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Technical disasters are
socially responsible.
Natural events against which there is no
or insufficient precautions have been taken
are not to be accepted as fate

For my wife Elisabeth

Preface

One could well get the impression that we are living in a time in which catastrophic events are increasingly burdening our social coexistence.

We decided that we would focus on four individual events with regard to this impression.

At the beginning we put the ballad “The Sorcerer’s Apprentice” by Johann Wolfgang von Goethe. The sorcerer’s apprentice is alone and tries a spell of his master to prepare a bath for himself. By his action, the sorcerer’s apprentice exposes himself and the community to what the sorcerer’s apprentice sees as a manageable risk. An examination of the concept of risk is therefore inevitable. With the appearance of the sorcerer’s apprentice, the “drowning” of the building is averted. The risk, initiated by the sorcerer’s apprentice, was averted by the warlock, it was mastered. The ballad “The Sorcerer’s Apprentice” is characterized by the structure of the sequence of actions.

Is the structure formed by the action also in the three catastrophic individual events of

- Chernobyl (26 April 1986, explosion of reactor 4),
- Fukushima Daiichi (11 March 2011, destruction of several power plant units by a tsunami wave)
- Explosion of the Deepwater Horizon oil rig in the Gulf of Mexico (20 April 2010)

available?

These three individual events and the ballad “The Sorcerer’s Apprentice” are analyzed in terms of their action features.

In the case of the ballad “The Sorcerer’s Apprentice” and Chernobyl, as well as Deepwater Horizon, human actions are evident as having triggered the accident. But there are also opinions, especially in the case of Chernobyl, that assume a technical failure. This is the contradiction we are going to resolve. The Fukushima Daiichi disaster is also seen, on a superficial view, as a natural event. In contrast, it is due to human decisions, brought about by the selection of the site for the power plant and an inadequate state of protection against external and internal accidents.

This assessment becomes clear when the four accident sequences are compared with the so-called Swiss cheese model.

In the second chapter, we seek an answer to the question of direction for the four individual events.

The fact that a cause is followed by an effect with a temporal and spatial distance is an everyday experience that describes the problem of causality. Nature seems to have an inherent arrow of time that is not known to the basic laws of physics. A variety of different arrows of time are discussed in science. We will focus, as Stephen W. Hawking did in Chap. 2, Hawking (1994), on the thermodynamic, the psychological, and the cosmological arrows of time, emphasizing the special role of the thermodynamic arrow of time, which represents the growth of disorder or entropy. This allows us to distinguish past and future; time is given direction. This phenomenon can be read sociologically as a law of increasingly rational action orientation. Human cognition, that is, the perception, recognition, and processing of information, creates the foundations of the intentional structure necessary for a task to be accomplished through purposeful action. Intentions to act, that is, reasons and purposes, are not causes as highlighted by the application of the cause-effect structure.

Jens Rasmussen has developed a model for the cognitive demands placed on humans by the processes of information processing. He distinguishes three levels: skill-based, rule-based, and knowledge-based. In making decisions in everyday life situations, people may choose shortcuts between these levels. Rasmussen has developed what he calls a stepladder model for such shortcuts. This stepladder model allows associative jumps between all decision levels, and thus freedom of action. For an intentional structure shaped in this way, a heuristic is presented that is commonly referred to as the Rubicon model. Once the Rubicon is crossed, there is no going back in the intentional structure of action. The heuristic of the Rubicon model is projected into the cause-effect structure. Under the aspect of the causal principle, the metaphor of shooting with a bow and arrow is presented.

The causal chain in archery consists of the following links:

- Preliminary phase
- Cause, generation of an internal state
- Entry of an external system
- Point of no return
- Triggering event, causal principle
- Probabilistic influencing factors
- Effect

The archer performs the bow shot according to his intention, the hit "into the bull's eye."

The causal chain and the intentional structure are also explained for the ballad "The Sorcerer's Apprentice." The two nuclear catastrophes of Chernobyl and Fukushima Daiichi are described in the same way. The two structures are also elaborated for the explosion of the oil rig in the Gulf of Mexico, Deepwater Horizon. All four individual events are condensed by the "consequential reasons for action" (Nida-Rümelin).

Consequential reasons for action are directed at causally intervening in the world and generating a state of affairs that is different from alternative states of affairs. Consequentialism does not use the scientific concept of causality and apply it to action, but proceeds the other way round. Causality is assigned to human action. Or in other words: The intentional structure is determined by decisions.

In all four individual events, there is no convergence between the consequential reason for action and the intentional goal of action. The decision makers have spread out the dual character of the action.

In his decisions, man is subject to the processes of nature, whether he knows them or not. He must obey them. In the three individual catastrophic events, nature prevailed and society was burdened with the consequences.

Our decisions move within the spatiotemporal relational framework of physics and our consciousness. Experienced time connects consciousness and intentionality. Experienced time is subjective time, is consciousness of the present, the past, and the future. At the same time, we know that only the moment is real, the past is already past, and the future has not yet occurred. This raises the question whether there is also a basis in the circulation of nature for the difference between past and future. This difference goes beyond the differentiation between "earlier" and "later." It can only be grasped with a dynamic approach to the processes of being and becoming. These processes are viewed in the cognitive sciences as taking in information from the environment and the behavioral dynamics it triggers. We are talking about intentionality.

The three catastrophic individual events are placed in a spatiotemporal relational framework. The spatiotemporal relational framework is formed by the physical variables in order to be able to describe decisions and the resulting actions.

Now the arc of Chernobyl, Fukushima Daiichi, and the Deepwater Horizon drilling rig is being extended. Included is US Airways Flight 1549 from New York. The captain of the flight steered the plane onto the Hudson River and thus avoided a catastrophe. This presents the tension that shapes our worldview with regard to human decisions. Humans shape our view of the world through their capacity for consciousness; they acquire a creative power with which they must deal responsibly.

In the fourth and last chapter, we take up the conflict between the natural sciences and the humanities. The natural science side asks: How can there be reasonable causes in a world of causes? The humanities side asks: How can there be causes in a world of reasonable causes?

These two questions are answered by explanations of the cause-effect structure and the intentional structure. Processes by which the physical external world passes into the world of daily life familiar to consciousness lie outside the realm of physical laws. As a physical system, the brain is also subject to probabilistic laws, in addition to physical laws.

Decisions presuppose previous events and anticipate the unknown future. Decisions for an alternative course of action, this everyday challenge, belong to the Very Smallest. The structure of the Very Smallest is formed by the culture of a company, in short, corporate culture, the decision premises, and the decision processes. Corporate culture and decisions, formed by decision premises and processes, are the two sides of the same coin, "operational organization." When decisions are made in operational organizations, the dual nature of actions also comes into play. As we already know it. Every decision has a favoring and a burdening character.

The Very Smallest is embedded in throughout the whole book.

The Very Largest of all are the four elementary forces that arose from the original elementary force: Gravitation, the queen among the elementary forces, the Electromagnetic Force, the Weak Nuclear Force, and the Strong Nuclear Force. All four still control the processes in the universe today. Thus, we are immediately before an answer to the question of the direction.

Consequential reasons for action are the means of directing. The stage on which we humans act is determined scientifically by time, space, and causality, and sociologically by the community – we have limited ourselves to the operational enterprise. The script is written by the laws of nature. We have introduced entropy and the thermodynamic arrow of time derived from it as the "script writer." The arrow of time determines the development that humans try to influence with their decisions. These are the components that shape our worldview. Space, time, and causality are not objects. Objects of all kinds are restricted, finite, and conditional. The same is not true for space, time, and causality. Rather, space, time, and causality are the three "vectors" that span our reality, the basis of all knowledge, the precondition of all objecthood. And because reality is so large and inexhaustible, it can only be based on just such a foundation, which is to be stabilized by holistic security research.

The author's aim with this book is to show how holistic security research can be used and applied purposefully against the resistance that still exists.

Penzberg, Germany Volker Hoensch
Christmas 2018

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1 Four Selected Accident Events

1.1 The Concept of Risk

We would like to start with a quote from the former German Minister for the Environment, Prof. Dr. Klaus Töpfer:

> The expansion of human possibilities through the use of technical aids, be it airplanes, power plants, oil rigs or the like, made the creation of wealth possible. Technology must remain a tool for improving human living conditions. It must be calculable and controllable so that forces are not unleashed that could also bring about the end of human civilization. Greek mythology already teaches us that blessings and curses lie close together when man strives beyond his natural powers. Prometheus was punished by the gods because he brought fire to mankind and made their lives easier, while at the same time giving them godlike powers. This ancient message is more topical than ever. It is necessary to use the enormous possibilities of technical progress for the benefit of mankind, without at the same time becoming an outlaw of the divine order of creation.
>
> There is no alternative to technical progress. Only with the help of technology can we maintain prosperity in the industrialised countries, improve the living conditions of people in the Third World and also overcome environmental problems. However, we know today that with the expansion of technical possibilities, the risks also increase. (Hauptmanns et al. 1987)

Examples include the accidents at the Chernobyl and Fukushima Daiichi nuclear power plants and the explosion on the Deepwater Horizon oil rig, which will be discussed in more detail.

Further in the foreword by Prof. Töpfer:

> Modern technologies are having a more profound and long-term impact than ever on our human society and on the natural environment. Many fear a momentum of its own that can no longer be controlled. Unreflective growth thinking and blind faith in progress are

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> therefore no longer responsible. Instead, technical progress must always be examined for inappropriate risks and dubious benefits. (Hauptmanns et al. 1987)

This means that we cannot avoid defining the prevailing understanding of the term “risk”. In colloquial language, the term “risk” is associated with danger, i.e. the possibility of suffering damage. In English, a distinction is made between “danger” and “hazard”. Danger is the possible effect of harm or the state of being threatened by a source of danger. Hazard is a source of danger, a risk. Although this differentiation helps us conceptually, we must note that there are different views on the concept of risk in the various scientific disciplines – engineering, social science and social philosophy, business administration and law.

1.2 The Sorcerer’s Apprentice

Because of this shortcoming, we would like to turn to the ballad “The Sorcerer’s Apprentice” by Johann Wolfgang von Goethe, which was written in 1797, the so-called Ballad Year (Sorcerer’s Apprentice 2018).

The sorcerer’s apprentice is alone and tries out a spell cast by his master. He uses a spell to transform a broom into a servant who must carry water to prepare a bath. The ballad begins with the following verses (http://www.reelyredd.com):

> That old sorcerer has vanished
> And for once has gone away!
> Spirits called by him, now banished,
> My command shall soon obey.
>
> Every step and saying
> That he used, I know,
> And with sprites obeying
> My arts I will show.

This quotation and the rest of the text of the ballad bring us closer to the scientific concept of risk, which is particularly common in the insurance industry. There, risk is essentially measured according to the objective extent of damage and its probability of occurrence, which is always determined in detail.

For the probability of occurrence in the sorcerer’s apprentice it says: “That old Sorcerer has vanished”.

The master is absent, so the sorcerer’s apprentice can become active.

The extent of the damage is described by the words: "How the water spills: How the water basins, brimming full the he fills! Stop now, here me! Amle measure: Of your treasure. We have gotten!"

Later, "Brood of hell, you're not mortal! Shall the entire house go under?"

So much for the ballad "The Sorcerer's Apprentice."

But the ballad "The Sorcerer's Apprentice" suggests another consideration. Does the sorcerer's apprentice have the necessary competence to act? Does the sorcerer's apprentice act reasonably?

Obviously, the sorcerer's apprentice overestimates his competence to act and thus his knowledge. For this we repeat from the first quotation:

Every step and saying
That he used, I know.
And with sprites obey
My arts I will show.

Second quote:

He returns, more water dragging!
Now I'll throw myself upon you!
Soon, O goblin, you'll be sagging.
Crash! The sharp axe has undone you.
What a good blow, truly!
There, he's split; I see.
Hope now rises newly.
And my breathing's free.

Woebetide me!
Both halves scurry
In a hurry.
Rise like towers
Threr beside me,
Help me, help, eternal powers!

The sorcerer's apprentice does not have the knowledge to conclude his original intention to act with a positive result, he also lacks the necessary knowledge and thus the competence to act to limit the damage.

With the quantification of "probability of occurrence" and "extent of damage", the risk can be estimated.

In its most general form, the measure of risk is understood to be the product of the probability of damage, related to a unit of time, and the damage impact of the consequence:

$$\text{Risk value} = \text{probability of damage} \times \text{impact of damage}$$

Further, the ballad shows us to distinguish between controllable risk and uncontrollable risk. The sorcerer's apprentice realizes that he cannot control the risk he has summoned and in desperation calls for help:

Sir, my need is score.
Sprits that I've cited
My commands ignore

The master, on the other hand, masters the scene through his knowledge and shows competence in action:

To the lonely
Corner, broom!
As a sprit
When he wills, your master only
Calls your, then'tis time to hear it

The sorcerer's apprentice does not have this knowledge and is desperate:

Ah, I see it, dear me, dear me.
Master's word I have forgotten!

Ah , the world with which the master
Makes the broom a broom once more!

We summarize the action sequence of the ballad in key words:

- Overestimating oneself, proving one's supposed ability, deliberately exceeding one's competence,
- Ignorance of one's own doubts,
- Power rush, achieving personal success,
- Fear of consequences,
- Desperate for control,
- Rescue by the Sorcerer.

Transformed to the product approach to risk value:

- Probability of damage: event deliberately brought about to confirm one's own competence.
- Damage impact: manageable and containable.
- Risk: The master's intervention neutralizes the challenge deliberately made by the sorcerer's apprentice.

The assessments of the sequence of actions and the product approach for the risk value made here for the Sorcerer's Apprentice are also to be taken up in each of the three catastrophes presented below and used as a standard of assessment.

The assessments of the action sequences for the total of four events considered are summarised in Table 1.1.

So much for the recourse to Goethe's ballad "The Sorcerer's Apprentice".

1.3 Dealing with Knowledge

Now we can turn to the question of what knowledge is and how it comes about. This question belongs to the fundamental questions of philosophy.

The definition of knowledge and thus action competence is important, according to the motto "define your terms", in order to avoid that different facts are understood under the same term.

The question of what exactly the "essence" of knowledge is, how knowledge actually arises and is ultimately translated into decisions and action, has remained without a binding answer to this day: Is knowledge, after all, rather the cognitive process itself in the form of a continuous construction of people and social systems? How does knowledge ultimately become action? What role do emotions, motivations, will, attitudes and values play on the one hand, and social relations and culture on the other?

Against the background of such questions pressing for clarification, knowledge is not the domain of one discipline alone.

The intelligent, efficient and responsible handling of knowledge is a major social challenge and thus ultimately also an individual competence. Is individual competence able to distinguish between controllable and non-controllable risk? Where is the limit of the danger threshold?

The simultaneous perception of harm, costs and benefits of technology is not uniform in society. Mostly there is no conception for the evaluation of probabilities of occurrence (otherwise nobody would play the lottery, because the probability for 6 right numbers is just under 1:14 million). The individual preconditions, which are shaped by the natural and social environment, by education and acquired ethical and political foundations, determine emotional assessments from a very different individual level of knowledge and information.

It can be said with certainty that the danger threshold was exceeded in the following three events:

- the accident at the Chernobyl nuclear power plant,
- the incident at the Fukushima Daiichi nuclear power plant, and
- the explosion of the oil rig "Deepwater Horizon",

which we would now like to discuss in more detail.

1.4 Chernobyl (26 April 1986; Explosion of Reactor 4)

A large amount of literature exists on this incident. We mainly rely on (Reason 1994), because there the technical accident sequence was extended by the human component.

The commissioning programme of a reactor also includes the experimental validation of the accident concept. The accident concept includes demonstrating that the no-load capacity of a turbine generator is sufficient to supply power to the emergency cooling system for the reactor core for a few minutes if a usable voltage generator is available. This would bridge the time until the diesel-powered backup generators are ready for use.

A voltage generator had been tested on two previous occasions but had failed due to a rapid voltage drop. On the 26 April 1986 test, the aim was to repeat the test before the reactor was due to be shut down for its annual inspection, which was imminent.

The experiment is characterized by the following chain of events:

On April 25, 1986, at 1:00 p.m., the reduction of reactor power begins with the aim of establishing the experimental conditions. The test was to be carried out at about 25% of the nominal reactor power (in the order of about 700 MW) in Unit 4. At 14:00 the emergency cooling system is disconnected from the primary circuit. At 14:05 the dispatcher from Kiev (supervisor for the power grid) orders to continue power generation of reactor 4. The emergency cooling system, which had previously been shut down, is not reconnected. At 23:10, reactor 4 is disconnected from the power grid. At 00:28, the reactor operator resumes the test. This fails to maintain reactor power, resulting in very low power. At this point the test should have been stopped given the very low power. The operator continues to attempt to control the reactor in an unknown and unstable area in order to continue the planned test, in the process the reactor exceeds the critical point. The overshoot is irreversible. The chain reaction gets out of control, at 01:24 the reactor explodes.

The chaos inside the damaged reactor under the sarcophagus and the pollution of the entire environment are unimaginable.

The main cause of the disaster is considered to be the design characteristics of the graphite-moderated nuclear reactor (type RBMK-1000; transcribed reactor Bolshoi Moshchnosti Kanalny, roughly high-power reactor), operation in an inadmissibly low power range and serious violations of applicable safety regulations by the operators during the test. The minimum value of the shutdown reactivity (reactivity is the measure of the deviation of a nuclear reactor from the critical state. The neutron multiplication factor k is the quotient of the number of neutrons produced divided by the number of neutrons absorbed and discharged. Instead of k, one often uses the "reactivity," ϱ; $\varrho = k - 1$ divided by k. The reactivity measures the deviation of the multiplication factor from 1 and therefore enters into the description of non-stationary processes. For the steady-state reactor, reactivity is $\varrho = 0$, and the neutron