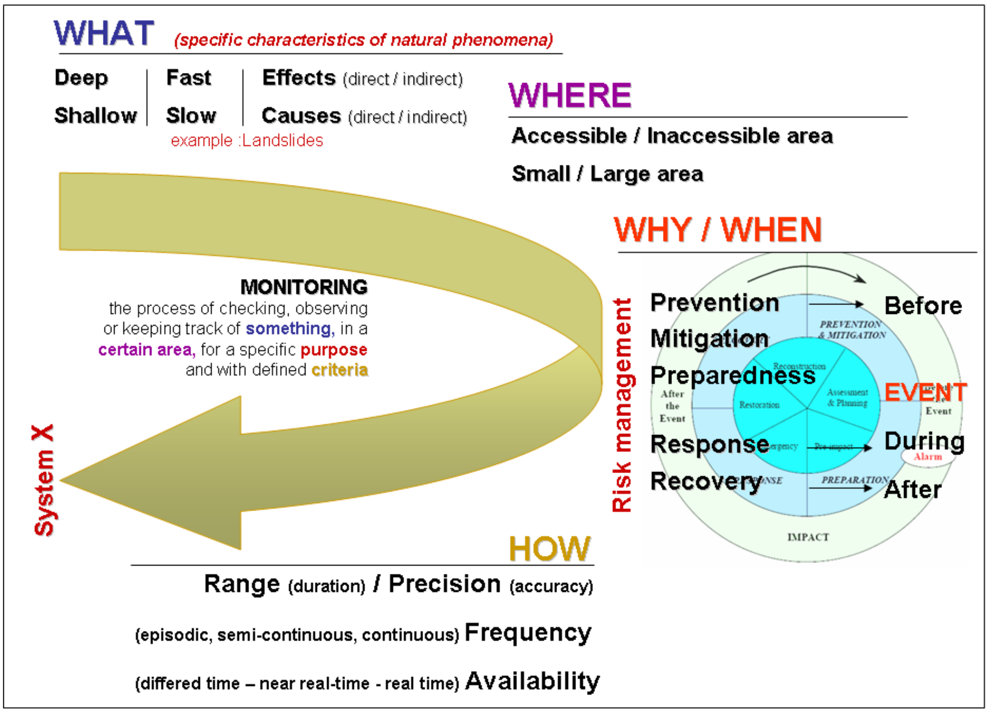


Figure 29: (CORSINI 2007; MONITOR WP 3 report)

Category	Situation Parameter	Parameter description
WHAT	Process type	Basic type of process
WHAT	Velocity of process	Entity of expected movements in the period of interest (L < 1 cm, M < 15 cm, H > 15 cm)
WHAT	Process specific parameter	Some parameters can only be defined process specific. For landslides deep and shallow landslides have to be distinguished.
WHAT	Visibility from air	If the site is not visible from the air, due to topography or vegetation coverage, then all aerial or satellite remote sensing systems are to be excluded.
WHAT	Visibility from ground position	If the site is not visible from a panoramic point, due to topography of the area or vegetation coverage, then all of the terrestrial remote sensing systems are to be excluded.
WHERE	Size of area	
WHERE	Accessibility of area	Is area accessible on foot ?
HOW	Duration	Time frame of monitoring.
HOW	Precision	How detailed (in spatial reference, thematic dimension) has to be monitored.
HOW	Frequency	How often are observations necessary ?
HOW	Availability	Allowable time lag between observation and data processing/interpretation ?

Table 9: Parameters of situation needed as requirements for definition of monitoring parameters

A monitoring situation as defined in the MONITOR project has thus to be categorised by these parameters, with the constraining factor being the purpose of the monitoring (WHY) and the period of interest (HOW LONG monitoring has to be carried out). If these parameters are known, recommended (monitoring) measures can be identified via the recommended-measure relation.

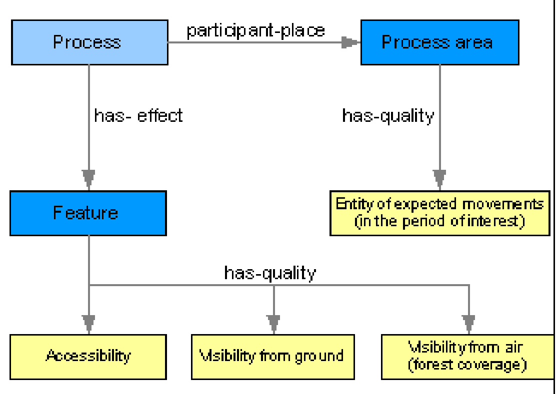
Another important factor for the selection of the most suitable method is the period of interest. The period of interest can be related to the risk management phase:

- Response (1 to 3 weeks),
- Recovery (1 to 3 months),
- Prevention (1 to 3 years and 3 to 10 years),
- Preparedness (2 to 10 years).

This affects the other key constraining factors like

- accessibility of the site (is it possible to place in-place sensing systems or are remote sensing systems the only option),
- visibility of the site from a panoramic ground position and/or from aerial position (determining if terrestrial remote sensing systems or aerial/satellite systems have to be excluded) and
- entity of expected variability (to see if the period of interest exceeds the range of measurement of a specific system).

And finally the selection of a specific monitoring system depends on the factor that needs to be monitored and whether the data should be operated automatically (collecting, transmitting, processing data in unsupervised manner) or manually where at some stage human intervention is needed.



The qualities describing the monitoring situation are some of the key constraining factors for the selection of the monitoring system.

Process (e.g. mass movement processes), and features and process areas like scarp, body, source area, track.

Figure 30: Qualities describing the monitoring situation

Hazard (event) Documentation

As a result of a number of international projects (DIS-ALP, DOMODIS) the documentation of natural disasters has been accepted as a integral part of risk management and standardised to some extent (KIENHOLZ et al. 2006). Accurate and comprehensive hazard assessment as a part of risk management is based on the documentation of former events (analysis and evaluation of written documents about former events and disasters, as well as analysis of the terrain (e.g. silent witnesses)). This knowledge about former events is indispensable when it comes to the development of suitable models for the prediction of future events (Hübel et al. 2002).

As mentioned above, the documentation plan defines the documentation tasks necessary to record the features of a certain natural disaster process. The process is the setting of the related natural disaster situation which in turn has plans as measures.

Disaster documentation tasks especially define the questions WHEN, WHERE and WHAT. WHEN deals with the temporal priority of a certain task or subtask and is defined relative to the event. WHERE defines the (process) area relevant to the specific task. WHAT defines the qualities to be recorded, which are either qualities of features (resulting from a process) or qualities of the ongoing process itself. The qualities also specify the kind of output (data) which will be obtained in the course of the task.

All natural disaster documentation tasks record observable (physical) qualities of specific features or the process itself. Subtasks include "to map", "to measure" and "to describe". These tasks are different methods of recording information about qualities, like the movement mode of a process, the velocity of an ongoing process, the shape of certain features,…

In the general model of disaster documentation shown below only qualities of features are shown (but also qualities of processes will be recorded). Damages are either qualities of features or sub processes to be recorded.

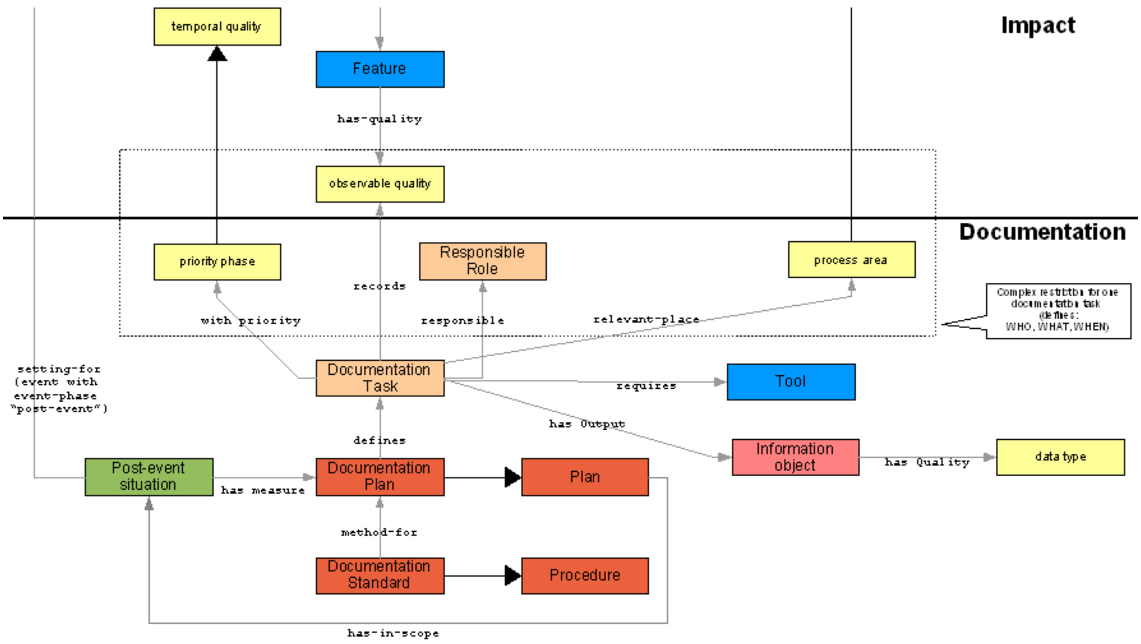


Figure31: General model for documentation

In addition to that a documentation task is carried out by a responsible person (role) and requires certain documentation tools. Basically the focus of natural disaster documentation is on observable qualities of features and is not so much concerned with the underlying mechanisms and causes of the processes.

Hazard mapping formalisation

When defining the terms related to hazard mapping one can build on the risk management terms defined above.

Starting point of hazard assessment is a situation of threat, for which hazard assessment is a recommended (or in some cases: a legally prescribed) measure. The goal of hazard assessment is to define hazard potential (qualitative as well as quantitative). It is a subgoal 'increase knowledge'.

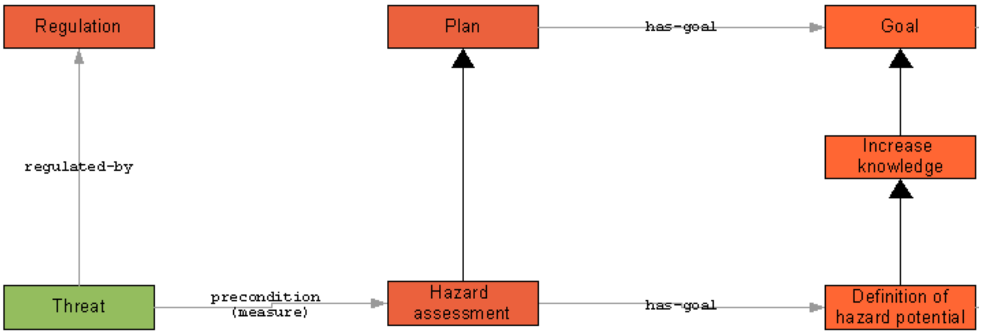


Figure 32: Hazard assessment plan

Activities in hazard assessment execution are carried out according to methods (rules, guidelines, practice…). These methods can be seen as a knowledge source for successfully reaching the goal defined for a plan. Subplans of hazard assessment are hazard inventory, hazard analysis and hazard estimation with each having a related goal.

Each plan needs resources (a role classifying endurants) for execution. These resources can be classified as authoritative resources (commanding social agents) and as allocative resources (classifying physical objects).

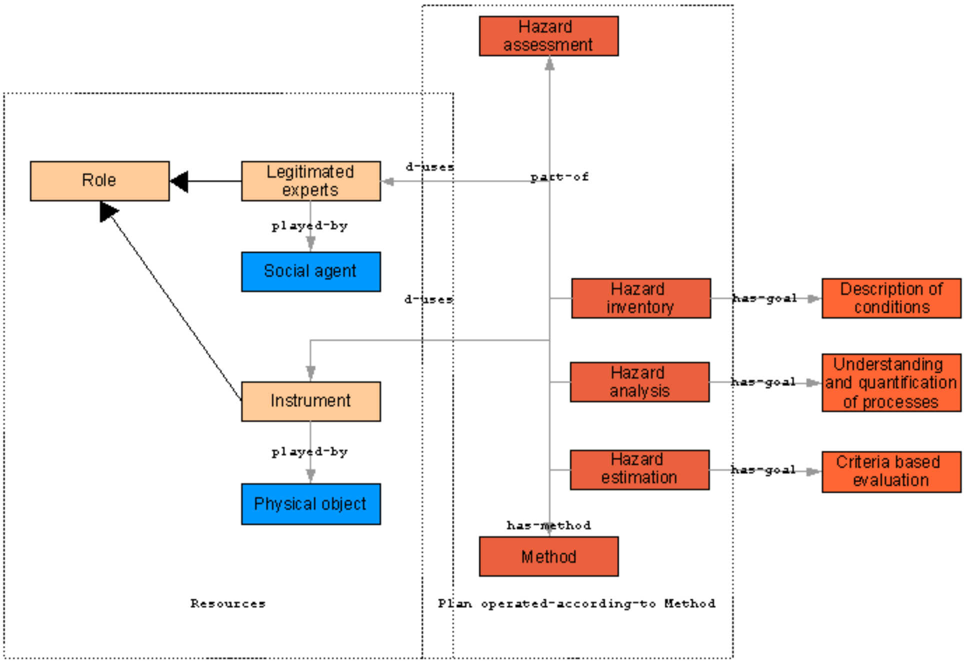


Figure 33: Resources used by hazard assessment plan

Hazard assessment has the subclass hazard zone mapping which then results-in a hazard zone plan. The relation 'results-in' describes the results (an endurant) of a plan. This is a shortcut for all effects which are produced as a result of the sequence of activities by the task of a plan. The hazard zone plan is expressed by hazard zone map or report (which are information objects) and are about a certain hazard potential (quality). With the hazard zonation defined (which is a goal situation), the goal, definition of hazard potential, is satisfied.

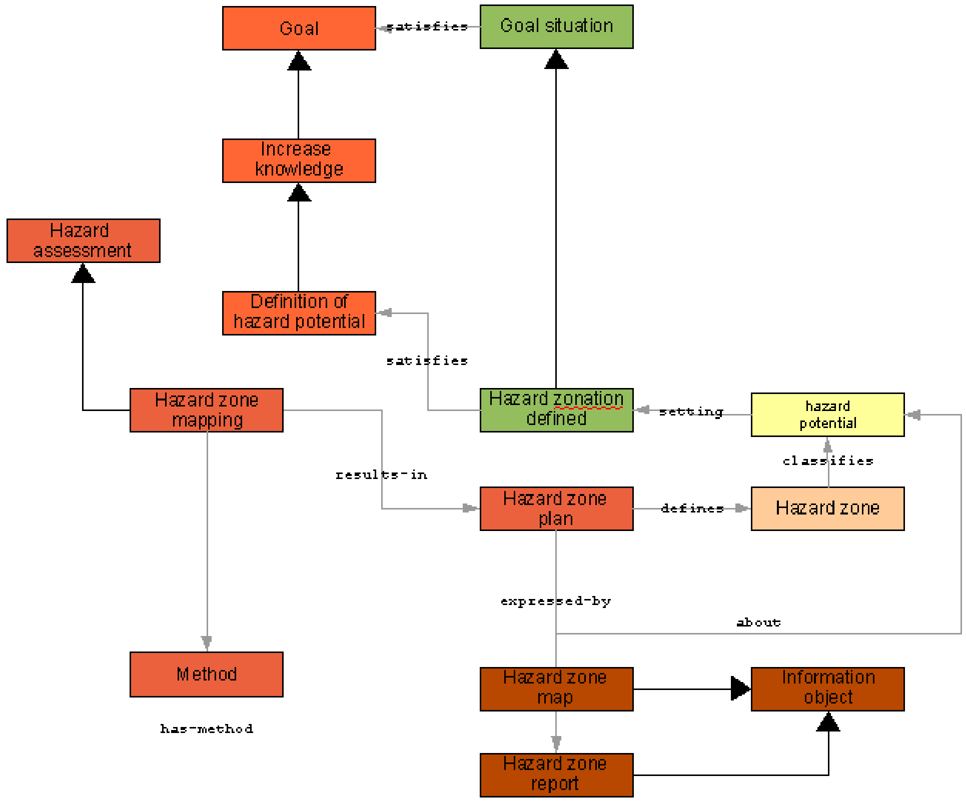


Figure 34 Satisfying a goal of hazard assessment through hazard zone mapping

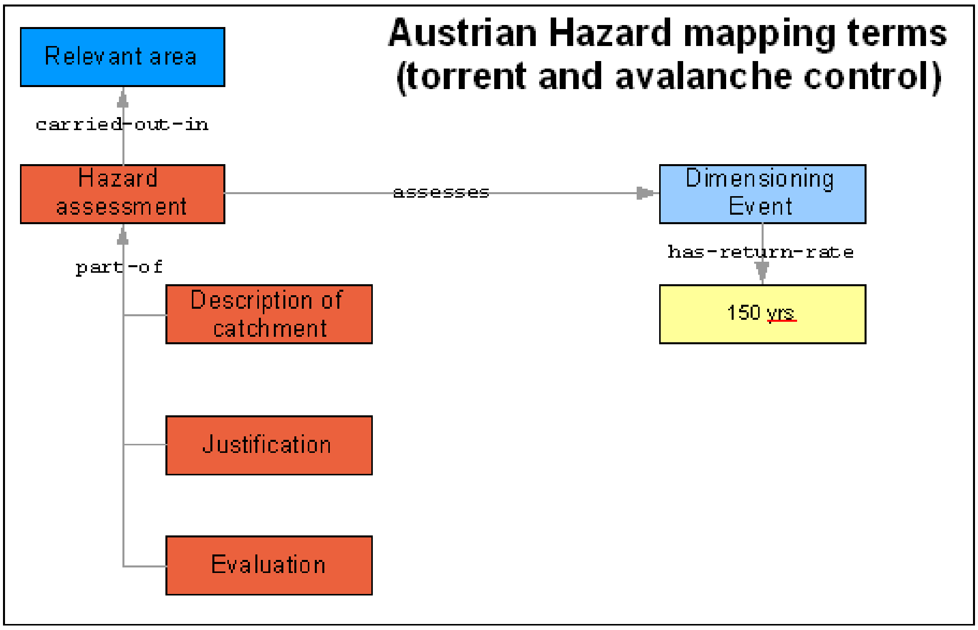


Figure 35: Austrian hazard mapping terms

PRACTICAL RELEVANCE AND OPEN ISSUES

When dealing with complex situations and processes, especially in an international context, it is essential to reduce communication problems to a minimum. As discussed before, one basic requirement is the use of a common “expert-language” as the meaning associated with terms can vary, especially due to the different language backgrounds of the users.

The MONITOR ontology combines all the benefits of a glossary, a taxonomy and a thesaurus but it also has some basic advantages against these other methodologies of knowledge representation. So in addition to the definition and hierarchical positioning of terms, the strict formalisation opens additional application options like automatic classification help and consistency checks. The collection of terms can be navigated through functional relations, which constitutes an additional type of knowledge presentation, and a host of additional information, besides the definition of a term, can be given to the user. Additional information can include: background information related to a term, literature, pictures, geospatial links, translations and an overview of relations and the functional context of an expression.

One mayor advantage of the use of a knowledge base like the MONITOR is that it can be easily made available to a large group of people. Whereas the ontology could be extended and personalised for the use of specific institutions, it is also made generally available to the public by using the internet. An existing data base for natural disaster events, the DIS-ALP Portal (http://portal.dis-alp.org/), has been used as a framework where the developed risk management ontology has been incorporated.

This Portal now offers a practical handbook which can be used online to collect background information about natural disaster processes, disaster documentation procedures, basic risk terms and terms of risk management. Currently the knowledge base is mainly structured for expert use, but interested laymen will also find interesting material for their information. Further additions will follow in the future to prepare the available material for the special requirements of different user groups, like decision makers and the concerned public. This will include risk communication tools where innovative non-paper media will be used for information presentation and knowledge transfer.

An example for applications developed during the MONITOR project are special use cases for the management of natural hazards. These use cases of the ontology were included in the DIS-ALP portal. The use cases offer an alternative approach to the knowledge content created in the ontology.

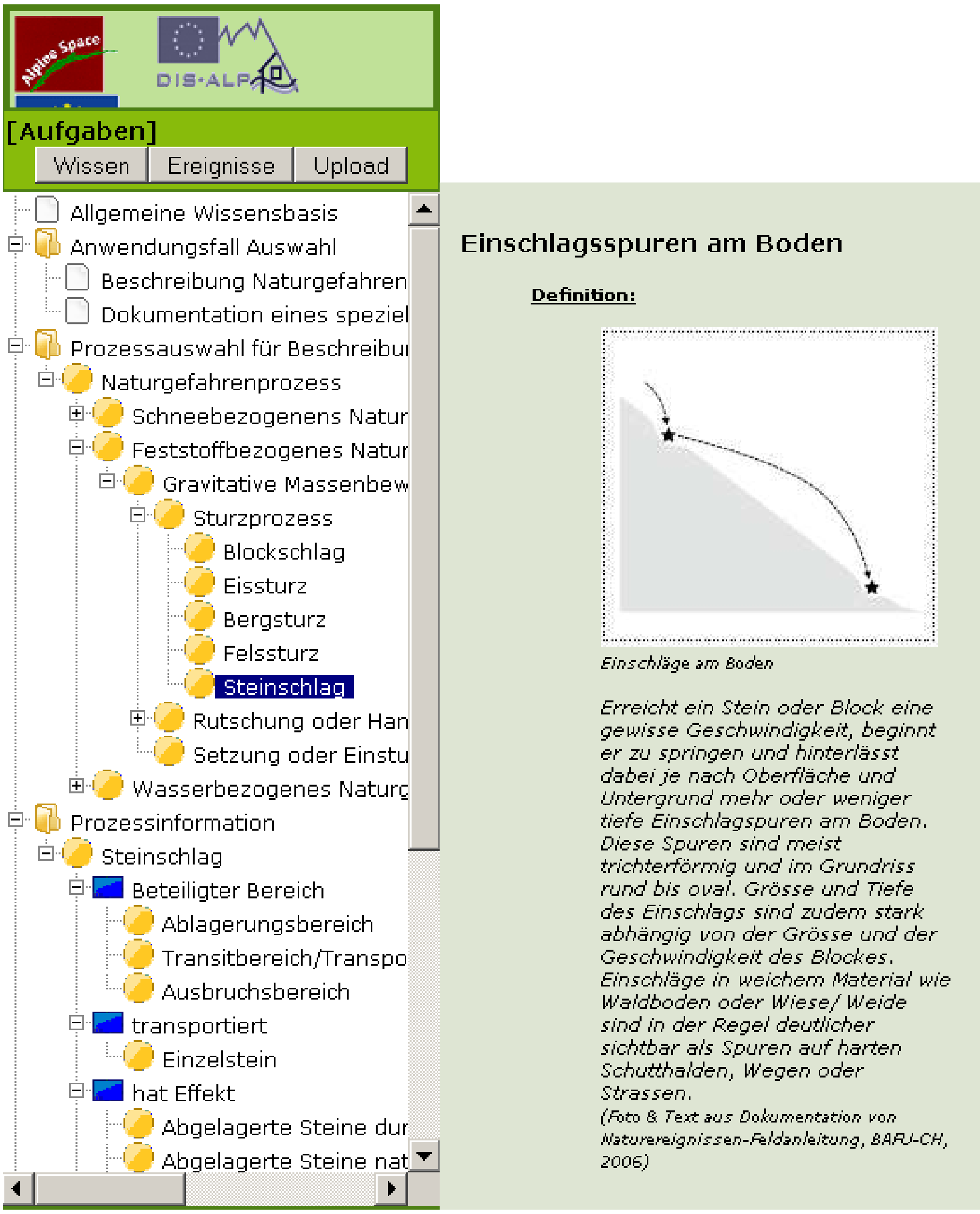


Figure 36: Ontological Knowledge base: use case selection, process information and additional background information

Examples of use cases are:

- **Natural disaster process information:** The user has access to information related to the specific natural disaster processes. A process can be selected (the selected term can be as general as e.g. “snow related disaster process” or as specific as “density flow avalanche”) and relevant information will be shown: Definition of the term, translation of the term, additional process information, picture, literature. In addition to that relations to other terms can be explored: The user can discover the process area involved, the type of transported material, the movement mode, effects and features and so on. As the user navigates along these relations all additional background information is of course available for these terms as well.

- **Documentation of natural disaster processes:** This use case has been especially developed for the documentation of natural disaster processes. It can help experts and other user groups to find out about steps to be taken when documenting a natural disaster event. It lists the features which are to be documented, which kind of data is recorded, how it is documented, and in what process area the feature is found.

- **Natural disaster identification support:** This use case is probably mostly of importance for non experts, for people from areas prone to natural disasters and for other interested people, but it can also be interesting for educational purposes. This application allows the user to select easy to distinguish criteria to arrive at the process defined by these characteristics. The main process categories can for example be distinguished between the type of amount of matter that they transport. Further distinctions can be based on the movement mode, on characteristic features (source zone features, accumulation form...), on a further distinction concerning transported material (solid/liquid fraction of transported matter, size, volume ...) or similar attributes.

The DIS-ALP portal also contains an extensive geo-referenced data base of recent or historic natural disaster events. There is still great potential for the combination of ontology with this event database. For the moment both aspects are included in the portal, even if the information has to be queried separately.

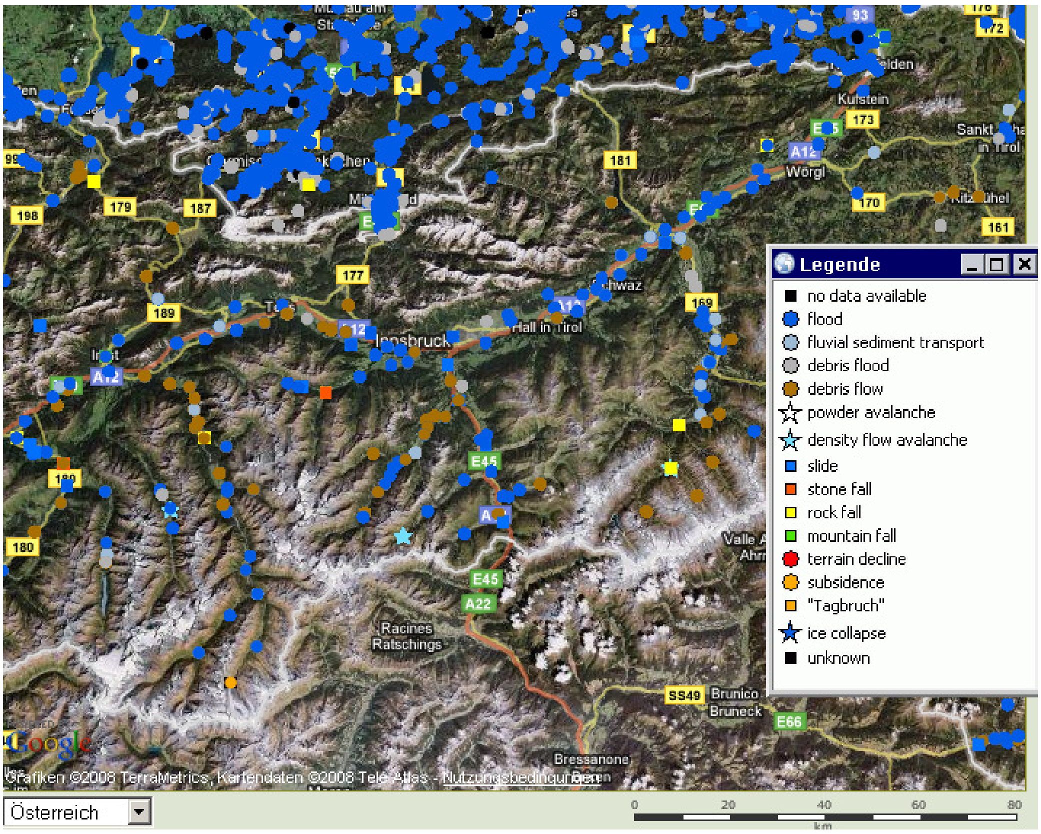


Figure 37: DIS-ALP portal map and event database

Special collections and summaries of information (e.g. fact sheets, regulations, documentation templates ...) can be added to the ontology where helpful. In the future a graphical depiction of the ontology will be developed to facilitate the navigation between terms and to provide a visual context for the information included in the ontology, which would be especially helpful for non experts.

A clear definition of terms is of direct practical relevance in at least two fields which are involved in risk management, namely insurance and legal issues. The latter includes problems related to clear definitions and specification of tenders when defining terms of reference.

One aim of the MONITOR project was to use synergies between existing knowledge and communication potentials and to integrate activities at different organisational levels for interdisciplinary risk management in order to lead to trans-nationally accepted standards. To achieve this, a Decision Support System (DSS) has been developed. In Work Package 3 effort has been put into identifying a core group of constraining factors that have to be considered while choosing a monitoring system for a specific application. The goal of the DSS was to develop an easy to operate computer application, to enable non-specialists to specify their problem and to receive suggestions for viable solutions. (MONITOR WP3 2008) This leads to informed users, public or private institutions dealing with natural hazards, who have a tool to provide them with basic information and enables them to compare suitable methods.

As the basis for the decision support system the Ontological knowledge background can be used. Decision Support Systems can draw information from the ontology and present the knowledge content in a way suitable for the user. This facilitates the information collection process for users from all different backgrounds.

Future application possibilities of the ontological knowledge base are numerous and multifaceted. The knowledge base can be supplemented with technical or specialised know-how to cover a even wider area of expertise. A discussion of commonly used terms can be initiated, and different aspects and views can be included into the ontology as well. The prerequisite for this is a common ontology-building knowledge of people using the ontology, which differs in complexity according to the ontology program used. An alternative to more complicated ontology-generators could be found in web-based ontologies which work towards an integration of different types of data (Text, pictures, maps, relations, ...) and can be directly edited by all users. This and other options are a promising outlook for further projects in the area of applied ontologies.

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ANNEX I: EXPLANATIONS FROM DOLCE

Category	Definition / Description from DOLCE
	Endurants
Endurant	The main characteristic of endurants is that all of them are independent essential wholes. Endurants can ‚genuinely' change in time, in the sense that the very same endurant as a whole can have incompatible properties at different times. To see this, suppose that an endurant – say ‚this paper' – has a property at a time t ‚it's white', and a different, incompatible property at time t' ‚it's yellow': in both cases we refer to the whole object, without picking up any particular part of it. Within endurants, we distinguish between physical and non-physical endurants, according to whether they have direct spatial qualities. Within physical endurants, we distinguish between amounts of matter, objects, and features.
Physical object	Physical objects are endurants with unity. However, they have no common unity criterion, since different subtypes of objects may have different unity criteria. Differently from aggregates, (most) physical objects change some of their parts

	while keeping their identity, they can have therefore temporary parts. However, if we admit that every object has a life, it is hard to exclude a mutual specific constant dependence between the two. Nevertheless, we may still use the notion of dependence to (weakly) characterize objects as being not specifically constantly dependent on other objects.
Feature	Features are ‚parasitic entities', that exist insofar their host exists. Typical examples of features are holes, bumps, boundaries, or spots of color. Features may be relevant parts of their host, like a bump or an edge, or dependent regions like a hole in a piece of cheese, the underneath of a table, the front of a house, or the shadow of a tree, which are not parts of their host. All features are essential wholes, but no common unity criterion may exist for all of them. However, typical features have a topological unity, as they are singular entities. Here only features of physical endurants are considered.
Amount-of-matter	Amounts of matter are endurants with no unity (according to Gangemi et a. 2001 none of them is an essential whole). Amounts of matter – ‚stuffs' referred to by mass nouns like ‚gold', ‚iron', ‚wood', ‚sand', ‚meat', etc. – are mereologically invariant, in the sense that they change their identity when they change some parts.
Mental object	Mental objects are dependent on agents which are assumed to be intentional (in the wider sense of conceiving some description). AKA „internal description".
Social objects	
Social object	A catch-all class for entities from the social world. It includes agentive and non-agentive socially-constructed objects: descriptions, concepts, figures, collections, information objects. It could be equivalent to ‚non-physical object', but we leave the possibility open of ‚private' non-physical objects.
Agent	Intentional social object ...
Situation	A situation is a social object that appears in the domain of an ontology only because there is a description whose components can ‚carve up' a view (setting) on that domain. A situation has to satisfy a description (see below for ways of defining the satisfies relation), and it has to be setting for at least one entity.In other words, it is the ontological counterpart (with due local differences or restrictions) of settings (situations from SC, contexts, episodes, states of affairs, structures, configurations, cases, etc.).A perdurant is usually the only mandatory constituent of a setting.Two descriptions of a same situation are possible, otherwise we would result in a solipsistic ontology. The time and space (and possibly other qualities) of a situation are the time and space of the perdurants in the setting.
Description	A description is a social object which represents a conceptualization (e.g. a mental object or state), hence it is generically dependent on some agent and communicable. Descriptions define or use concepts or figures, are expressed by an information object and can be satisfied by situations. The typology of descriptions is still preliminary.
Goal	DOLCE proposes a restrictive notion of goal that relies upon its desirability by some agent, which does not necessarily play a role in the execution of the plan the goal is a part of. For example, an agent can have an attitude towards some task defined in a plan, e.g. duty towards, which is different from desiring it (desire towards). We might say that a goal is usually desired by the creator or beneficiary of a plan. The minimal constraint for a goal is that it is a proper part of a plan. For example, a desire to start a relationship can become a goal if someone decides to take action (or lets someone else take it for her sake) to obtain it. A goal is different from anobjective, because the second one is independent from the cognitive state of a particular physical agent. In practice, an agent (physical or social) may aim at realizing an objective even though the realizing situation conflicts with a goal-situation of the same agent. In ‚private' plans of a physical agent, realizing situations usually coincide with goal-situations. Different cases occur with plans endorsed by social agents like organizations, institutions, etc., which are more clearly aimed at realizing objectives.

Method	A description that contains a specification to do, realize, behave, etc. Subclasses are plan, technique, practice, project, etc.
Plan	A plan is a method for executing or performing a procedure or a stage of a procedure. A plan must use both at least one role played by an agent, and at least one task. Finally, a plan has a goal as proper part, and can also have regulations and other descriptions as proper parts.
Information object	Information objects are social objects. They are realized by some entity. They are ordered (expressed according to) by some system for information encoding. Consequently, they are dependent from an encoding as well as from a concrete realization. They can express a description (the ontological equivalent of a meaning/conceptualization), can be about any entity, and can be interpreted by an agent. From a communication perspective, an information object can play the role of „message“. From a semiotic perspective, it plays the role of „expression“.
(social) Concept	AKA C-Description. A non-physical object that is defined by a description s, and whose function is classifying entities from a ground ontology in order to build situations that can satisfy s.
Role	Also known as ‚functional role’. A concept that classifies (in particular, it is ‚played by’) endurants, as used in some description. Roles are the descriptive counterpart of endurants, and, as endurants participate in perdurants, they usually have courses as modal targets (see).The typology of roles is still preliminary.
Course	A concept that classifies (in particular, it ‚sequences’) perdurants (processes, events, or states), as a component of some description. Courses are the descriptive counterpart of perdurants, and, since perdurants have endurants as participants, they are usually the function of some role.
Task	A course used to sequence activities or other controllable perdurants (some states, processes), usually within methods. They must be defined by a method, but can be *used* by other kinds of descriptions. They are desire targets of some role played by an agent. Tasks can be complex, and ordered according to an abstract succession relation. Tasks can relate to ground activities or decision making; the last kind deals with typical flowchart content. A task is different both from a flowchart node, and from an action or action type.Tasks can be considered shortcuts for plans, since at least one role played by an agent has a desire attitude towards them (possibly different from the one that puts the task into action). In principle, tasks could be transformed into explicit plans.
Parameter	A concept that classifies (in particular, it is ‚valued by’) regions, as defined by some description. Parameters are the descriptive counterpart of regions, and, as regions represent the qualities of perdurants or endurants, they can be requisites for some role or course. A parameter has at least one region that is a value for it.
Perdurants	
Perdurant	Perdurants (AKA occurrences) comprise what are variously called events, processes, phenomena, activities and states. They can have temporal parts or spatial parts. For instance, the first movement of (an execution of) a symphony is a temporal part of the symphony. On the other hand, the play performed by the left side of the orchestra is a spatial part. In both cases, these parts are occurrences themselves. We assume that objects cannot be parts of occurrences, but rather they participate in them. Perdurants extend in time by accumulating different temporal parts, so that, at any time they are present, they are only partially present, in the sense that some of their proper temporal parts (e.g., their previous or future phases) may be not present. E.g., the piece of paper you are reading now is wholly present, while some temporal parts of your reading are not present yet, or any more. Philosophers say that endurants are entities that are in time, while lacking temporal parts (so to speak, all their parts flow with them in time). Perdurants, on the contrary, are entities that happen in time, and can have temporal parts (all their parts are fixed in time).
Event	An occurrence-type is stative or eventive according to whether it holds of the mereological sum of two of its instances, i.e. if it is cumulative or not. A sitting

	occurrence is stative since the sum of two sittings is still a sitting occurrence. In general, events differ from situations because they are not assumed to have a description from which they depend. They can be sequenced by some course, but they do not require a description as a unifying criterion. On the other hand, at any time, one can conceive a description that asserts the constraints by which an event of a certain type is such, and in this case, it becomes a situation. Since the decision of designing an explicit description that unifies a perdurant depends on context, task, interest, application, etc., when aligning an ontology do DLP, there can be indecision on where to align an event-oriented class. For example, in the WordNet alignment, we have decided to put only some physical events under ‚event', e.g. ‚discharge', in order to stress the social orientedness of DLP. But whereas we need to talk explicitly of the criteria by which we conceive discharge events, these will be put under ‚situation'. Similar considerations are made for the other types of perdurants in DOLCE.A different notion of event (dealing with change) is currently investigated for further developments: being ‚achievement', ‚accomplishment', ‚state', ‚event', etc. can be also considered ‚aspects' of processes or of parts of them. For example, the same process , rock erosion in the Sinni valley' can be conceptualized as an accomplishment (what has brought the current state that e.g. we are trying to explain), as an achievement (the erosion process as the result of a previous accomplishment), as a state (if we collapse the time interval of the erosion into a time point), or as an event (what has changed our focus from a state to another).In the erosion case, we could have good motivations to shift from one aspect to another: a) causation focus, b) effectual focus, c) condensation d) transition (causality).If we want to consider all the aspects of a process together, we need to postulate a unifying descriptive set of criteria (i.e. a ‚description'), according to which that process is circumstantiated in a ‚situation'. The different aspects will arise as a parts of a same situation.
Action	A process that exemplifies the intentionality of an agent.
Activity	An activity is an action that is generically constantly dependent on a (at least partly) shared plan adopted by participants. This condition implies that an action must be sequenced by a task. Intuitively, activities are complex actions that are at least partly conventionally planned.
Qualities	
Quality	Qualities can be seen as the basic entities we can perceive or measure: shapes, colors, sizes, sounds, smells, as well as weights, lengths, electrical charges. Qualities inhere to entities: every entity (including qualities themselves) comes with certain qualities, which exist as long as the entity exists.
Region	Regions define the possible values a quality can adopt (value domain). The region for quality color is a color space, the region for a quality location can be defined as some spatial reference system and the region for a temporal quality can be defined by some temporal reference system (like the regorian calendar).
Quale	AKA value. One specific element from a region.

ANNEX II: MONITOR "INTUITIVE DEFINITIONS"

ANNEX III: MONITOR GLOSSARY

Term	MONITOR definition
Alarm Situation	An alarm situation is a situation, which is the setting for a risk, which is above a defined alarm threshold.
Capacity	Capacity is defined as the quality (of objects) of the environment, which describes the ability to cope with some process.
Chance	Probability of a positive impact of an event (as opposed to damage). Gain and loss as used mainly in economy. Nicht in Onto!
Constructed risk	Constructed risk is based on the perception of the damage extent, the capacity to deal with, to control and to minimize risk, and the knowledge of hazards
Damage	Damage is the concept which classifies an impact to have negative consequences
Damage extent	Damage extent is the extent of an impact, which is classified as damage.
Damage potential	Damage potential is a quality of the environment, which results from an event (of an defined size)
Damage situation	A damage situation is a situation, which is setting for an impact, which is classified as damage.
Danger	Danger is a situation which is the setting for an event which is classified as hazard.
Disaster	A disaster is a situation, which is the setting for a damage extent, which is above a defined disaster threshold.
Disposition	Disposition is a quality of an endurant, which defines that given certain (possible)conditions it would likely participate in a defined event. (MEIXNER 2004) (In case of natural disasters, disposition is usually regarded as a quality of an area/region.)
Emergency	Emergency is a situation, which is the setting for risk (classified to be above emergency threshold) or a damage extent, classified to be above disaster threshold.
Endangered objects	Endangered objects are all objects which are within reach of an event classified as hazard.This concept therefore classifies objects of the environment
Environment	The environment (as a term subsuming natural, built and social environment) consists of endurants. These endurants participate in events.
Evaluation	Evaluation was interpreted as a “component of risk assessment in which judgements are made about the significance and acceptability of risk”, which comes closest to our use of the concept ‘evaluation’.
Event	Events are perdurants (occurrences) which happen within this environment and which “cause” impacts.
Exposure	The exposure is the relation of participating events (which actually means a spatio-temporal co-location).
Glossary	A glossary is a list of terms in a particular domain of knowledge with the definitions for those terms.
Governance	Governance is the non-final (process-like) plan, which is oriented towards the optimised use of (state) authority as resource. This use has to conform to some rules of conduct (social norms). The term governance is seen here to be widely synonymous to policy (but with explicitly positive connotations).
Hazard	Hazard is the concept which classifies an event as one (potentially) causing negative consequences (with an impact which is socially classified as damage). Or in short: Hazard is an event, which causes damage.
Hazard potential	Hazard potential is the quality of a (potential) event, which is classified as

	hazard.
Impact	An impact "changes" (qualities of) the environment. A change of quality in this meaning may include substantial changes like generation and destruction of objects
Information situation	The information situation includes all the information available about the target situation (generated by observations).
Interpretet situation	The interpreted situation is based on interpretation (classifying elements we have information about) according to social concepts.
Knowledge Management	Knowledge management can be defined as the systematic collection and structuring of knowledge within a specified domain of knowledge with defined pragmatic objectives (usage) in mind.
Management	Management is the non-final (process-like) plan, which is oriented towards the optimised use of scarce resources (as a sub-goal). It does not take into account external plans. It is iterative with no clear a priori sequencing of tasks.
Measure	Measure is the final (event-like) plan, which is oriented specifically at providing solutions for one known problem situation. Measures can be permanent even if the goal has been achieved.
Monitoring	Monitoring is a process-like plan with the goal of long-term information provision about a specific topic.
Objective situation	The „objective“ situation is the situation which should be described. It can not be directly observed / measured. It is the target situation of observation. It is setting for all endurants and perdurants to be observed.
Ontology	An Ontology is a formalised specification of a conceptualisation within a domain of knowledge (GRUBER 1995). That is, an ontology is a description (like a formal specification of a program) of the concepts and relationships that can exist for an agent or a community of agents.
Plan	A Plan is a description that describes a method for executing or performing a procedure or a stage of a procedure.
Project	Project is the final (event-like) plan, which has, unlike a measure, a defined beginning and end, which is either defined by a temporal duration or by the achievement of the goal situation.
Risk	Here risk is seen as a quality (the probability) of an impact, which is classified as damage. In contrast to the definition of risk the generation of risk is dependent on the hazard potential and the damage potential- So whenever a hazard potential AND a damage potential are co-located then a risk is there.
Risk (narrow)	RISK (narrow) is the probability of an impact of defined extent, which is classified as damage.
Risk Management	Risk management is the (continuous, process-like) management which aims at reducing risk to a level, which can be classified as acceptable. The corresponding goal situation (which satisfies this goal of reducing in order to keep it below a certain level) is security. The goal 'risk reduction' is identical to the goal 'increase security'.
Risk treatment	Risk treatment is the plan that subsumes different strategies (see management & strategies) which again have different measures as (final, event-like) plans which can be permanent or temporary.
Security	Security is a situation, which is the setting for risk classified as acceptable.
Security	Security is a situation which is the setting for risk classified as acceptable.
Strategy	Strategy can thus be defined as the non-final (continuous) long-term plan, which takes into account external plans.
Tactics	Tactics is the non-final short-term plan, which takes into account external plans.
Taxonomy	A taxonomy is a controlled vocabulary whose terms are classified (by means of the superclass and subclass relationships). This procedure is further refined in a

	Thesaurus.
Thesaurus	A Thesaurus is a controlled vocabulary, whose terms are related to each other by a set of pre-defined possible relations. The definition can be given in a scope note (which is not obligatory). The main relations of terms to each other are
Threat	Threat is a situation which is the setting for elements of the environment which are exposed to an event classified as hazard.
Vulnerability	Vulnerability is the quality of the environment, which determines damage, given a defined (hazardous) event. In environmental science (e.g. water management) vulnerability has been clearly distinguished between the general conditions of vulnerability (called "intrinsic" vulnerability) and the "specific" vulnerability, which describes vulnerability in relation to a certain type or magnitude of hazard. As a shorter (more intuitive) definition this can be formulated as: Vulnerability is the quality of an object, which describes its probability of getting harmed in an event.