What is systems thinking?

by Werner Furrer

Systems thinking – or more precisely *to think in systems* – is a concept, a universally applicable method, to describe and analyze whatever type of reality or problem we are confronted with, may have in mind. Everybody thinks in systems, but better so, with more success, if he does it consciously, deliberately.

Systems thinking, a universally applicable method

The universally relevant concepts of systems thinking remind us of many analogies. Thus the mighty stream, overflowing its banks and the drop of blood, which breaks open the boundaries of its veins is in both cases a potential disaster. The ever so abundant flow of vehicles in our metropoles bears some similarity to those cases. Money equally flows through established channels. But the danger, that it might be too much, is a rather exceptional problem. Anyway, the concepts of systems thinking can inspire the engineer of water regulation, the biologist, the financial planner and so on.

In our courses the participants apply the concept of systems thinking to any topic and discipline and prove the usefulness of this tool for students as well as for academically trained employees in an enterprise.

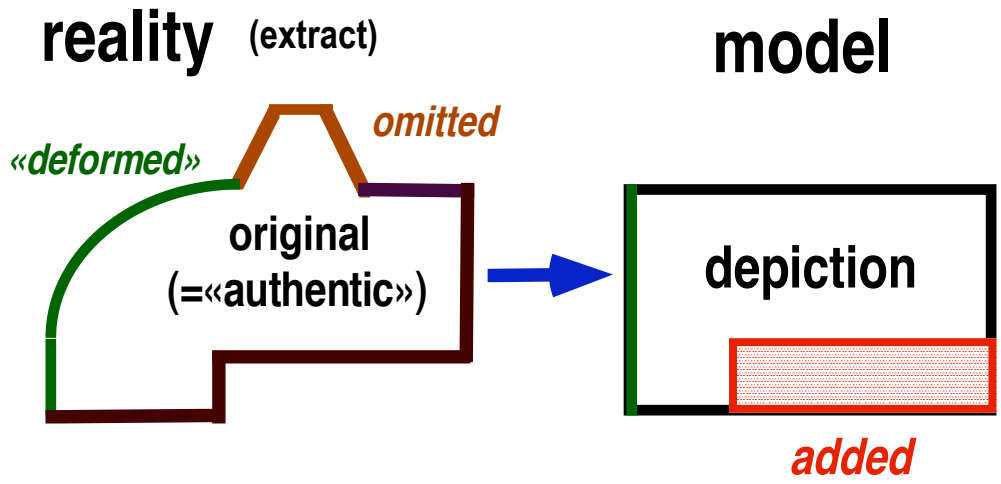
With systems thinking we combine knowledge, wich has its roots in philosophy with principles and ideas of science and engineering disciplines, like informatics, cybernetcis, statsitics and so forth.

A *model* is a *depiction of reality on our thoughts*

A model is a **depiction** of some ***extract of reality***, the «original». In the narrower sense the model is a *depiction on our thoughts*, in a broader sense modelling includes the secondary process of the

depection on some information device, like paper, computer data, mathematical or other formulas, the representation of our thoughts through the langauge or a physical replica of the original and so forth. The *model represents* the original partly for some specific purpose or entirely.

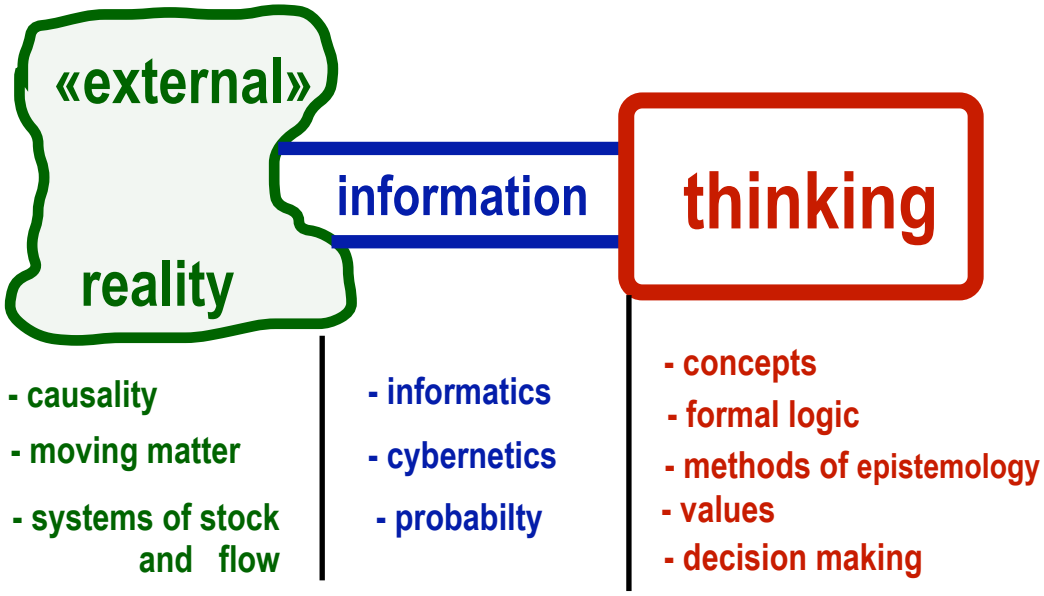
The following graphic illustrates the process, how our mind constructs a model:



Understand the world (easier) through systems thinking

We integrate all topics and elements of thinking in one systemic graphic and get the following representation:

Main topics of systems thinking:



Information is
a link between reality and thinking

In the perspective of a thinking individual the environment, including his body is «external» reality. Science, like physics, astronomy, chemistry, biology, its various applications like geoscience and engineering as well as economics and other social sciences deal with moving matter and describe this «external» reality.

Our language and concepts are main elements of our thinking, various disciplines of information science make up the link between the external reality and thinking.

Systems thinking, a discipline with history

The term systems thinking is relatively new. But the discipline deals with concepts and ideas, which have been expressed in former times. The paramount term «category» - universally relevant

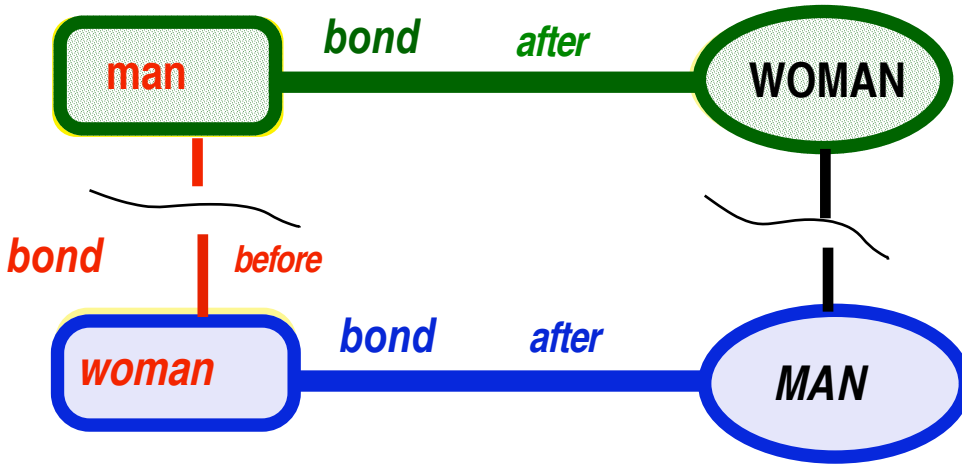
qualities - was designed by the greek philosopher Aristoteles in the 4th century b. C.

Categories are some sort of universally valid qualities, or «**dimensions**» of the analyzed system – as for space and time even in the strictly physical sense of the term, for the other categories more as a metaphoric association. ***Criterion*** is a suitable equivalent for category, when we analyze a system.

Unconsciously inspired by the possibly most important pair of categories – ***parts and relations*** – philosophers already in antiquity have postulated the existence of atoms, an idea, which was scientifically founded by chemists from the beginning of the 19th century.

Also **Goethe**, the foremost German poet had some knowledge of the at his time young science of chemistry. In his novel *Elective Affinities*. the poet demonstrated an analogy between a known chemical process and a possible scenario of social interaction with the example of 2 married couples, when their mutual emotions are disturbed at a brief encounter.

The psychological process and its analogy in chemistry can be demonstrated with the same graphical representation.



change the coupling of components, analogously in chemistry and in a scenario of social interaction

Analogy of the chemical and the emotional bond.

In our times, a teacher of chemistry with pedagogical skill will in the opposite way of Goethe demonstrate fundamantal concepts of his discipline with some analogy to emotions, like pair bond, strong or week bond. Such a comparison is not a naive antropomorphism, but refers to fundamental system principles.

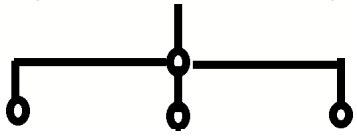
Catalogue of the categories.

Many words of our natural language indicate a term, which is relevant in systems thinking or analysis repectively. We can use the list of such words in the following appendix as a «check of list» and describe so to say any type of reality.

In the following catalogue the categories are listed in a «natural-objective» order. Sometimes it is more convenient to begin with the subjective category. *«Which **problems** do I have, do we have, and which aims, duties and competence»?*

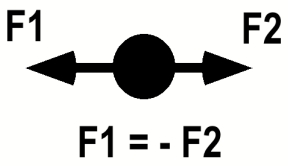
Universally relevant are the categories space, time, matter, causality, parts and relations and possibly quantity. The specific way a category is coined in a given situation, we find in many simple case as an answer to a question, which typically starts with the character **w**, as shown in the following table:

category	Inspiring question
Space 	- ***where** is, may be found? **where to or from** moves the relevant object?* - ***which form** and **appearance** has the object*
Time 	- ***when** was (this event)? **for how long** does, did it last (processes, events, actions))? **what** has **changed**, remained stable?* - *past, present, future, before, during, after.* - *How has the system **evolved, developped** (its history), will evolve (probably, hopefully, scaringly), what actions are*

	needed? *- periodicity: How often? never, rarely, frequently, always.*
Matter (substance) 	*- **what** is it, what is it made of? (things, products, material)*
parts («components») 	*- which parts make the whole object?* ***society:*** *groups, individuals* ***biology**: organs, cells* ***matter**: molecules, atoms* ***technique**: parts, bricks*
relations	 *connections* (between components) **structures**  **order**
Causality (cause and effect) 	*- **why** does, did this happen?* ***- how, by what mechanism** does this system work? How are the influences between the various systems? Given context. **How** can we obtain a desired effect, get to work a useful mechanism, prevent a threatening damage?* *- **what** happens, **if**...?* *- synergy and antagonisms (-> negation).* *- **Logic: proves**, contradictions, refutations. How do you prove your claim?*
Quantity **1 2 3 4 7**	*- **how much** (time, length, money, weight, etc.) ?*  *?*

«moving matter» = changes (combination of categories) 	- ***Stock and flow****: over which pathes, (from where.. to where; from whom to whom), by which mechanisms, over which paths does the relevant matter move? Where is it stocked? Input / output.* *- what happens, what is changing, has changed; may/ should change – by which cause, how, why, when, how fast?* *- relevant information from technique, science, economy?*
«subjective» category (involved persons) 	- ***who:*** *I and or who else? Acting, speaking, observing, adressed person(s) – individuals, groups.* *- enduring, suffering, used, favoured, benefits enjoying persons?* *- who is / was (role, competence, responsibility) acting, knowledgeable, willing, able, obliged, entitled, did it?*
social category Relations between involved persons	- ***who*** *has* ***which relations with whom****?*  *- human communication, common and controversial opinions, discussions.* *- cooperation, contract, sympathy, positive or negative feelings, benefits, threats, competition* *- «social system»,* ***society, state*** *-> law, politics, economy, culture*
one sided relations	- ***who*** *has which attitudes,* ***towards whom and which topic*** *(convictions, interests, sympathy, antipathy towards persons, events, circumstances)?*
Subjective causality: Thinking  **decision making**,	- ***what for, why?*** *is it done, it happens, people act (purpose, values, aim, means)* *- will, wishes, hopes, fears, coercion, possibilities: What do I want to, may or must I have, do, get, deliver?* *- Analogously other people in cooperation, competition or indifferent to my own aims?* *- Who has which* ***problems*** *and* ***interests****?* *- Which choices (= «variants») do we have, I, other persons*

acting ? yes / perhaps / no	*and groups?* *- Proposed, for whom possible, useful undesired solutions?* *- Who will (presumably) have which benefits, thanks to which measures?* *- Why are you, do you do, have, want to?*
Thinking 	*- Make assumptions, recognize, analyze and understand* ***facts***; ***logic****: prove or refute statements, assumptions. Recognize and solve problems; develop methods.*
Information 	*- where and how do I find sources, statistics, knowledge, apparent and background information?* *- What are my / our / your opinions, existing or lacking knowledge?*
Recognizing	***- Selection: Relevant topic*** *at the moment or permanently, to be considered to a certain degree, less, not at all.*
Truth	***- yes or no****? Is this statement true?* *- How much of it is true?*
Probability contingency	*Assumption, degree of uncertainty* 
Negation 	*- **Deny, reject, invert**: Truth, good things, beauty* *- errors of thought and deed, impossible aspirations.* *- **scarcity** (resources, knowledge, information, moral, justice), problems, open questions; damage, breakdown, defect, sickness, disadvantage, decrease / end of usefulness, costs, antagonism, hostility, controversy, risk, fear, pain, suffering, mourning, punishment.* *- contradictions in thinking and doing; paradoxa, competition, conflicting interests and opinions -> objection* *- criticism, agression, violence (instead of discussion), distruction.* *- refute a conversation or service.* *- too much, not enough*

	- naivety, distrust
- negation of negation = positive!  **F1 = - F2**	*- Repair damage and compensate it economically, relieve suffering, avoid risk or insure it, solutions to a problem.* *- Defence, protective measures, prevention, provision.* *- If I discover my own or other peoples error, this may be a chance. The disadvantage of my opponent may be my advantage, e.g. in a competitive game.* *- To reach a benefit, a «negation of some disadvantage» we have to provide an effort, some expenses and perhaps run some risk.* *- Many systems are not either positive or negative, good or bad, but inevitably, perhaps usefully, sometimes in an optimal way, a **balance between opposing forces** or tendencies in analogy to Newton's discovery of a dynamic equlibrium between celestial bodies. Some of his countrymen in politology adopted such ideas for their discipline and recommended an equilibrium between powers.* *- Instead of total ignorance more subtly a lack of information may be accepted as a **degree of uncertainty**.*
emotions 	*- joy, anger, fear, longing, hope, love, hate; pleasue.* *- **Who** feels (should, could feel) **what towards whom**, which circumstances, objects, or could, should (or hopefully not) **develop** which feelings?* *- Which emotional relations exist between which persons – permanently, potentially, certainly not?*
Values: ethical, esthetical, economical = bebefit	***- What is how to assess and value?*** *- good / evil, bad; beautiful / ugly; useful, (un)economic, (dis)advantageous, (un)convenient, (un)desirable, **should or must be done** or not?* *- **Central ethical question*** *a) from a **subjective point of view**: «what, which services do **I owe to whom**? To which services from whom do I have which **legitimate claim**»?*

	*b) objectively: «**Who owes what to whom** and has which legitimate claim towards whom»?*
Economy / technique 	*- **how much costs / benefit**, which means and resources?* *- Who has to provide for how much of the expenses, for whom is how much of the benefit?* *- what presumable, possible risks and opportunities ly in our intentions, plans, endeavours, events, situations?*
Law 	***- Who is allowed to, has to** do, what, towards whom?* Same questions as in ethics, but often different answers!

Space, time, matter describe «objective», physical qualities in the examined system; other categories are constructed rather subjectively. «Parts and relations» are universally relevant in all fields, like, admittedly, all categories if we describe whatever extract of reality extensively.

In a less detailed classification we could integrate economy and law into one subcategory «society» or «social dimension» and this one together with the values «information» and «negation» into a general «subjective category» and within this «truth», «probabiltiy» and «negation» as part of «information».