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ETHICS AND ENGINEERING – AN ANALYTICAL APPROACH[1]

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Abstract

After short historical remarks, a general structure of an ethic theory is proposed, encompassing principles, values, priority rules between such values, basic norms, rules and rights up to customs and rules of good conduct. It is shown that every concrete moral, derived from an ethic theory may include conflicts between norms or values. Particularly such conflicts are known in the force field between technological requirements and basic norms. A principle that may help to resolve such conflicts is presented. It is expressed as the principle of conservation of the conditions for responsible behaviour. Some applications for engineering ethics are given.

Keywords: ethics, engineering ethics, technology, moral conflicts, conservation of conditions, responsible behaviour.

1. Introduction

Moral issues in technology have always been discussed. So Thukydides is reporting about the blaming of soldier as coward using iron swords instead of the old bronze weapons. Since during the battle an iron sword would not broke anymore, thus they prevent the opportunity for the soldier to show his quality and virtue of braveness in the fight man against man without weapons. This former critique against a new technology has made use from an obvious moral argument.

After the atomic bomb 1945 the moral turn in discussing about science and scientists diffused to the area of engineering in the early 70ies when the reach of modern technology became obvious by the first civil applications of nuclear energy, computers, world wide communication up to the genetic and fertilisation

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technologies in our days. Thinking about technology becomes more and more moral laden and the rise of the concept of responsibility began after the disseminating book 'Principle Responsibility' by Hans JONAS [17], [18].

After the 80ies a lot of ethical codes of conducts has been passed by scientific and engineering professional associations, collecting a set of convictions that reflected the experience of a possible non-controllable technological development and the necessity to check and balance the economic and environmental interest with better arguments. Nevertheless, these ethic code of conducts were designed not very systematically; there was an emphatic sound to hear suspecting everywhere immoral interest and not legitimated structures of power.

Therefore, a more rational foundation of such guidelines and moral conviction are wanted and it remains the task for experts in Ethics and Philosophy to look for plausible arguments how to find, to found, to justify and to deduce moral statements concerning technology and engineering practices.

So we may have some sufficient reasons to reflect about ethics when being Engineer:

- World has become more complex due to technology. Therefore, it has become difficult to integrate comprehensively the world of awareness (Merkwelt) and world of impacts (Wirkwelt, cf. K.O. APEL [1]).
- The interaction between social and technological systems has become subject of scientific investigation since 30 years. Result: In shaping technology, this interactions cannot be neglected anymore
- Due to the complexity of technologically driven economy and society, new forms of moral conflicts will arise on professional working level.
- Responsibility has become a central term – but who is responsible individually for a collective decision?
- New orientation and new vocational trainings for engineers are necessary. This includes ethical issues as well as political ones.
- The new technologies have a tendency to become more universal due to digitalisation and 'biologisation'. This is widening the scope of potential future possibilities never faced before.
- Religious, ethnic, cultural and traditional value systems will continue to lose their binding force due to globalisation. The pluralism in ethics has become unavoidable. Thus, helps and guidelines are necessary for orientation.

2. General Structure of an Ethical Theory

There have been many attempts in the history of Ethics to conceptualise an ethical theory as a kind of a calculus. The similitude of the aimed structure of a rational ethic theory with systems of axioms in non-complete logical calculi is stunning. Removing one axiom, the logical calculus is underestimated. Adding a further axiom that cannot be derived from the already present ones it is possible without

causing any contradiction. In some calculi such an adding creates a complete calculus.

Otherwise it cannot be expected that ethics will be able to be designed as a complete calculus that is free from contradictions, too. Nevertheless, there have been many efforts in the history of Philosophy. So B. Spinoza has brought up the idea of an *ethica more geometrico,* whereas geometry was a contemporary paradigm for a mature, deductive and throughout formal science which would allow to conclude everything if the premises are known and certain. Even G. W. LEIBNIZ,[1] J. LOCKE,[2] I. KANT,[3] and others have looked forward for such approaches. These approaches may be useful as kind of guidelines if one wants to deal with ethics rationally.

Whereas an ethical theory as a comprehensive building of coherent convictions, principles, values and normative statements is not erected axiomatically, a concrete moral may be built up by the observed convergence of conviction people have with overwhelming majority. This empirical approach does not suspend the task, to ground, to justify and to deduce such convictions as moral statements from more general ethical principles and well-defined values. This way to an erection of an ethic theory allows mapping the different arguments, contradictions, differences and so on, occurring in ethical discourse. Thus the presentation of a general structure of an ethical theory fulfils two tasks. First, there is an educational purpose: a general structure allows to show on which level the different moral statements are made, it facilitates teaching ethics and it allows to find easier where conflicts and controversies take place. Second, the consequences of altering or substituting one of the leading principles or values can be demonstrated very quickly.

On the other hand, a general structure of an ethic theory is not equivalent with a general ethics itself. So it is not the aim to write down ethics that should be valid to deduce a moral for all cases and all times. I. Kant was convinced that there exist a universal moral law that can be recognised by man.[4] Today we believe rather in a pluralism of values in ethics, but the search for a principle that may give support to deduce moral statements and judgements in concrete cases, has not stopped until now.

In the meanwhile a lot of so called partial or area ethics has been designed and discussed. This is presumably due to the considerable pressure of decisions that have to be made in this extremely fast developing fields like science, engineering, medical health. This article is written by the conviction, that so called area-ethics are not genuine ethics in themselves but different expressions of a general ethic theory that has been modified and adapted for different purposes and application fields. Therefore, environmental ethics should not differ in principle from an ethic

[1] Cf. G. W. LEIBNIZ: Noveaux Essays (IV 12, 8).

[2] Cf. J. LOCKE: Essay IV (IV 3, 18 and 20; IV 4, 7 and 9, IV 12, 8

[3] I. KANT: Critique of Pure Reason (Kritik der reinen Vernunft) (KdRV B 508/A 480) and Critique of Practical Reason (Kritik der Praktischen Vernunft) (A 45, 167); cf. also HÖSLE (1990, pp. 123 f.) [14].

[4] I. KANT: Foundations for the Metaphysics of Morals (Grundlegung zur Metaphysik der Sitten), GMS, BA 50, Vol. VII. (1991, p. 50), [19].

in medicine and an engineering ethics should be regarded as a specified application of such a general ethics with a structure that is common to all particular ethics.

The deeper reason for this conviction relies to the fact, that there is a tremendous consent in basic values in nearby each culture, nation and religion. The essential difference between them lies in the priority relations between the values: For a journalist the value of truth has another range in a set of values than for a politician or a manager. Both believe in the content of the value 'truth', but in conflicting situation they will pond them differently. The same may hold for the priority rule in different religions.

In order to show how this shift of priorities will generate an altered set of normative statements, the following structure will be useful.

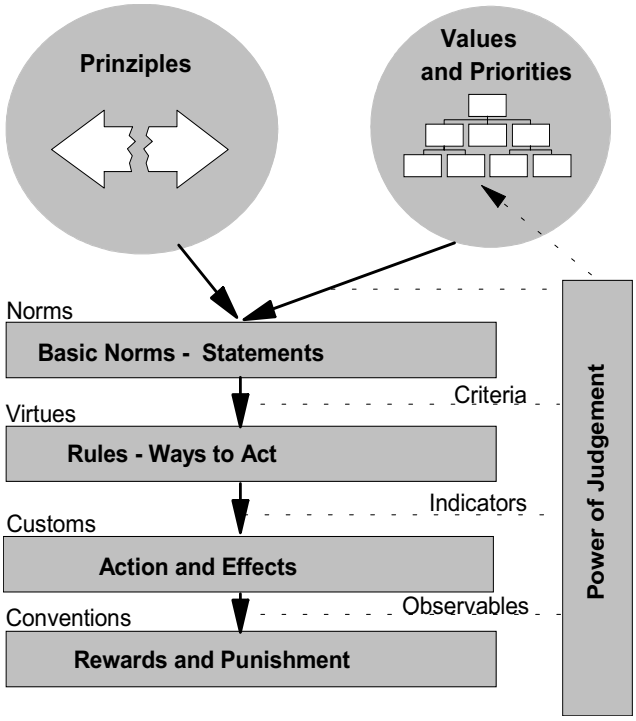

Fig. 1. General Structure of an Ethical Theory. Explanations cf. text below.

Fig. 1 indicates that it should be possible in principle, to generate a concrete moral system by this scheme by 'plugging in' certain values and principles. If one makes a choice for a certain principle and a selected set of values, specifying them with defined priority relations normative statements (prescriptive statements like 'it is obliged', 'it is allowed' etc.) can be formulated. Each legal law for instants represents such a normal statement, too. Using the human power of judgement ('Urteilskraft' according to I. KANT), should it be possible to derive rules for ac-

tion and prescriptions for ways or types of behaviour.[5] At last but not least, correct conduct, customs and usual type of symbolic laden behaviour like rituals could be grounded in such a scheme. Institutions must be able to execute sanctions; i.e. reward and punishment (in a very general sense), otherwise each ethics, forming a concrete moral, remains teeth less. The whole structure is entangled into institutional structures. Institutions like organisations, authorities, firms, communities are incorporating norms; moreover they do represent norms. Without these respective values, institutions could not exist – a finding, already made by Max WEBER [41].

Principles can be regarded as trials to provide theoretical concepts that cover ethical and moral experience. They offer a possibility to classify such experiences. Mostly they contain a procedural part with which one is enabled to judge actions and decisions according to the respective moral.

The arrows in *Fig. 1* indicate the direction of deductive argumentation often applied for didactical use. In practical terms the starting point will be the other way around – a scenario, a concrete situation that is characterized by an n-fold alternative (n options) to decide. According to the situation the different levels in the structure showed in *Fig. 1* may be used to answer the question of KANT: 'What we have to do?'[6]

2.1. Principles

There different principles have been developed during the history of Ethics. It is not necessary to list them all here. The different principle may be inserted within the scheme in *Fig. 1* like 'plug ins' in order to test their consequences. Nevertheless, it should point out that they could not be selected completely independent from a given value set and its priority relations. Moreover, it can be shown that there exist some relations between the different principles. The one principle is more compatible with a primordial value than another one. So the Greatest Happiness Principle if St. Mill' s Utilitarianism prefers welfare and happiness as a guiding value. The Golden Rule[7] corresponds more or less to the value to avoid harm, the Principle that Man is part of Nature as an ecological paradigm prefers more or less the life conditions on the whole earth as prior to individual or economic interests. The Categorical Imperative by Kant can be regarded as a control procedure, whether the own way

[5] A historical condensation of such ways of action, conduct and behaviour can be found within the discussion of the virtues, e.g. by Aristotle: Ethica Nikomachica.

[6] The second famous basic question, posed in: I. KANT: Critique of Pure Reason (Kritik der Reinen Vernunft), KdRV A 805/B 833, (1788), [20]. It is easy to see that the different directions within the scheme in *Fig. 1* (arrows) when making conclusions must not lead necessarily to the same result.

[7] Already put forward by Kong Fu TSE (CONFUCIUS): 'Do not do to others that you would not have done to yourself' (cf. SPIER [39], p. 17), it may be found also in Islamic Sunna Writings: 'None of you truly has faith if he does not desire for his brother what he desires for himself'. Cited according to Encyclopaedia for Applied Ethics; cf. SHEPERD, [38], p. 737).

could be apt to a general law for everybody in all cases, and as a generalisation of the Golden Rule. With respect to the principle to conserve the conditions for a responsible behaviour, it has been shown that it is a generalisation of Kant' s Categorical Imperative. Other principles have been offered like the pragmatic view of D. Mieth, that problem solvers should not generate greater problems by solving the simpler ones.[8] It is obvious that in the field of practical moral one is inclined to select such principles that are more adapted to a regional, local area of problems like genetics, information and communication technology, waste management and so on. Since there are relations between the principles, a transformation between the respective resulting norms should be possible. Sometimes it is possible to show, that with different principles and different value systems a nonempty set of equivalent normative statements can be produced. This explains why we have so many discussions about principles and values whereas in everyday practice most people would agree to a basic set of normative statements without hesitation.

2.2. Value Systems

In everyday life we make decisions by preferring or rejecting goods or options. This represents an evaluation of these goods and options according to values. M. SCHELER has proposed such a system of values, classified according to circles of aesthetics, religion, everyday experience, community etc.[9]

Whenever an exploration of values could be performed empirically, e.g. by inquiries or by analysing basic texts of cultures, religions, communities, constitutions and so on, one can find that the values are quite constant and stable over a great range of history, cultures and religions, but the grounding ideas are different and moreover the priority relations show considerable variations dependent from time, culture and religion.[10] This is what we call value change (Wertewandel) and which can be observed immediately when regarding the globalisation process.

For the sake of evaluation of technology the German Association of Engineers (VDI) has proposed a list of possible values, and a discussion about the conflicts between these values has taken place. The VDI has not proposed any priority relation but it has recommend to start a discussion about evaluation of technology with this catalogue of values, trying to establish the adapt priority rules that expresses

[8] Firstly received as an oral communication, Tübingen 1991. Cf. also WILS, MIETH [44].

[9] M. SCHELER [36] Distinguished between the value classes of the pleasant, of the nobility, of the beauty, of rights and, of the epistemology of truth, and of the holy. Scheler put forward a certain apriorism of the emotionality. According to Scheler, the hierarchical order imposed on the set of value can be reckoned a priori (cf. SCHELER [36], Vol. 2, p. 10).

[10] Formally, a relation of preferences or priorities can be seen as a well-defined order on a set of discrete values. This view excludes conflicts between values. As a model a hierarchical graph could serve. The work of KÜNG [26], [27] and KÜNG, KUSCHEL [28] that has investigated such a value system shows that the priority relation differs from religion to religion, but the set of values and their respective meaning seem to be comparable to a wide extent.

the moral world view of the evaluator. This would allow making the discussion more transparent. The values are (in alphabetical order to avoid any suggestions): Development of Individual Life Quality, Ecological Quality, Health, Safety, Societal Quality, Technological Performance, Welfare (economy, macro-level), Welfare (individual, micro-level).[11]

The conflict relations between the values are corresponding to the non-decided situations with respect to the priority relations. It should be noted here very clearly that it might be happen that for each priority relation that is applied the situation may lead to unacceptable consequences. This we call a moral dilemma.

It is a misunderstanding, even within the field of practical application, that conflicts could be removed by means of rational ethics in any cases. Here are rules how to solve such kinds of conflicts to a certain extent, WERHANE [43], LENK [30]. but conflicts represents rather a constitutive element of an ethic than an evil that has to be avoided at any price. Such a certain non-consequentialism[12] should be possible.

Catalogues of values can be extended,[13] either for the purpose of clarification or in order to remove or attenuate conflict relations among them, but when skipping only one value from the VDI – Octagon of values, a comprehensive evaluation of technology does not work anymore (RAPP [34])[14]

2.3. Basic Norms

Norms,[15] expressed in normative statements, are rules of conducting to aim at unified and valid behaviour in a societal group or community, or in society at all that defines expectance of behaviour and rules of action with respect to certain values. When an individual or a group violate norms a community must have the

[11] Cf. The recommendation Nr. 3780 of the German Association of Engineers (Verein Deutscher Ingenieure VDI); VDI [40]. To avoid any misinterpretations: The authors of this recommendation put emphasis that the eight values and their interpretation are representing a proposal, not an obligation. Nevertheless, to remove one value from this octagon will produce a deficit when evaluating technology with the help of them. For the discussion around this recommendations cf. also RAPP [34].

[12] HUBIG [16], [15] has introduced the term 'non-consequentialism'. To confess it honestly, I am very sympathetic with this term.

[13] For instance with the values stability, error friendliness, introduced by von E. U. von WEIZSÄCKER [42]. Cf. KORNWACHS [21].

[14] Cf. KORNWACHS, NIEMEIER ([25], p. 1560, *Table 17*). Value catalogues are very sensible against any removal of one or more values – they will loose their utility. Beside there is a stunning similarity with non-complete axiom systems in logics. To remove one axiom from the catalogue that defines a calculus makes the calculus 'underdetermined', but it is possible to add further axioms (not derivable from the other axioms by definition) without producing contradictions.

[15] We should distinguish between moral norms expressing values and technical 'norms' as technical standards like Deutsche Industrie Norm (DIN) that provides rules for producing products, regularities for procedures definitions for key terms in technology.

possibility to apply reward and punishment regulations.[16]

Normative statements include 'it is allowed that …' or 'it is forbidden that …', or 'it is an obligation that …'. Having a deontological character, they urge us to certain actions whereas values define aims or goals of action.[17] A given set of norms of a concrete community tells us something about the social world in which the members of such a community live. Norms, uttered by a subject or prescribed by an institution do relate more to real world than values, and they have a more forcing obligatory character.

As examples for moral norms the well-known Ten Commands in the Book Exodus may serve. As an example of legal norms the well-known laws may be taken. Whereas legal norms are only valid for a certain time and area, the validity of moral norms is conceived to be invariant from individuals and institutions uttering them. Since there is a great convergence of values between the cultures and religions, a certain convergence of acceptance of basic norms should be observed. (Cf. KÜNG [27]).

GERT [10] has proposed a certain modern Decalogue. It is easy to show that these norms express values explicitly and that most of us would agree if one neglects the order of this commands as a priority order: '1. Don't kill. 2. Don't cause pain. 3. Don't make anybody disable. 4. Don't reduce freedom and opportunities. 5. Don't cut any rights. Don't steal. 7. Keep your promises. 8. No frauds and trickery. 9. Behave according to laws. 10. Fulfil your duties'. The relevant values can be mapped: '1. Live; 2. Free from Harm; 3. Quality of Personal Life; 4. Liberty; 5. Respect of Personal Rights; 6. Respect of Property; 7. Reliability and Stability; 8. Trust; 9. Stability; 10. Trust and Reliability'.

2.4. Rules and Rights

Basic rights, as defined in modern western constitutions, are related to the human rights very closely. They define rights that in everybody has right to live not because of being a member of a community or society but due to the fact being a man. This cannot be founded without any recourse to natural right ideas. This idea presupposes a definition of the nature of man. It is possible of course that basic rights (including right to opposite, refer to consciousness) may collide with the positivistic view of law, according to that laws has to be obeyed without limitation – *pacta sunt servanda*[18].

It is not the place here to discuss all the distinctions between several types of basic and human rights. (Cf. KORNWACHS [22].) The important point with respect to ethics in the field of engineering – and elsewhere – whether there are intangible rights at all and whether they may collide with some technical and organizational

[16] Ranging from a warning up to the execution of an individual.

[17] As an example: The normative statement sounds: You should not kill. The relevant value can be found as being alive. Life is a personal good.

[18] Contracts have to be fulfilled at any case (cf. CICERO, De Officiis 3, 12).

systems that require a delimitation of basic rights for the sake of safety or stability. Nobody would delimit human rights, freedom of thoughts, consciousness, religion and speech, the personal liberties, political rights and economic rights without necessity and on a lawful basis, but the question rises whether modern technology forces us to delimit such rights due to their organisational structure (like safety issues with material flow of Plutonium), the possibility of abuse (like harmful chemical and biological materials applied for purpose of terrorism) or due to the duty to rid of effects and consequences of modern technology like climatic change, flood, acid rain etc. This is not only a problem for the politician but it starts to begin a problem for the engineer as the shaper of technology and therefore shaper of conditions of our every day life.

3. Conflicts

3.1. Moral Judgement

The field of basic conflicts comes into focus here. A moral judgment of such conflicts is running along a matching procedure that can easily be shown with respect to our scheme in *Fig. 1*. Each concrete situation of decision or planned action as well as scheduled actions can be evaluated with respect to the commensurability the deducibility from the justification and the foundation with the Principles, the Values ordered by priorities and, if they are not known, by the present norms.

If we only look for intentions of act and judge them morally, the result would lead to an Intentional Ethics or ethics by Consciousness (Gesinnungsethik). Evaluating the rules of actions, according to which decisions and actions has been performed or planned; one would speak of a Principle Ruled Ethics (Prinzipienethik). If one evaluates an action itself, a more law-oriented ethics (Ethics of Laws and Rights) would be the result. Looking at the effect of actions (and thoughts), their consequences and side effect, Teleological Ethics will result. All these kinds of ethic respective evaluation procedure have advantages and disadvantages and it is a nice exercise in course of applied and theoretical ethic to discuss cases of individual behaviour in the light of the different ethic types. It has become clear that all these special views may solve some cases and other ones do not and vice versa. This leads to the development of an Ethics of Responsibility, which tries to avoid the particular obstacles.

There are some reasons for this. A pure Teleological Ethic cannot exclude the violation of human rights (e.g. in thinkable extreme cases of terrorism) and Principle Rules Ethics disregards the non-anticipated or not acceptable side effects (e.g. in case of so called ‘crusades’ or wars for liberty). If one accepts that respecting the moral conviction of an individual as well as the freedom of his consciousness are very important values to protect, one must accept that there is a plurality in ethics that cannot be dismissed anymore. So the conditions to speak freely about ethics, to negotiate norms in a society and to debate principles and values in a discourse free

from pressure and power constraints should be regarded or at least as a value itself. This value is considered to ensure the condition for the possibility to establish a rational ethics at all.[19] So one to has leave the idea of a universal moral that is valid at any time and any places without any conditions for all men. On the other hand, the task of moral judgement has become a duty for everyone and this task must be find forms, for instance mediated by a philosophically free debate about engineering ethics among engineers, technicians and users of technology.

3.2. Some Contemporary Confusion

Particular engineers and people dealing with ethics in this field – to avoid the term engineering ethic as a partial ethics – could face some disappointments in this field.

First, as it already has been stated, the ethical theory looks like a calculus with principle as axioms, defined values as forming rules and a semantic defined by the validity of derived norms (whether they are morally true or not). But it is looking only like that; the power of deduction cannot be applied without modification of moral arguments. Even the use of deontic logic as a modified modal logic does not provide us with the material definition of values and the priority rules must be set, they are not derivable from principles, but can only be supported by additional meta-rules (see below).

Second, using the scheme in *Fig. 1*, sometimes a different 'plug-ins' of principles, values, and varied priority relations may lead to same or similar normative statements. Mostly the debate about ethics in engineering runs on the level of a concrete moral, i.e. on the level of normative statements.

Third, there is a great consent about values and normative statements, but not about priorities. But conflicts are mostly generated by different priorities between values and not by differences about values at themselves. So everyone may agree to a value defined code of ethical conduct – in case of a conflict priorities must be decided in order to solve it.

Fourth, the most different opinions may be found in the field of concrete rules, the ways to act, the actual assessment of impacts, risks or side effects and their acceptability and in the field of ascribing responsibility on an individual or collective level.

Thus the experience is predominant that there is no concrete moral (i.e. an ethic laden with concrete 'plug-ins') that can avoid moral conflicts.

3.3. Types of Conflicts

The best-known conflicts are very general and they can be characterized as conflicts between values. So the problem is known what kind of (real or truth) needs should

[19] Cf. HÖSLE [14], APEL [1], HABERMAS [12], [13] as most prominent authors dealing with the so-called transcendental pragmatic foundation of ethics.

be more important, the common goods or the private consumption. Protective measures to ensure safety may run against liberty rights and flexibility, the use of natural resources goods as economical goods may run into conflict with environment as an exhaustible resource, individual health is in conflict with general welfare, the individual 'right for fun' may collide with social duties.

Conflicts between value priority systems are represented by the questions like: Economy prior to ecology or vice versa? Would be preferred firstly the image, than the justice; or firstly the company' s interest, then legal concern? Conflicts between norms can be shown in the field where health and healing affects problems of human dignity like cloning and the use of generative cells from embryos. The problem of triage: who comes first when applying help with limited capacity in man made catastrophe like war, accidents and so on? Even the question of justice of distribution of goods, opportunities and chances will raise conflicts on the level of norms.[20]

The most obvious conflicts have been recognised as conflicts between interests that may be justified themselves by the role the proponents play. The difficult relations between producer, supplier, provider, user, client, and purchaser respectively show the multitude of these spectra, but these kind of conflicts cannot be reduced simply to conflict between norms or values. The conflicts between interests can be modelled by game theory where the gain of the one is the loss of the other. So it may be reflected whether it is morally meaningful, to generate or to induce such antagonistic situations. If there are rules how to play the game, this may be helpful to ritualise and to solve interest conflicts like in democratic politics or in civil codes. Nevertheless there are situations in which such rules are not valid anymore or there are no existing rules at all like in fighting terrorism versus the deliberation of a nation or a group from the siege of unbelievers.

First of all, non-solved or badly solved conflicts will produce further conflicts. One of the starting points of conflicts can be figured out to the unclear priorities between high-level values. This may be regarded as a deficit of conducting power inhuman society as in firms, institutions and groups as well. Another possibility that may be excluded here is the willingly producing of dilemmatic situation in order to reduce the options of another person.

[20] ZOGLAUER [45], p. 30, [46], [47] made the point that conflicts between moral norms on the one hand and between values on the other hand show the same logical structure. Each conflict with respect to values can be reformulated as a conflict with respect to norms. Norms are institutional facts as J. R. SEARLE [37] has pointed out. The distinction between institutional and natural facts has been exemplified by K. POPPER [33], Vol. I, pp. 70–71: One is not able to draw more coins from a bourse than the number of coins is really within (natural fact), but it is possible to overdraw the bank account, presupposed there has been negotiations before (institutional fact). – Each conflict between norms disables to conclude rules for actions. Such a conflict could be considered as a menace or limitation of rational arguments in ethics. In much situation such conflicts are solvable, e.g. by readjusting priority rules or meta-rules, but there is no guarantee for any cases by principle.

3.4. Force Fields

But there might be other causes of conflicts. We must face that in highly differentiated societies with a high-level of division of work, competence and mobility into different cultures, there do exist different cultural fields (or moral fields), applied to the same time with the requirement to be respected by one and the same person. These different fields are not only mediated by different religions (like Christian or Islamic cultural area) but also by a cross over of role specific value priorities in professional live.

Thus an engineer may be confronted by two requirements that he has to regard at the same time. The economic issue on the one hand and the safety issue on the other hand give rise to a portfolio (cf. *Fig. 2*) where he is forced at least to define where the line of attractiveness may lie.

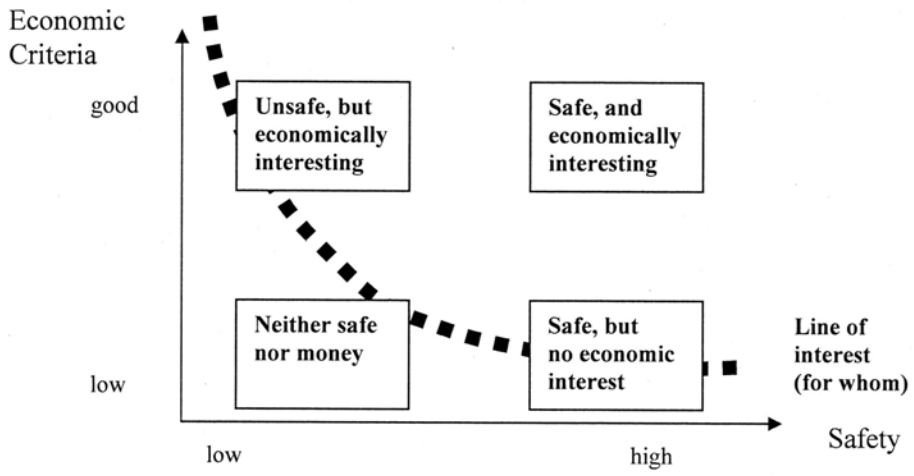

Fig. 2. Force Field Portfolio between economic and safety issues. The line of interest must be defined by each individual, which is involved responsibly according to his preference of values.

Very similar portfolio may be drawn for the conflict between the necessity of well-based and expensive knowledge and the urge that is pressed by the term ‘time to market’ when developing new products and technologies. Thus the line of interest or attractiveness of acquiring the necessary knowledge (for whom?) may run along the field ‘stupid and too late’, ‘well-grounded and sophisticated, but too late’, ‘quick and dirty’, and ‘well-grounded and just in time’, Again the cost function will discriminate this fields.

One could comprehend this kind of conflicts also by the ‘Different Hat Approach’. This approach covers the experience that the young engineer Roger

Boisjoly had to make in 1986, when warning about technical malfunction of details shortly before the launch of the space shuttle Challenger. A manager of NASA said him: 'Take off your engineering hat and take on your management hat'.[21] So he was urged to shift his role responsibility from safety thinking to thinking in terms of corporate identity and success at any price.

There may be different hats and many situations in which one is urged to substitute the one hat for another one like the professional hat, the engineering hat, the management hat, the religious hat, the ethnic hat, the cultural hat, and the individual hat. A combinatorial set of such relations may classify a lot of conflicts happening in the engineers' world!

4. Technology and Ethics

4.1. Ethics to Whom it May Concern?

Ethics as a philosophical discipline may help to develop the moral self-understanding and reflection of men. With respect to the task of engineers who are not professionally dealing with ethics, its history and logical structure and so on, any efforts in moral thinking should provide to him means and rules to solve moral problems like conflicts, meaningful interpretation and judgements.

4.2. Responsibility

The rise of the term responsibility in ethical debate since the late 70ies has brought up a precision about what engineers may feel or be made responsible. Responsibility has been defined in accordance to some ideas of Roman Right: Somebody has to respond to questions before a court (the instance), about what he (the subject) has done (object) by free will and free choice. Here we have already all constituents for responsibility: The free subject, acting and generating effects, consequences and impacts to a certain extent (object and reach), is responsible before an instance (this may be a boss, a court, the husband, the children, the nation, the history or God) and with respect to a moral judgement of this action the individual or a group of persons or an institution may be subject of sanctions, rewards or punishment, forced to compensate or make a damage minimal (liability).

In the modern society mostly the instance that executes sanctions is not the same that the preferred instance of responsibility. In a highly divided world of working, with distinguished competences and formal responsibilities, a diffusion of responsibility can be observed: frequently decision is made by groups, committees and institutions, not by single individuals and the compliance of the firms allows

[21] As reported in: Der Ingenieur – Held oder Netzbeschmutzer. In: DER SPIEGEL Spezial (1999, Heft 1, S. 41–43.)

them to prove that they have obeyed all relevant formal rules. This diffusion of responsibility is a very trickery problem not only for courts and parliaments but also for developers of new products and technology, since a product like a car is never developed by a single individual. Even 'the management' does not consist only of the company' s president but encompasses a lot of people in different levels on hierarchy of such an enterprise.

In well known cases (e.g. DOWIE [9], MACCORMAC [31], [32]) where 'the management' has not only been made responsible by moral judgment, say for a certain way of thinking strictly in economic terms, but engineers and managers have been astonished by the fact that they have become responsible and liable with respect to law in front of a court and that they were sentenced to jail.

The most astonishing in these cases is that engineers are astonished to become lawfully responsible for what they are doing. They believed that the technological mean they create to facilitate life and to ensure economic success would be morally neutral. They believed for long time that it is only the individual user who decides whether he uses a technical artefact in a good or bad way. But the situation has changed dramatically due to the new technological possibilities: a nuclear weapon is no more a neutral thing that can be let to the 'user' for free application or it is the case with TV stations, World Wide Web, genetic products, medical care technology and so on.

The conflicts have been turned to be conflicts in responsibility. The value born conflicts between safety and economy are now becoming a conflict: who is responsible for damages that have been caused by a non-hesitated and eager economic and profit oriented thinking? Are these their shareholders, the management, the engineers or the clients pressing prizes by selecting extremely their purchase behaviour? Who is responsible for the shortcuts and obstacles of ecological policy? Are they the politicians, the entrepreneurs thinking in old terms, the engineers, not being able to be innovative in a non-classical field like alternative energy technology or the citizen not able to change his consumers habits and not ready to pay more for environmental issues but taxes? Is there a responsibility has not been cleared before the complicated relation between interests of an enterprise and individual interests, between responsibility *in officium* and universal morally responsibility?

4.3. Resolving Conflicts

Despite having recognized that ethical dilemma are unavoidable, the contemporary ethic research has looked for means how to weaken or remove such conflicts when they can be described as a moral dilemma.

One of the possibilities is offered in some principles that rule the conflict between different laws concerning he same case. So, *lex superior derogat legi inferiori*, (the law on a higher level is considered to be prior to a law on a lower level), *lex specialis derogat legi generali* (the more specified law is applied prior to general laws), *lex posterior derogat legi priori* (the law that has been announced at

least will supersede the law announced before).

Another possibility is to change the meaning of relevant values or to add new values on the value system. Of course the priority relation is the most prominent issue: A change of these relations in terms of an informed consent will resolve most of the problems, but not all of them. Sometimes only disambiguating unclear priorities would help. This presupposes an open discourse at least.

In severe cases, one could apply so called meta-rules. Universal moral responsibility should supersede particular responsibilities *in officium* (or role responsibilities). The problem is here to define clearly what a universal moral responsibility does mean. Is there a universal moral law as Kant stated? If there is one who does not believe in such kind of law, the universal moral responsibility must be defined in another way. Introduced by H. LENK [29], 1993), one could argue that the instances for sanction and "response" are on a higher level than for role responsibility – a consciousness and a moral conviction is here a more primordial instance than the boss of a company.

Another meta-rule has been given by WERHANE [43] and LENK [30]: Moral rights of individuals should be preferred against utility issues. And, additionally: 'Public welfare should be prior to particular individual interests as far as they are not of moral nature'.

4.4. The Particular Case of Technology

All what is said up to now is valid in a general ethic debate and is related to everybody's moral live. Insofar every engineer is encompassed and one could argue that a good and well-formulated moral should be sufficient for an engineer even to cope with problems seemingly caused by his professional role.

We have therefore to show that Ethics for Engineers is not only a pragmatic formulation of moral issues easy understandable for the hurrying up practioneer in everyday practical life, but also a very wicked problem dealing with the structure of technological knowledge.

In normal life (and even in a philosophical theory of action) one is used to explain, why an individual has act in a certain way. Since Peter knows that he can reach Amsterdam only by train tonight, and I know that Peter has successfully tried to reach this train, I can conclude that Peter wanted to go to Amsterdam. This figure is called the practical syllogism.

An engineer is proceeding a little bit the other way around: if he knows, that $A \rightarrow B$ due to some causal relations, and he wants to put B into practice, he will try to apply the rule B per A. This I called the pragmatic syllogism.

The decisive difference between the usual theories of action is, that the rule B per A can be applied without knowing $A \rightarrow B$. The statement is not explaining why a subject has done A, but it gives a possibility to apply knowledge $A \rightarrow B$ (causal relation) by transforming it into a rule (mean goal relation). This transformation is not a deduction in a logical sense – knowledge is not founding logically the rule,

only by a practical commitment. This pragmatic statement (as even the practical syllogism) is not derivable in a modal deontic calculus, only the negative forms (cf. KORNWACHS [23]). Moreover the rule expresses a normative statement: If *B* is wanted (as a goal, according to a value defining it); *A* must be done (technical ought).

Responsibility relates not only to the action *A* but also for the selection of *B* and for the certainty and quality of the knowledge $A \rightarrow B$, or, if this knowledge is not available, for the effectiveness of the rule *B* per *A*. This makes things more complicated than in everyday life action.

As an ideal case, doing *A* will have the (reliable) effect *B*. In real life *A* causes the intended effect *B* to a certain probability *p* (say in %) and some side-effects, say *B'*, that could be known or unknown, wanted or not wanted, foreseenable or not foreseenable. For example the development of a vaccination and its application may cause not foreseenable harms. Another example is the well-known discussion about the long-range perils of nuclear waste management.

These side effects can be classified according the following scheme

Table 1. Scheme for classifying side effects

	Intended	Not intended	
Side Effect *B'*		Foreseeable	Not foreseeable
Wanted	Over-Engineering Marketing Effects	Synergies	Positive surprise
Not wanted	'Crime'	Slippery Slope Argument	Technology Assessment

Looking on this scheme one can ask: What is the object of responsibility? The application of the rule *B* per *A* as an action of an individual and all the consequences of this application, including the unforeseenable side effects and the probability of occurrence of *B* and the side effects? This has raised the question whether probabilities could be moralised (ROPOHL [35]).

On might show, that the intended side-effects will occur with a certain probability, but for the unforeseenable side-effects, no probability can be estimated. Surprise remains a surprise. Nobody can tell us something reliable about the geological behaviour of the same waste deposits over a range of 2000 years.

The main problem of Technology Assessment lies in the fact that the not wanted and not known surprising side effects can be guessed hardly by forecast, only by some intuitions or feelings. In a public discourse about technology, the uttering of fears and bad perspective may lead to a more anxious mood where not acceptable effects are presumed more frequently than in other discourses. So the idea of moratorium has launched: Let us wait with possible dangerous technologies until we know more about their side effects. Unfortunately, a lot of technologies

have started to be applied without such knowledge like civil and military use of nuclear energy, release of genetic manipulated organism, installation of large scale systems without the possibility to draw the plug-in out like the World Wide Web, the warning systems for space and flight control or the world wide electronic capital exchange system.

If there are unacceptable side-effects of doing A that can be foreseen, this could lead to the so called slippery slope argument: if we do A that may be itself not morally wrong, we could start a process which will lead us to an unacceptable side-effect B. Therefore, we have to postpone the action A (Cf. BURG, V. van der [7]). The current synonyms for this type of arguments are the snowball-effect or any domino theory.

The real dilemma starts, when an omitting of A that produces unacceptable side effects B', will cause another damage, let's say C that may be caused by the privation of the originally intended effect B. Thus, under the actual conditions a substitution of nuclear energy by alternative forms of energy providing like sun or bio-energy may be become very expensive. As an effect of this substitution a lack of energy supply and economic breakdown have been guessed. Therefore to end the nuclear energy, let's say to omit A in order to avoid accidents like Chernobyl (B') would produce another harm, i.e. a breakdown of economy.

This example is really sketched, very simplified in order to show the structure of the dilemma. Mostly the difficulty lies in the estimation of B' and C, and this estimation cannot avoid the own interests, fears and concrete moral of the person or institution, performing this estimation. Therefore, it is necessary to include moral arguments in order to make the discourse about technology and rational choice more transparent.

5. The Principle of Conservation of the Possibility of Responsible Behaviour

5.1. Plurality and Many Value Principles

Therefore, we have to cope the situation that is no single, primordial value, under which all other values could be subsumed, ordered or deduced. It is possible that different values may have the same range such that priority is not unique – one of the most frequent causes for conflicts. Moreover, the priority relation (hierarchical order) as well as the values and their semantic interpretation can be subject of chance in time – even for an individual during his biography.

The most important issue is here the fact that there are values in one moral context (say culture, religion, country, company whatsoever) that may not be considered as a value in another one and vice versa. So, the human rights have not the same range in China as in Western World, life protection and individual health are typical values of western culture but not in some others and a person when being teenager is thinking in other terms of values than in his adult times.

Taking this serious, it should be possible to understand the moral judgement

of somebody in a concrete case if one knows his values and priorities, principles and norms. It should be possible to make translations between different morals with respect to the judgment of the same case. This does not mean that one should accept the value choice of the other subject under all circumstances but it helps to understand why a person has acted in such and such ways.

In other word: the first step to get a presupposition for a conflict resolving discourse is given by the trial to present the respective other moral in terms of own moral. Here the differences become clearer.

If one believes that the possibility to act in a responsible way is a constituent of human dignity and a good life, than we should enable us mutually to act in a responsible way. Therefore, we must concede to everybody that he is trying to be morally in the sense that he or she is trying to act in a responsible way according to his or her actual moral system. This leads us to a principle that may enable us to come to common set of norms, acceptable by a wide range of different moral cultures or contexts invariantly from limited changes of value systems.

5.2. Conditions of Responsible Behaviour

To clarify the principle it is necessary to look for the conditions of responsible behaviour. For this we remind to the constituting issues of the concept of responsibility above. So we have to ensure the free choice of options or we have to ensure that options do really exist. We have to ensure that the person in question can be subject of responsibility by ensuring free will and conscious mind. There must be a clear definition of the object of responsibility. Whether a firm or an engineer as a single individual is responsible for unforeseenable side effects or not, is not clearly discussed. Here must be an instance and it must be able to execute sanctions up to liability or punishment. The time horizon for effects of action should be in the range of human scale.

5.3. The Principle PCRB

We can now formulate the principle we propose for further discussion in the field of engineering and ethics: Act in such a way that the condition of the possibilities for responsible behaviour be conserved for all individuals involved (KORNWACHS [21], [22]).

The principle has been presented in German literature elsewhere, but there are some consequences of the principle that are relevant to engineering field. The Principle of Conservation the Conditions of Responsible Behaviour (PCRB) is only practicable with respecting the fact of plurality of values as indicated below. We have to concede that ‘the other’ is judging his thoughts, actions and effects in terms of his own moral systems with the respective values. In conflict ‘the other’ will judge my actions and produce effects in his moral terms firstly, and so do I. The

respective moral system of 'the other', the existence and applicability thereof is necessary for his moral existence. So I have to recognise it by translating in my own terms. This is considered to be a duty – I have to 'understand' the moral system of 'the other'. Of course this duty should be considered to be mutual. As a direct result the requirement of tolerance and the impossibility of intolerance can be deduced. Nevertheless, mutual understanding and tolerance does not mean that we have to accept or to nostrificate the moral choice of the other. But we must accept that he has the right and the duty to make a moral choice consciously and act according to it.

Thus it would be against the principle to let run somebody in a moral dilemma where he is no more able to act morally, since every option he has, will lead to mortal unacceptable results.

5.4. Engineering Issues of PCRB

We can now apply the PCRB to the particular case of the pragmatic syllogism. To do this, we check the conditions for responsible behaviour according to the component of the pragmatic syllogism, schown in *Table 2*.

Table 2. The pragmatic syllogism and he conditions for responsibility

Conditions for Responsibility	Knowledge $A \rightarrow B$ B per A	Aims and Goals (Will) B!	Action A	Effect B and $p_{\%}(B)$	Side-Effect B' and $p_{\%}(B')$
Free choice	Free research, Options	Discourse	No force to perform A		
Subject of R.	Who is in charge of something? Duty to know	Reflect about B, if B' and $p_{\%}(B')$ is known	Individual or collective	Producers Liability	Liability by principle of causation
Object of R.	Reliability of A→B > B per A Duty to estimate $p_{\%}$ (B)	Responsibility for choice of B	Action	Can probability be moralized?	Responsible for surprise?
Instance	Science and Engineering Community	Market, boss, individual consciousness	The embedding organisation	All persons who are involved	All persons who could be involved
Time horizon	Validity of actual knowledge longer than v. of technology	Planning time, decision time, time to act, long term effects	Time range of action itself (e.g. inter-generation projects)	Long term effects. Sustainability problem	Sustainability, Moratorium, Deceleration
Sanctions	No? Technical norms. Ethic codex	Not on a legal level	Institutions (legal, social, moral)	Polluters pay principle, causers principle	Not clear

Most parts of the table may be self-explaining, but some comments should be given here.

The requirement of free choice with respect to the necessary knowledge leads to the condition of free research without force of premature application on the one side of theoretical knowledge, and on the other side of practical or technological knowledge there should be always the possibility to have options A' or A'' in order to put B into practice. In other worlds: there should be not only free research but also 'free design'. A discourse about goals and aims (B!) should be possible and there should not be a technological ought to be forced to do A.

The subject of responsibility is in charge to acquire the necessary theoretical and practical knowledge; there is a 'Duty to Know'. The subject of responsibility has to reflect about the goals and the possible outcomes if B' and the probability of its success, say $p_{\%}(B')$ is known. The action A may be done by an individual or by a collective – but a satisfying theory about institutional or collective responsibility has not yet developed.

The object of responsibility is not simply to determine. An engineer is in charge to check the reliability of knowledge $A \rightarrow B$ (if known) and at any case the technological rule B per A. He has the duty to estimate the probabilities p if possible and he or his company or another institution are responsible for the choice of the goal B. Of course he is responsible for performing the action A, but it remains highly questionable whether he can be made responsible for surprising effects. It has been argued (GRUNWALD [11], ROPOHL [35], BANSE [2]) that probability cannot be moralized. On the other hand, technology assessment has developed some methods to get rid with the surprise. Since there is no possibility to estimate probabilities of possibilities that are known, one can sketch so called development paths of technology. Let us see what could be happen if a development will run fast, normal or slowly. Without estimating probability one obtains a list of fields of possible impacts than may give some hints for surprising developments. Of course this method is not sufficient and it does not remove uncertainty at all, but it widens the scope at least and it should be a duty to perform such methods.

The instances for engineering actions are manifold: Science and Engineering Community plays the role of audience for knowledge applied, markets, bosses up to the individual consciousness may 'control' the decision for or adapting of a certain goal, the embedding organisation up to the cultural context (moral field) may be relevant for the concrete action A and an engineer should respect all persons who are involved in the effect of his action as an instance for his responsibility. Concerning side effects and surprises, the problem is present whether all persons, who could be involved, now and in future, should be considered as instance. Here we have the question of responsibility toward future generations. The answers run from no obligation argument up to the position that we are obliged to inform future generations about the possible long term effects of our nowadays or planned technology.[22]

[22]This issue has been discussed in BERNDES, KORNWACHS [4, 5], BERNDES [3], and KORNWACHS, [24].

Related to this point very closely the specific time horizon must be taken into account. The validity of actual knowledge may run longer than the validity of actual technology. Nevertheless, one has to consider that there is always a certain half time of validity of knowledge. To define a goal and to look for means in order to reach the goal, it takes time. This planning time has to be distinguished from decision time, from the time to do the action A, and from the time horizon of short term and long-term effects. The time range of action itself may be long, takes for instance projects longing over generations like swamp or forest cultivation, building cathedrals or dams. Mostly the long-term effects are the not wanted side effects. This affects the sustainability problem and how to handle it: should we support a moratorium if we are not sure whether there will be not wanted side effects endangering the ecological basis of human life? Should we decelerate the technological development when we got the impression that the change will running faster than the development of means to cope it?

The possibility of sanctions has also to be discussed. With respect of knowledge, even scientific knowledge, there is no sanction possible beside the cases of fabrication, manipulation, plagiarism and fraud. But violating technical norm (like defined by industrial norms and standards) could be subject of very hard sanctions, also the violation of safety rules. What we wanted is hardly the subject of moral judgement, whereas values are driving our choice as discussed below. Therefore, one should emphasize this point very clearly: The choice of goals or the acceptance and adapting of them is an act for which an engineer is responsible if he is free to do so. But, in most cases he has to accept goals given by the institution he has joined to work with. Therefore, in this case an ethic codex for engineers may be helpful in order to protect an engineer if he tries to solve a conflict between his values and the values of the enterprise when morally judging the goals in question. Even in such cases it is important for the enterprise to enable responsible behaviour of the individual encountered with it and it is important for an engineer to understand the values and aims of an enterprise in terms of his own moral system. If he recognizes that he cannot solve the conflict, he should be free to leave the enterprise without sanctions and the loss of job possibilities.[23]

On the other hand, the resulting damage of a certain action should be compensated or attenuated by the responsible actor. Thus the Polluters Pay Principle in Ecology as a concretisation of the Causer' s Principle that has gained a broad acceptance. But it is still unclear who can be made liable for surprising effects that may lead to disaster or catastrophes. The question mostly is posed around the problem, how surprising the side-effect may really has been for the causer, doing A, leading to B'.

[23] This problem has become well known as the Whistleblower Problem; cf. SPIER ([39], p. 25. ff.).

6. Outlook

The discussion about the conflicts in engineering field concerning ethics and moral has lead us to the ethical principle to conserve the conditions of the possibility of responsible behaviour. Whereas we believe that this principle is a very general one, it may be applied also in engineering fields. Here we have found that some interesting norms can be obtained. These findings are invariant from a chosen value system and its priorities (where the most differences could be found).

- One of these norms is discussed as the duty to know, see below.
- A further norm is the duty to hand on knowledge (in form of understandable information) to future generations about the long term effects of nowadays and planned technologies
- Another requirement is to act in such way that moral dilemma can be avoided in advance. When respecting the PCRB and the plurality of value systems as discussed below, we may use the resolving power of PCRB, providing the procedure of discourse with the duty of mutual translation of the respective moral system.
- Since most of us runs into moral dilemma since we are not heroes to solve them, the shaping tasks in engineering, technology and society should be to facilitate non-heroic solution when dealing with technology and organisations.

On this basis an Ethic Codex has been proposed.[24] The role of an Ethic Codex in a legal, professional and political context can be summarized as follows: The target group contains professionals within defined area of working (e.g. engineers or managers) with strong power of shaping living conditions and therefore with high responsibility standard requirements. The effect lies in an orientation in moral and ethical questions for decision support, not in a substitution or automatisation of it. Member's support in moral problem solving and a certain protection by their professional association is intended primarily.

It is expected that such a code ensures a self-binding and self-obligation by accepting such a codex. It may influence and give an impact on public opinion and public moral discussion. There is an important legal effect when court judgement is forced to be oriented according to the 'state of the art' in a respective discipline. A codex supports a permanent conscious foundation for moral judgement in professional life by accompanying the codex with background writings and seminars. Certain orientation pressure for technology politics is not excluded.

Further investigation of the consequences and impacts of the proposed PCRB is surely necessary. It remains the conviction of the author that there is no particular engineering ethics necessary but a widening and improving of our well-known ethics due to changed world.

[24] The Ethic Code of Association of German Engineers (VDI) has been discussed in 1998–2000 by the Committee for Technology and Philosophy, Subgroup Engineer and Responsibility. First Proposal to VDI was made in March 2000, for interior discussion. Final Edition is expected Summer 2002, (published, translated and representing then a legal part of the members contract)

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