1.
Risk as a key concept in TA – the problem-oriented dimension

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Early warning – the Achilles' heel of technology assessment (TA)?

The early warning function of technology assessment (TA) is seen as an essential service (Komwachs 1991; Paschen/Petermann 1992; Roßnagel 1993). It should help to recognize future technological consequences in good time, prevent negative consequences, and extend our foresight for the consequences of our actions as a whole in terms of time. Viewed as a whole, it is hoped that this will lead to more comprehensive and more preconditioned planning of technical developments, which should find expression in a higher degree of rationality in decisions.

So much for the promises, which sound plausible at first glance. Only when this program is implemented does it become clear that early warning is not an easy business in many respects; it is usually met with ingratitude and little recognition. There are several reasons for this. The error rates can be high, in which case you are sure to be ridiculed by those who follow you. But even if the person giving the warning later remains right and is able to provide solid reasons for his warning, it is the rule that his predictions are not heeded and he is hardly listened to. The fate of the Jewish prophets of the Old Testament should serve as a lesson here. Although they proclaimed God's word, who never made a secret of his intentions and his will, who never deviated from his words, who wanted nothing more than for the contract between him and his people to be kept, i.e., conditions that were clear and understandable and for which the consequences could easily be foreseen in the event of a breach (Weber 1980), even these unconditional predictions were rarely believed, and even less so the corresponding conclusions for action.

Even back then, dealing with the future seemed to be difficult. Perhaps this is the reason why the ancient wisdom teachings always linked the brightening of the future with a reintroduction of darkness in the Oracle's saying; otherwise their foresight would not have been accepted (Luhmann 1992). One need only recall King Croesus, who was threatened by the young, militarily successful Cyrus and prepared a pre-emptive strike. To back up this decision, he sought advice from the most renowned TA institution of the time: The Oracle of Delphi. This spoke clearly and unambiguously: If Croesus crossed the river Halys, he would destroy

a great empire. Croesus felt vindicated, marched off and lost his empire. He had forgotten to ask whose empire.

But all this belongs to a sunken world. Thales of Miletus, who not only predicted a solar eclipse based on an in-depth study of the movements of the stars, but also bought up all the oil presses when he expected a rich oil harvest and thus cleverly increased his wealth, comes closer to how we deal with the future. So it is no wonder that people have always been fascinated by prediction and forecasting. Reinhard Koselleck even sees this as an anthropological determinant of human action, which can be seen in the ability to distinguish between possibility and reality that is typical of humans (Koselleck 1976).

Since we have neither an Oracle of Delphi nor a genuine belief in prophets in our scientific and technological world today, we must try to grasp the future on the basis of methodical instruments. We know that early warning as a scientific and political task is recognized today as legitimate scientific business, despite the countless false predictions that have not come true (Swiss Science Council 1986).

1. The concept of early warning

Early warning has so far remained an unanalyzed term, which is essentially considered to be good because of its appeal function (Bechmann/Gloede 1991). Who would not want to be warned of possible damage in good time? In the context of technology planning and technology policy, early warning combines at least three aspects:

Time dimension

In terms of time, anticipations are made. One must be able to distinguish between past, present, and future, whereby the present is only the point from which the difference between past and future can be determined and their difference marked at all. But that is not all. We also know that much of what will be the case in future presents depends on decisions we have to make now. But since we can only make decisions when it is not yet clear what will happen, there is also a gap between the present and the future. Less and less can the past be used as a basis for orientation in the future. We must therefore perceive the future from two perspectives: As the future present, which will be as it is now, and as the present future, which is as we imagine it to be. Rationalizing this difference is the task of scientific anticipation.

Factual dimension

From a factual point of view, early warning is about determining and assessing the unintended consequences of a technology. The unsuccessful formula, or rather the political compromise formula, which is that TA has the task of assessing the opportunities and risks of a new technology, obscures the actual core of TA. The opportunities, objectives, or intended consequences of a technology have not actually been a problem up to now. They are always provided free of charge by the inventors and promoters – their effects are only seen in a positive light and underpinned by reliable data. The real problem with technology development today is the unintended side effects, which can have a counterproductive effect in relation to the desired goals. Unintended consequences can be described as a class of phenomena that are "the results of human action, but not of human design" (von Hayek 1964, p. 243). Unintended consequences are not deficient means-ends relations that could be remedied by rationalizing the use of ends and means, but are the necessary consequences of means-end rational patterns of action – according to the more recent rationality debate (Spaemann 1980). It is therefore about the non-rational preconditions of purposeful rationality. To put it bluntly, the side-effects make us aware of the fade-outs on which purposive rationality is based and relativize it to a form pattern alongside several other types of rationality.

Social dimension

From a social point of view, early recognition is about the acceptability and acceptance of knowledge. If one analyzes the term "early recognition," it has two components of meaning: A cognitive one (early recognition of problems) and a normative one (timely recognition of the developing problem situation, which calls for political action). Although mixed up in the specific case, the analytical distinction between these two functions is helpful. On the one hand, it is a problem of knowledge, the stimulation of research, more precise or even sensitive observation and the understanding of contexts. On the other hand, it is a problem of recognizing risky problem situations that are not clearly given, i.e., accepting that action must be taken without undeniably certain knowledge.

The early warning is based on a paradox that is almost impossible to resolve and repeatedly leads to heated debate. If the warning is successful, it is no longer possible to determine retrospectively whether what was warned against would have happened at all. If it is not heeded and the damage occurs, it was useless because it did not prevent anything (Clausen/Dombrowsky 1984). Recently, another problem of early warning has been pointed out. Volker von Prittwitz has

called this the disaster paradox. Using many examples, he develops the thesis that ecological and civilizational dangers and risks are often perceived politically in the opposite direction to their dangerousness. One could almost say that political action is only taken when the actual danger has passed (von Prittwitz 1993). In the following, only the anticipatory aspect of early warning will be examined.

2. The need to consider the future

There is no question that early warning is the anticipation of future events and, in the case of TA, the anticipation of unintended consequences. In general, it can be said about the structure of all attitudes toward the future that, in thinking ahead to the future, they also include visualization of the current state of affairs. Anticipation thus means the structural unity of anticipation and visualization. Georg Picht distinguished between three forms of contemplating the future, and in this way drew attention to how scientific-technical cultures visualize the future. He distinguishes between prognosis, utopia, and planning (Picht 1971, p. 13–19).

Scientific forecasts or other predictions attempt to predict what will presumably or probably occur in the future and which events seem foreseeable. Picht aptly describes forecasting as a "diagnosis of the future." Utopia, on the other hand, is the entire blueprint of the future that precedes all purposeful action. It is both an anticipation of possible alternatives to the existing situation and a critique of what has been achieved so far. These are possible overall developments in society that can and should be realized. The close interlocking of normativity and factuality distinguishes utopia from mere fiction, just as it keeps its distance from the purely empirical description of society.

Planning, in turn, is the elaborated draft for shaping the future. Planning selects one of the recognized possibilities and begins to implement the possibilities determined by utopia and prognosis into a program of action. It is analytical insofar as it uses the means-ends scheme to develop a strategy for implementing and realizing the utopia. These three basic forms in which human action can relate to the future are in turn interrelated:

> There is no prognosis without utopia; there is no utopia without prognosis. Planning mediates between utopia and prognosis; but there is neither prognosis nor utopia without planning, because every theoretical design is itself necessarily subject to planning, which presupposes its own utopia and prognosis (Picht 1971, p. 17).

This reciprocal entanglement of prognosis, utopia, and planning implies several things.

- Forecasts, utopias, but also planning are related to a context of action. They are not objective predictions of what will happen, but only of what could happen if the identified trends continue.
- Forecasts, utopias, and planning are strongly determined by expectations. They intend and articulate the desired and expected future. The future is imagined from relatively certain points of reference as a process predetermined within certain limits by the dynamic factors of the present, i.e., the future is projected and anticipated as the probable product of already existing conditions and ongoing developments in terms of their process stages.
- Forecasts and utopias, but not planning, have a warning function. A large proportion of forecasts are not expected to come true, as they only have the one purpose of pointing out undesirable developments. The analyses of the Club of Rome or the current forecasts of the population explosion essentially point to trends that need to be changed *now* or stopped in their tracks. Incidentally, this is probably also the reason for the often lamented misuse of forecasts. Because forecasts are intended as warnings, they generate appealing pressure on decision-makers, which they interpret as encouragement or as an imposition, depending on their coloration, but they always feel restricted in their freedom of choice. Forecasts create pressure to act, which is their real social secret.

In addition to the points mentioned above, the connection between forecasting, utopia, and planning also points to another fundamental aspect. From an anthropological point of view, Immanuel Kant pointed out that considering the future is a constitutive feature of human and social action. Although the future fundamentally eludes our experience, there are nevertheless predictions that can be transposed from experience into expectation with greater or lesser plausibility. This is the ability to predict, the *praevisio*.

> "To possess this faculty," says Kant, "is of more interest than any other: because it is the condition of all possible practice and ends to which man relates the use of his powers. All desire contains a (doubtful or certain) foresight of what is possible through it. Looking back on the past (remembering) only happens with the intention of making the foreseeing of the future possible: by looking around us from the standpoint of the present in general – in order to decide something or to be prepared for something" (quoted from Koselleck 1985, p. 46).

Kant points to a dilemma here. As a biologically undetermined, cosmopolitan being, man is compelled to always plan for the future for his actions in order to be able to exist. However, since the future will always remain empirically unknowable, he must anticipate it, whether accurately or not.

3. Forecast dilemma

If it is true that people are dependent on anticipating the future to the extent that they realize that their future could look very different from what they have planned, then a forecasting dilemma arises.

Hermann Lübbe (1987) has observed a loss of certainty about the future in modern society. This means that the time horizon of modern societies has shifted from the past to the future (Koselleck 1976, p. 17ff.). Not only has society's range of possibilities increased immensely, but the fact that the past no longer forms the standard of orientation for action, but rather an uncertain future, is probably of equal importance for modernity. More and more decisions in the life of the individual are taking the form of a risk calculation. In other words, decisions where it will only become clear in the future whether they were right or wrong. *Social contingency is becoming the dominant life experience* of modern man. Every action can also be carried out differently. Every social situation is constituted by a decision and is therefore, in principle, also conceivably different. The pressure to make decisions has therefore increased immensely. Even living conservatively is based on a decision, and preservation (conservare) becomes a selection process.

The divergence of experiences and expectations as a fundamental experience of modernity creates a pressure on science to alleviate precisely this discrepancy through scientifically guided analysis and forecasting. The loss of certainty of expectation with regard to the future creates a need for compensation. In the field of estimating and evaluating new technologies, this problem is further exacerbated by two factors.

Especially in areas where purposeful rational action and planning is practiced in its purest form – in science and technology – one becomes aware that every action has its side effects and, far more importantly, begins to counteract the effect of the intended action.

Karl Popper emphatically pointed out that motives and purposes of action on the one hand and structures and institutions on the other must be strictly distinguished. This is because the intention and results of an action rarely coincide, as only a minority of social institutions are consciously planned, while the vast majority of institutions simply grow as an unintended result of human action (Popper 1972).

Side effects occur all the more frequently the more long-term and holistic the planning of action is, as it becomes difficult or impossible to disentangle causes and effects with the increase in complexity in factual, temporal, and social terms. Long-term projects in particular are subject to the constantly accompany-

ing phenomenon of unplanned planning, which constantly forces revisions and improvisation due to unexpected and unintended repercussions.

The innovation cycle in the field of technology development has accelerated, with the speed of development and innovation values increasing. More and more new products and technical systems are being created or improved. Systems are becoming more complex and their diverse effects more complicated. Both of these factors mean that surprises are inevitable and there is a compulsion to constantly adapt to new developments.

Borchardt (1979) has derived a forecasting dilemma from this, in which he shows that the demand for forecasts increases in turbulent times, while at the same time the conditions for a reliable forecast deteriorate, as new experiences and old expectations fall apart.

> Forecasting is relatively easy when nothing changes and there is therefore little demand for forecasts, because the constancy of the course of events does not remain hidden. When forecasts are in great demand, the forecasters usually have no strong certainty either (Borchardt 1979, p. 8).

What are the consequences of this dilemma for the validity of the forecast?

The philosophy of science attempts to counter this problem with a restrictive concept of prediction: Predictions are scientifically substantiated statements about previously unknown, real, or possible facts that can be derived within the framework of a scientific theory from known statements of law and statements about initial and boundary conditions of the process to be predicted with the help of a logical conclusion (Stegmüller 1966). This structural identity of explanation and prediction is only plausible if prediction is used to verify statements of law (Lenk 1972). However, since this is already hardly possible in the natural sciences, it is probably even less possible to make exact forecasts in the field of technology assessment. On the contrary, forecasts are not aimed at explanation, but are a call to action. Their need arises from the political and social utilization contexts. They should be action-oriented. However, a different concept of prognosis must then be found.

4. Forms of prognosis

Assuming that forecasts are *not* a prediction of future developments, but an analysis of *possible* futures from the point of view of the present, they provide us with information about what developments could be expected if the changes

in the influence variable structure observed in the past continue with the same consistency.

According to Knapp (1978), explanatory forecasts should be distinguished from so-called "inexact" forecasts. Explanatory forecasts have long been the subject of scientific-theoretical discussions, whereby forecasts in this context are understood as statements that can be derived from laws and boundary conditions in a purely logical manner. In the case of TA, this type of forecast is likely to play a minor role, as the necessary legal knowledge will rarely be available. Forecasts are characterized by two features: Their statements are statements of expectation, and the expectation preferences expressed in them must be justified. If this justification cannot be made on the basis of legal knowledge, one will have to fall back on trend forecasts and expert forecasts (Helmer/Rescher 1959). In both cases, an attempt is made to describe the basic structure of a change, and the direction and the speed of changes as tendencies and inherent possibilities. In addition, a well-founded assessment of a particular development is required, which then results in the preference of one future extrapolation over possible other extrapolations.

Empirically meaningful statements can only be made if the most important parameters are fixed over a defined period of time. A special form of this so-called coordinated forecast is the action-dependent or action-related forecast. Here, the occurrence of the predicted states and events is made dependent on particular actions of the forecaster or other persons, so that the actor has defined possibilities to influence the realization of the prediction, i.e., to bring about the conditions. The decisive question and thus the central problem of prognostics is how probable a given prognosis – wherever it may come from – is in absolute terms or in comparison to alternative prognoses, and whether the empirical basis presented for its empirical-inductive justification can be regarded as sufficient according to intersubjective criteria and requirements. Additional difficulties arise in the field of social sciences and in particular in the area of the interdependencies between technological development and social change, as there is only a limited amount of theoretical knowledge and well-founded empirical data available. In contrast to the economic sciences, where there is agreement on the concept of national accounts, no valid measurement and classification system for technological progress has yet been developed. Each analysis works with its own concept and definitions.

Furthermore, it has not yet been possible to isolate the effects of technological developments – e.g., on labor market conditions, qualification, and economic structures – from other influences such as economic cycles or the influence of

global economic development. So far, only relatively arbitrary attributions exist. The development of early indicators for impact chains that can indicate the diffusion of technical development with a certain degree of reliability is encountering great difficulties.

The issue here is the link with innovation research, which describes what is technically possible or has already been developed, but cannot indicate which innovations will spread in what way, at what speed, and in what space. It is even more difficult when it comes to forecasting changes in values or organizational changes: Futurology, which used to be conducted with great enthusiasm, no longer seems to be in vogue.

So if it is not possible to make precise statements about possible consequences or side effects of technical innovations, TA analysts should commit themselves to developing structural analyses and theoretical knowledge that can then guide the impact analysis, whereby it is initially important to identify bottlenecks, important development trends, or contradictory patterns of action. An important task thus arises in the continuous observation and analysis of technical and social change, whereby an attempt should be made to link explorative forecasts with empirically sound assumptions.

Kern and Schumann (1985) have introduced the term "bandwidth determination" for this purpose:

> We can thus characterize our method of prediction in summary as theoretically guided and empirically supported bandwidth determination. "Theoretically guided" because we refer to a theory of capitalist development that is based on the distinction between logic and forms of rationalization and contains certain assumptions about the change of form [...]. "Empirically supported" because we use empirical means to prove that the old forms are beginning to be replaced by new concepts of production. The concept of "bandwidth" is intended to define fields and boundaries within which the development can be expected (Kern/Schumann 1985, p. 378).

Thus, in a purely logical sense, forecasts of the indicative type are dispensed with, and one restricts oneself to naming danger points and limits of development. However, this is an opportunity to obtain empirically sound statements without having to submit to the constraints of a deductive forecast.

The model forecast can be distinguished from the trend forecast. In a model forecast, several mutually influencing variables are examined simultaneously with the relationships between them. The compilation of the relevant variables that can be found by a theoretical concept and the relationship between them is called a model. With the help of this model, which can be made increasingly complex as long as enough data and theoretical assumptions are fed in, an attempt is made

to simulate possible consequences of complex relationships, possible bottleneck developments, and perhaps also possible consequences of human intervention.

> In this context, the scenario technique is also used more frequently. A scenario encompasses a qualitative (verbal) representation of a future situation and the development path that leads to this situation, and in this respect can be regarded as the qualitative counterpart to the quantitative model (Steinmüller 1993, p. 21).

5. The importance of prognosis in TA investigations

In the context of TA studies, the forecast has different tasks. On the one hand, it can serve to make explicit the prerequisites for decisions where there is no shared consensus. Every decision about technologies has a future reference. A decision for or against a technology is at the same time always an examination of alternative possibilities in the future. With the help of forecasts, the premises on which the decision-making process is based can be made clear and an objective discourse can be conducted on the basis of the predicted developments. Particularly in decision-making situations where the traditional consensus on the essential goals and values has been broken, legitimacy can only be generated through the persuasive power of a systematic approach. However, we must not ignore the fact that any gains in greater transparency achieved must come at the price of increased social complexity. Forecasts and their comparisons can increase the potential for conflict due to the pluralistic diversity of opinions and interests, and the decision alternatives can quickly grow into an immense number (Frederichs/Hartmann 1992).

Secondly, forecasts are not statements of fact, but statements of probability, which means that the basis for decision-making is partly fictitious. Niklas Luhmann (1992) pointed out this aspect:

> Under modern conditions, it is practically only possible to talk about the future in the mode of the probable or improbable, i.e., in the mode of a fictitiously secured reality (duplicated by fictions). We therefore know that the future present will be different from what the present future expresses, and it is precisely this discrepancy that is expressed by only discussing probabilities or improbabilities when it comes to the future. Whoever claims to be certain exposes himself to deconstruction in any case and can only expect support from fellow believers (Luhmann 1992, p. 187).

Luhmann thus alludes to one of the main problems of the discourse on new technologies and their effects. It is always about assessing future conditions and developments. However, even with a high level of scientific expertise, there is no a priori certain basis for this on which a broad and future-proof consensus can be

reached. Agreement can only be reached on a situational basis on the assumption that the preconditions for agreement can be revised at any time. This could be called the probabilistic aspect of prognosis.

Thirdly, forecasts can be used to learn how the time horizon of action itself changes. In TA studies in particular, we often find that the further into the future the study extends, the more likely it is that unforeseen consequences will outweigh the recognizable ones. And there is something else. The unpredictability threshold of the future is now moving closer to the present. Known ignorance, i.e., the knowledge of gaps in knowledge, is increasing to the extent that it is already appearing on the horizon of decision-making. This can be visualized using the example of the current energy-environment problem. It is a decision-making problem with different time horizons in three phases.

Firstly, it concerns our direct dependence on oil, which we must reduce in order to avoid political blackmail and to bring about an international balance of payments. This is likely to take a period of ten years. Secondly, the prospect of depleting gas and oil reserves, a problem that will have to be solved within a generation or so. Thirdly, the combined problem of the depletion of fossil fuels in general and the impact of their combustion on the climate. The time span of this third problem is about a century. In terms of knowledge, different degrees of certainty are evident here with regard to the facts and possible connections. The horizon for action has increased immensely, which no longer corresponds to certain knowledge at the level of action. As a paradoxical effect, this dilemma is exacerbated by the increased ability of science to generate an almost infinite amount of perception and knowledge. The expansion of new laboratory technologies and measurement methods increases our ability to detect and assess even the smallest direct and indirect effects of our actions.

Fourthly, however, it can be said that forecasting is a scientific and not a political instrument. Although forecasts are repeatedly used in political disputes, they are a neutral procedure. They are characterized by a methodical approach and the explication of their assumptions. They are hypothetical and undogmatic. They can be revised at any time and are argumentative, provided their conditional form is not concealed.

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