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THE RELIABILITY PHILOSOPHICAL ASPECTS OF COMPLEX TECHNICAL SYSTEMS

J. Z. CZAJGUCKI
Gdynia Maritime University
Faculty of Marine Engineering
Departament of Engineering Basic Sciences
e-mail: jzczaj@am.gdynia.pl

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Abstract: *This paper contains selected philosophical categories and notions which constitute standpoints on the reliability of complex technical systems. At first attention is given to the notion of reliability and philosophical categories connected with reliability, and among them to three of them which constitute the highest ethical and aesthetical values. Three philosophical notions have been distinguished which are related to the considered reliability, namely: first, the so called entire standpoint on reliability, as particularly essential for activities in favour of reliability, second, the probabilistic conception of reality chosen due to the nature of reliability, and third, the transcendental comprehension of cognition – as less appreciated but worth presenting on account of the particular means and effect of cognition. The paper ends with conclusions from the performed considerations.*

1. INTRODUCTION

"Everything is attainable except perfection".
Plato

The aim of this paper is to formulate relations between philosophical categories and reliability of complex technical systems.
Philosophical literature is mainly quoted – this results from the chosen subject. However, it should be noted that many discussed problems are reflected in science. K. Jaspers: *"Philosophy as knowledge is consideration. Science is a methodical cognition"*[1]. By so delimiting philosophy and science the following question should be put: what philosophy offers to science? In the answer to the question we have simultaneously the answer: what does the paper add to the science of reliability? The quotation taken from [2] may serve as an answer: *"About how certain ideas, and even certain metaphysical feelings can inspire scientific research, said Einstein: it is certain that some conviction akin to religious feelings, concerning rationality or conceivability of the universe appears behind every important scientific work"*.
The content of this paper mainly deals with the study of reliability of technical systems; but methods of action in this field are only accentuated by quoting examples from literature.

2. THE NOTION OF RELIABILITY

Reliability is a feature (propriety, property) of a defined object e.g. man, machine, technical system.
The predicates of reliability are the terms describing it, such as working connections, functioning accuracy, certitude of realizing purposes.
Reliability measures are the mathematical expressions containing mathematical and physical quantities which help to measure reliability of an object on the grounds of the estimated measure values.
The argument of reliability is the independent variable of the reliability measure. A variable physical quantity may be an argument.
A set of features (properties, proprieties, parameters, characters) distinguishing the object and process occurring in it and its surroundings are called **conditions of action or functioning of the object**.
The awareness of the predicate, of the measure and argument of reliability, and of the conditions in which the object operates or functions is connected with the definition of an object reliability.
Our considerations of reliability concern **complex technical systems** i.e. such systems which consist of many elements and have a complicated functional

structure. They are for example: power plants, production plants, ships, aircrafts, locomotives, cars, computers, research equipment. These systems will be called in short, technical systems.

The reliability of each technical system may be defined as follows: the reliability $R_s(t)$ of a technical system is called probability P (measure) of its correct functioning – not damaging $\overline{U}$ (predicate) during a definite time (argument) in definite conditions {w} hence

$$R_s(t) = \left(P\left\{\overline{U}(0,t]\right\}\right)_{\{w\}} \quad (1)$$

It may be said that such an understanding of reliability, which has been expressed in this point constitutes a synthesis of reliability notions given in literature, among others in [3] and in the papers quoted therein.

3. SELECTED PHILOSOPHICAL CATEGORIES AND RELIABILITY

According to W. Tatarkiewicz [4] the highest values are: **good**, **truth** and **beauty**. *"They have been mentioned altogether by Plato and since then have subsisted in european thought"* [4].

In our considerations **good** is understood in the meaning of value as the result of man action. Man can do good in regard to himself, to another man, to society and to the products of his work and nature.

Good has not been strictly defined. *"The known sayings about good, that it is, »what is desired«, »what satisfies«, »what deserves approbation«, »what is better than ill«, are not good definitions, they at most lead to the meaning of the word; however without a perfect definition we know how to understand good and ill"* [5].

What is the conceptual relation of reliability to good? We can say that the creation and utilization of reliable technical systems means to do good in regard to man – user, not only, but in regard to the sphere surroundings the utilized system – in regard to people, other technical objects and nature. If technical systems are reliable in the broad meaning of this word, they can be not only surely utilized but they don't either constitute a danger for their surroundings, mainly for people and natural surroundings.

Truth is associated with the cognition of reality. The cognition of the reliability of technical system is a part of this cognition. To do good, it is indispensable to know a definite reality.

One of the varieties of beauty distinguished by J. W. Goethe is **perfection** [4]. Perfection is conceived as the highest degree of positive features [6]. We may say that the pursuit of a high (appropriate to needs) reliability of technical systems is one of the expressions of the pursuit of perfection, hence in this understanding such a pursuit is a beautiful thing. Beautiful is not only the result arrived at – reliable systems, but also what they serve and they can serve particularly the cognition of beauty in its various forms. For example the faultless television broadcast of the concert given by J. Carreras, P. Domingo and L. Pavarotti, permitted to know the beauty of the voice of three famous tenors not only to the people present at the concert.

Efficiency – in praxeology, according to T. Kotarbiñski [7] *"is a general name of each of practical values; and so precision is a kind of efficiency and so is effect as well as simplicity etc. Efficiency synthetically understood is the whole of these values taken together: in this understanding we act the more efficiently the nearer our action is getting all the values of good work and this at the highest level"*. In this paper the notion of efficiency is understood as in praxeology. One of the values of good work is reliability. To do well means also to act efficiently so that reliability of technical systems among others might be adequately high.

If we admit that these three distinguished values are essential to the progress of civilisation, then our proceeding in the field of reliability of technical systems should involve tendency toward these values.

4. SOME PHILOSOPHICAL VIEWS AND ACTIVITIES IN FAVOUR OF RELIABILITY

How should we act so that technical systems possessed the required reliability when being utilized? We will try to answer this question through philosophical opinions about actions in general. We shall first have in mind the four rules given by R. Descartes concerning the methods of acting and given in his discourse on method [8]. Here they are: *"1)... never to accept as true any thing that has not been recognised as such ..., 2)... to divide each of the examined problems into so many parts as possible and necessary to their best solutions, 3)... to compose our thoughts from the simplest and most accessible to cognition and ascend step by step to the knowledge of more compound objects, 4)... to carry out everywhere so entire calculations and so common surveys as to be sure that nothing has been neglected"*.

What is the required reliability of technical systems? The answer to this question is to be found in [3] and concerns the engine room of a ship. We will generalise its contents for every technical system. The **required reliability** of a technical system is called value of this reliability in a definite moment and results from rational needs among which we mainly range the need to fulfill definite functions by a system, the need to ensure safety in a broad meaning and the need to efficiently exploit a system.

We can distinguish three macroscale processes where action in favour of reliability of technical systems should occur, namely: **valuation, creation** and **exploitation,** which in turn are divided into composing processes.

Valuation concerns social needs and the postulated required reliability of technical systems is to be found there.

Creation of technical systems having the required reliability is: investigating, designing and producing.

Exploitation is understood as the utilization, maintenance and liquidation of technical systems.

As we have mentioned in the introduction three philosophical views have been distinguished which will be the basis to define more precisely actions in the above mentioned macroprocesses in favour of technical systems. These are:

1) **integral**, contemporaneously systemic point of view of reality,
2) **probabilistic** treatment of reality,
3) **transcendental** conception of cognition.

Here are some thoughts of philosophers expressing the above views. For **1)**, W Tatarkiewicz: *"In Aristotle's thoughts the problem of system, i.e. of relation and order of a whole is connected with the problem of (conceptual) content, aim and beginning of this whole; it suffices that they be defined and thereby the system is also defined"* [9]. As to J.M. Bocheñski:

"a system is its elements and order expressed by the relation between elements" [10]. Concerning **2)**, M. Hempoliñski states: *"contemporary empirism quits the traditional ideal of absolute certainty and is satisfied with the achievement of probabilistic knowledge in the field of learning about facts"* [11]. As to **3)**, J.M. Bocheñski on Kant's philosophy concerning the so-called **transcendental idealism**: *"up to now, cognition was considered as a certain absorption of reality in oneself, and since then, as Kant teaches, by cognizing we must understand creation of reality. That is why, to distinguish his idealism from theories, which mix the object with the cognition act, Kant called it »transcendental«. Since then by idealism we shall understand in general not the ontological idealism of Plato or St Thomas but theoretical idealism, i.e. the doctrine according to which cognition is creative"* [12].

In the first place we deal with the **integral point of view of reality** (of course only with its fragment concerning reliability of considered systems).

The **valuation** of social needs is met by a branch of philosophy called axiology – the science of values. Here are some thoughts from this branch of philosophy. J.M. Bocheñski: *"Aristotle is the first author of the scientific doctrine which, like many others, has lasted to now. Here is its main frame. The aim of every human activity is "eudaemonia" – happiness, as we desire everything to attain happiness ... and so the greatest happiness cannot be the possibility but the act itself, which is for man the action i.e. perfect action. However only virtue makes perfection possible, and virtue is simply the disposition to efficient execution of acts"* [12]. We can note here the concurrence of Aristotle's and Kotarbiñki's opinions on human activities. According to Aristotle's [12] *"the essence of happiness consists in doing what is beautiful and good, in devoting everything to this act and such an act is, in a certain manner, scientific contemplation"*. The essence of this philosophy is to tend to the three highest values mentioned above. The next quotation is from Bocheñski [12] – *"The ethics of St Augustine is eudaemonistic: the aim of man is happiness and man will reach it by uniting with God,... and union can be attained by doing the good"*. As in Aristotle doing the good is the higher feature of man's activity. St Thomas holds the same ethics as St Augustine [12]. In his philosophy we find the notion of fitness which interests us: *"Virtue itself is a fitness acquired through work, which tends to an easy and agreeable accomplishing of a certain type of actions. It is done only through training, though various people have various aptitudes for each groups of virtues"*. From this quotation we see that fitness must be shaped in action. Kant's maxim: *"Behave so that humanity, in your or another person never be a mean but a target* [12]*"*. In my opinion this maxim may become one of the essential elements of the valuing bases of social needs.

Elements of the valuing process of technique in connection with social needs are given among others in [13,14].

From the above quoted thoughts it results that the good and fitness, truth and beauty contained in it are the attributes of happiness and perfection. We see also that all these categories are interdependent. Hence we may say that they constitute a **system of values.**

We might propose such a proceeding: to adopt a defined system of values and next to appraise the social needs according to this system. Postulating the required reliability of technical systems which is contained, as we have mentioned, in the valuations of social needs, would also contain the accepted system of values.

Let's now characterise the **creation** of technical systems. In order of precedence we shall do that with reference to research , designing and production.

When we consider **research** on reliability of technical systems and connections with this reliability, as a whole then the parts of this whole are as follows:

a) project research by computer of reliability relations (project simulation of reliability by computer), whose main aim is to estimate the requested reliabilities of elements,

b) service research (observations) whose aim is to estimate the reliability of elements in real conditions,

c) model research (experimental: laboratory, positional, by computer, analog and hybrid) whose aim is to define the reliability of elements in simulated conditions,

d) physical and chemical research on processes causing damages of elements in real and simulated conditions, comprising also the shaping of reliability of elements, so that they had the requested (designed)

reliability values, by examining the influence of various features (e.g. material, shape, load, strain, strength, surrounding) on the damages to elements,
e) investigations of man's reliability as element of the anthropotechnical systems,
f) research on the influence of unreliable (possessing unsatisfactory reliability) technical systems on the surrounding: men, technical objects, nature and changes in the natural surrounding on the life of living beings, due to this influence.
The investigations described in the presented work [3] are an example of the research conducted in a). In a similar way, as shown in this paper, such a kind of investigation can be carried out in each technical system.
Investigations b) mentioned above are quite commonly carried out. The ways of carrying them are described in many items of literature concerning reliability, among others in [3].
In turn investigation c) mentioned above have a similar aims as in b) – determination of reliability of elements but in different conditions. In both cases the realisation of elements life in defined conditions are registered. However investigations mentioned in d) constitute a development of investigations c). Examples of investigations c) and d) are given among others in [3].
Investigations mentioned in e) – man reliability are the most difficult and very important at the same time, as most damages of technical systems are caused by man unreliability. These investigations are an integral part of research on man's brain, described among others in [15,16], and on man in anthropotechnical system, among others in [17].
Investigations f) mentioned above come within ecologic research mainly and are described among others in [18,19].
The **designing** of technical systems constitutes also a certain whole. In this understanding designing should be extended to the designing of functioning, construction, technology of production and process of eksploitation (utilisation (including a constant diagnosing), maintenance (here also periodic diagnosing, prophylactics change of elements, repairs) and liquidation) of technical systems. In the object meaning designing is not limited to only technical systems, but also includes the relations of these systems to man – operator (user) and to the farther surroundings: people, other technical objects and nature. Hence, we have to deal with designing of technical systems as parts of anthropotechnical and socioecotechnical systems. The designing of technical systems should be done due to their determined features and also to reliability. The last reliability aspect of designing in the systemic conception is given in [3,20,21,22]. The systemic approach of the designing process of technical objects is presented, and particularly from the point of view of praxeology, in [23].
In **production** – as the third phase of creating technical systems, we have to deal with reliability of producing objects and with quality of produced systems – connected with reliability. Besides, we have to deal with reactions between production objects and man, between people, surroundings objects and nature – due to unreliability of man and producing objects.
The same occurs in the **exploitation** of technical systems; we have here also to deal with the reliability of these systems associated to the action between these systems and elements of the nearer and farther surroundings. In this process there occurs a verification of the phases of creating technical systems.
Recapitulating the above, actions in favour of reliability of technical systems in the processes of: valuing, investigating, designing, producing and exploitation, form a determined whole that we can name **system of actions** in favour of reliability of technical systems.
The successive point of view concerning the reliability of considered systems is **the probabilistic treating of reality** [7,8,11,24,25,26]. In so treating the reality we may distinguish two approaches: 1) the probabilistic way of expressing knowledge about reality and 2) the probabilistic conception of reality. In the first case the knowledge about facts is presented with the help of probabilistic mathematical apparatus. In the second, however it is said that reality is probabilistic. But how is it in fact? We don't know. How do these views stand to reliability – as a feature that we designate? The order of things is as follows: certain (often defined, but not always precisely) physical and chemical processes occurring in determined objects functioning in certain (sometimes defined) external conditions, cause determined (recognised) events – damages of elements. It occurs in defined periods of time called realisations of elements life. Basing on the knowledge of these realisations the reliability of elements is estimated. Such events are expressed in a probabilistic way, because very often we are not able to precisely define the causes (namely physical and chemical processes in mathematical way) of the damages of elements. Due to this the probabilistic expression which becomes
a formal description of reliability is justified. If reality was probabilistic then the probabilistic description of reliability by itself would be justified. We may suppose, according to the newest achievements in physics, as those presented in [27], that reality is defined but not entirely known to us. J. Werle says: *"It is a fact, that we have not arrived to a full knowledge of nature and we know only a sequence of better and better approaches"* [28]. The description of a certain fragment of reality accepted as deterministic often constitutes (we may say almost always) only an approach to the description of this fragment.
Recapitulating the above consideration we may conclude that reliability is a probabilistic feature of

technical systems, but not only, and of man too. In other words this means that reliability is conceived probabilistically and all models of reliability are probabilistic models. If a model of reliability is considered deterministically, then in the above understanding, this model is one of the possible models.

We shall now discuss the **transcendental notion of cognition**. Cognition is an unusually complex process which is not recognised to the end. Much time has been devoted to this complex process, by philosophy too – by epistemology, a philosophical science about the essence and the limits of cognition [2,11,12, 24,26,29,30]. Our point of view, so far as cognition is concerned, is transcendental and only in Kant's understanding as, so called **transcendental idealism** – mentioned above [2,11,12,29,30]. This set of thoughts tends to create ideal patterns – models of defined objects independently of empiric knowledge. Such a creation is a mental process which gives special attention to not precisely known but entirely confirmed processes occurring in our subconsciousness which we understand as *"higher neural action, resulting directly from biologic ground, precisely from neurophysiological conditions existing in our brains"* – J. Tr¹bka [16]. How such a mental idealisation may be utilised in a broadly understood activity in favour of reliability of technical systems? The meaning of creating ideal patterns – reliability models of considered systems is that practical actions can be directed toward approaching these ideals. For example in the process of designing technical systems with reference to their required reliability, an ideal model of reliability of these systems, as quoted in [3] is created, assuming the equality of reliability of elements which occur in series structures. In this model there are no so called weak links in series structures. Tending to such an ideal is a rational action. In each action in favour of reliability in macroprocess distinguished earlier (in valuing, producing and exploitation) and in processes contained in them, there can occur a need of mental creation of ideal models being patterns, which reality shaped by ourselves, can be referred to. The essence of this creation, in a transcendental meaning, inheres in the fact that, as we have mentioned, this creation occurs also beyond our consciousness – in our subconsciousness which we incite to create through consciousness by conscious search of an ideal. It might be useful to quote here two further fragments of [16] concerning subconsciousness. The first is conceived in a medical way: *"By subconsciousness the neurophysiologist understands the internal regulating and informing state of the brain controlling the rest of the organism linked to the external surrounding by means of multiple and multidirectional feedback loops. The importance of subconsciousness at the service of consciousness consists in registering a huge quantity of information continuously bombing the brain of which hardly a tiny fraction can be consciously received during the perception process"*. The second fragment, is the opinion of D.O. Hebb quoted in [16]: *"There are many reports from researchers, poets and musicians stating that sometimes new ideas appear in their minds suddenly and in a ready, elaborated shape. They are discovering and creative, hence they must have been elaborated subconsciously"*. At the end of quotations concerning subconsciousness we mention the work [31] of A.K. Wróblewski concerning A. Einstein's opinion of the creation of general theory of relativity: *"My own mistakes in reasoning were the causes of two years of hard work before*

I recognised them as mistake in 1915 ... Finally the results seem quite simple; every intelligent student will understand them without difficulty. Years of research in the darkness of truth that can be felt but cannot be expressed, the deep desire, the continuous belief is the apprehension, till the moment when we see clearly and understand, all this can be understood only by the one who has experienced something similar". I think that we can ascribe to this creation the role of subconsciousness as dominating over consciousness which even in the genial intellect of Einstein revealed itself little by little.

Actions in favour of reliability in distinguished processes: of valuing α, research β, designing η, producing $\hat{e}$ and exploitation ε, must be connected. They are informative connections, they are the results of actions – the output in a cybernetical way, from a process they are informational input for actions in other processes. The presented philosophical opinions and not only those, as many others, can be called a **philosophy of actions**. This philosophy adopted by subjects acting in processes can be utilised by them. It plays before all an inspiring role; besides it is a factor fastening the adjustment of our thinking, in the integral approach to solve problems, it facilitates the understanding of reality, when treating it in a probabilistic way, and it helps our creative imagination in looking for ideal patterns of objects in the transcendental approach to knowledge. Figure 1 gives a general informational diagram of links in the activities in favour of reliability in distinguished processes. In connection with this diagram we can also say that in the practical activities in favour of reliability of technical systems we have to deal with a system of actions.

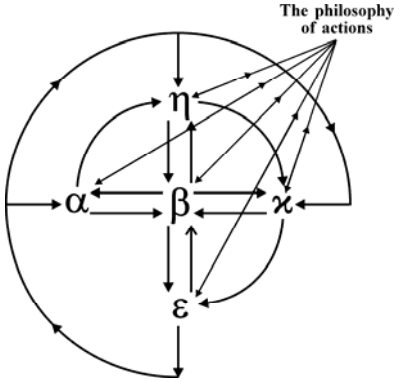

Fig 1. *General diagram of relations in the activity in favour of reliability*

Figure 2 shows the dependence between the earlier introduced notion of system of values <W> and a set of reliability {R} of technical systems. According to our earlier considerations, valuing α should occur in the consciousness of the adopted system of values <W>, which implies this valuing, and this in turn is characterised by the tendency toward values implying further actions in favour of reliability {R} of technical systems. These actions, as we know, occur in the earlier distinguished processes β, η, ϰ and ε (as in figure 1).

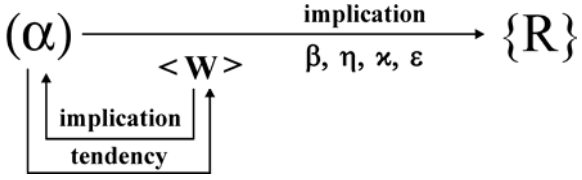

Fig. 2. *General scheme of dependency between a system of values and a reliability set*

We sum up, in a general form, the contents of figures 1 and 2. The philosophy P is connected with the activity δ_R in favour of reliability of technical systems and this activity appears in the earlier processes α, β, η, ϰ and ε. This is shown in figure 3.

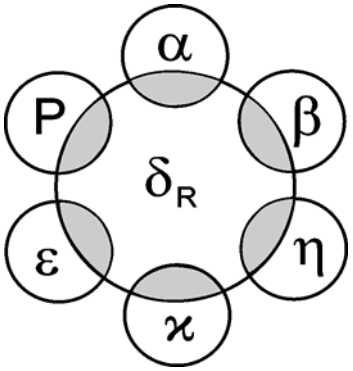

Fig. 3. *General view of the activity correlation of reliability and philosophy and processes*

I think that we may say that philosophy precedes activity in science. Some philosophical currents are opposed but each incites to think and this is essential. For the development of science it is worth while using this philosophical currents, and they are numerous and significant, which inspire, put in order science particularly in a logical and systemic way, and steer. This thought also concerns the small parts of philosophy and science dealt with in this paper.

5. CONCLUSION

Summing up the presented picture of reliability of technical systems as seen through selected categories and philosophical views we can formulate the following conclusions.

1. The starting point in the activity in favour of reliability of technical systems is the **valuing** of social needs, including the postulate of required reliability of these systems. This **valuation** should take into consideration the tendency toward **higher values**.
2. Technical systems, in the activity in favour of their reliability, are treated as elements of anthropotechnical and socioecotechnical systems. This constitutes an **objective whole**.
3. **Processes** which deal in favour of reliability of technical systems form a determined whole – a **process whole**.
4. Activities in favour of the reliability of technical systems in distinguished **processes** constitute a determined **system of actions –** an **activity whole**.
5. The **reliability** of technical systems is a **probabilistic category**.
6. **Transcendental** search for ideal patterns – models of reliability of technical systems may facilitate the steering of practical actions in the sphere of reliability of these systems.

We can say that the approach to activities in the field of reliability of technical systems, which would result from the above conclusions is a part of a new paradigm. It is something that we don't know precisely yet and that we continuously look for in human activity. Let me quote here F. Capry: *"We need a new paradigm, a new vision of reality; our former thinking, perception and values must change"* [32]. This new vision of reality is *"the just emerging systemic approach to life, mind, consciousness and evolution"* according to Capry, also in [32].

Let me express the hope that philosophy will contribute to create a new vision of reality in our consciousness, as well as in the field of reliability. Here I shall quote J.M. Bocheñski: *"Knowledge, reason are so threatened today, as it rarely happened in the past, and together with them, what is simply human; and even the existence of man probably. Only authentic philosophy , which uses all means in order to know, might be the rescue in this situation*" [24].

I would end this paper with Descartes' sentence

"*Cogito ergo sum*" [8], who said about it*: "I admitted undoubtedly that I could accept it as the first principle of philosophy, which I was searching"* [8]. I think that this maxim is continuously true.

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