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# NEWTONIAN AND BERGSONIAN TIME IN TECHNICAL DIAGNOSTICS

**Henryk Borowczyk**

*Air Force Institute of Technology*
*Ksiecia Boleslawa Street 6, 01 – 494 Warsaw, Poland*
*tel.: +48 22 6851151 fax: +48 22 8364471*
*e – mail: borowczyk@post.pl*

**Paweł Lindstedt**

*Bialystok University of Technology*
*Faculty of Mechanical Engineering*
*Wiejska 45C Street, 15 – 351 Bialystok, Poland*
*tel.: +48 85 7469220, fax: +48 85 7469210*
*e – mail: p.lindstedt@pb.edu.pl*

**Jerzy Manerowski**

*Air Force Institute of Technology*
*Ksiecia Boleslawa Street 6, 01 – 494 Warsaw, Poland*
*tel.: +48 22 6851961 fax: +48 22 8364471*
*e – mail:j.manerowski@itwl.pl*

***Abstract***

*Testing and reasoning are two main closely related diagnostic activities. Diagnostic testing is realized in Newtonian (short) time while diagnostic reasoning - in (long) Bergsonian time. Both sort of time are used to analyze different kinds of problems in diagnostics and reliability of technical objects. Newtonian and Bersonian time differentiation needs some expert knowledge. In this paper, considerations are based on observation that Newtonian time of diagnostic testing is related to object maintenance (adjustment) and Bergsonian time is related to object is reliability.*

*A significant change of the object's technical condition (signals or parameters of the state) causes changes of its regulation state (quality indicators change) and the characteristics of reliability. As it is required for the operation and reliability to be always appropriate and permanent, the control should be adjusted to functional needs of the object, and the use should be adapted to the current characteristics of reliability. Therefore, change of the settings of the control device (made during the handling of the object) represents the change of technical condition and state of reliability. It is presumed that, during the operation of a technical object, the selection of the control settings for damaged object is impossible. This fact, when predicted, becomes the basis for the prediction of the object reliability.*

***Keywords***: *technical diagnostics, reliability, Newtonian time, Bergsonian time*

## 1. Introduction

Machines (technical objects) are subject to the same destructive processes, such as living organisms (biological objects) and the whole nature. A new machine ages and is therefore transformed into an old machine (into the wreck of the machine), similarly, a child turns into an adult and, at the end, into an old person (person's wreck), or young plant into a centuries-old tree.

This process is inevitable and irreversible, and technical facilities, biological and natural sciences have no effect on its course. It happens over irreversible time, in other words, time evolution or Bergsonian time – $\theta$. It can assume various values of $0 < \theta < \infty$, and there is also always an additional rule that $\theta_0<\theta_1<\theta_2$. Therefore, present $\theta_1$, past $\theta_0$ and future $\theta_2$ times are on the way of $\theta$ course of time. So it could be used to describe the relationship between the past, present and future of energetic, material and information systems of major technical, economic and natural sciences systems [1, 6, 7, 12].

It has been discovered that there are sufficiently $\Delta\theta$ short times, where virtually Bergsonian time is 'standing' still, however, in such moments (which have no relevance to the course of $\theta$ Bergsonian time) important works related to the establishment of current state of operation and current technical conditions are carried out. It is different in the moments creating space in *t* time. Various studies to identify the object are conducted. The process of the study of the object and system implemented in the course of *t* time i.e. reversible and Newtonian time can be programmed planned, depending on the needs. It can be lengthened and shortened. It can be reversed from final value (end of the study) to initial value (again from the start of the study) [1, 6, 12]. When examining the relationship between *t* and $\theta$, it can be obviously stated that the Newtonian time is applied to the Bergsonian time (Fig. 1).

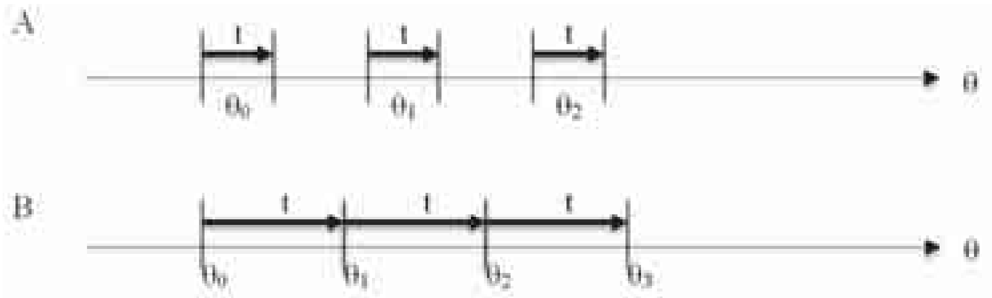


*Fig. 1. Bergsonian θ and Newtonian t times: A - sequential method of testing, B - continuous studies of a technical object*

When analysing the A case (Fig. 1), the relationship between *t* and $\theta$ time, it can be concluded that, for example, for $\theta_0$, $\theta_1$, $\theta_2$, a short time of *t* experiment constitutes the autonomous time within the study that can be repeated many times, and, therefore, *t* time is reversible. The examples of such tests constitute the studies of the wear of products in tribological systems lubricating oil (oil sample can be repeatedly taken and tested) [4, 11].

When analysing the B case (Fig. 1) concerning the relationship between *t* and $\theta$, it can be concluded that *t* time in periods $\theta_0$ - $\theta_1$, $\theta_1$ - $\theta_2$, etc. fully coincides with $\theta$ time. Since *t* time fills $\theta$ time *in* 100%, one can mistakenly conclude that *t* and $\theta$ times are identical. The extension of *t* time for the entire period of time i.e. $\theta_0$ - $\theta_1$ does not mean that it has the characteristics of $\theta$ time. Such a proposal is completely illegitimate, because within the *t* time, past, present and future times cannot be considered. In addition, what is happening at *t* time can be reversed, amended or cancelled (for example, results from the observation of the object within $\theta_0$ - $\theta_1$ time cannot be taken into account - declared no to be present) but the $\theta$ time irrevocably made its way from $\theta_0$ to $\theta_1$ time. The examples of such studies may be ongoing vibroacoustic signal studies (e.g. signal within $\theta_0$ - $\theta_1$ times can be analysed differently or even cancelled) [3, 5].

## 2. Newtonian and Bergsonian times in the cybernetic system of exploitation of the technical object

The scheme of cybernetic model of technical object exploitation system in Fig. 2 shows that, during the use and storage of the object, it is constantly and imminently destroyed (regulation changes, wear, increased reliability), and its appropriate operation is possible with adequate supply of energy, material and information. Hence, the existing phenomenon of destruction decides about the shape of the system maintaining its usability (service) and guaranteeing a required relationship between its material, energetic and informational part. The service system should consist of regulatory, diagnostics, and reliability systems.

The purpose of regulation is to maintain optimal operation of a technical object according to the information under the terms of automation. It is maintained within the Newtonian time i.e. dynamic – *t* [7, 8, 11].

The objective of diagnostics is to obtain the information about technical changes that occur during the operation of the object with indirect methods, without the need of its disassembly, using the measured diagnostic and ambient signals. The diagnostic systems include maintenance activities that are performed in a dynamic *t* time (object identification) and maintenance activities, performed during a $\theta$ exploitation period. Knowledge (information) about the changes of technical conditions gives rise to the optimal (safe and cheap) exploitation of objects according to technical condition [4, 7, 8].

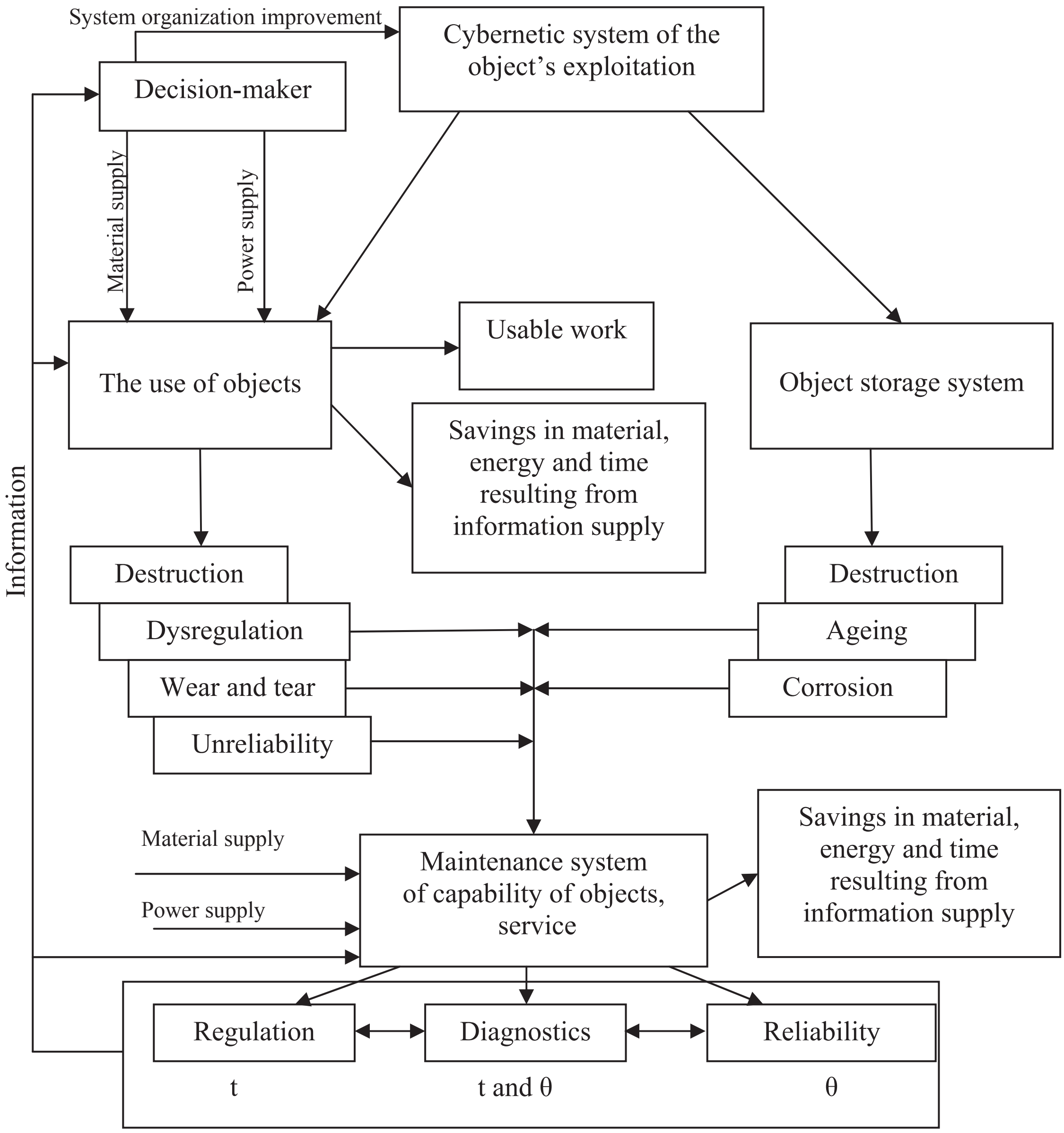


*Fig. 2. The main elements of a cybernetic system for the object's exploitation: t – dynamic time (Newtonian), θ - operating time (Bergsonian)*

The purpose of reliability practice is a continuous refinement of reliability characteristics based on knowledge of damage suffered (catastrophic, parametric and transient) during the use of the object. Currently, the methods for determination of reliability characteristics are used on the basis of parametric and temporary damage before the occurrence of always dangerous and catastrophic damage. Reliability characteristics are described in the $\theta$ operation time [2, 5, 10].

Information about the state of regulation, technical and reliability condition (Fig. 2) is delivered to the object's maintenance staff (in order to improve the quality of maintenance), to the user (in order to adapt the terms of use to the technical abilities of the object) and to the decision maker (in order to constantly improve the organisation of the system) and finally changed (according to Maxwell's formula: $\Delta E=10^{-23}\Delta I$ *[J/K]* binding $\Delta E$ energy increases with the increase of $\Delta I$) information for the purpose of time, material and energetic savings [9].

The changes occurring in regulation, diagnostics, and reliability are observed and documented in accordance with the principles of cybernetics in the process of handling technical objects. These changes are described in the $\theta$ operating time and are the basis for planning appropriately matched maintenance changes and operation of the object.

A diagnosis via its direct link with the systems of control and reliability plays a special role in the maintenance of the object.

## 3. Newtonian and Bergsonian times in technical diagnostics

Diagnostics systems scheme of technical object and its links with the system control and reliability are shown in Fig. 3 [11].

An analysis of Fig. 3 shows that the diagnosis can be applied equally to the diagnosed object and its environment, and is realised in two different times - the $t$ Newtonian and $\theta$ Bergsonian times but are closely related to diagnostic activities, which always include: diagnostic tests (implemented at $t$ time) and diagnostic reasoning (implemented at $\theta$ time)

Diagnostic tests (Fig. 3) are essential for diagnosis and largely determine their effectiveness. It is divided into several stages, among which are:

1. Knowledge of the object: in this phase concerning diagnostic tests, it is necessary to obtain a wide-ranging knowledge about the object and its environment, comprising:
   – a formal description of the object, a description of the construction and operation in the environment (including the equations of motion and static and dynamic characteristics), the object's manufacturing technology, the characteristics of reliability and safety, including a set of typical defects generated by diagnostic signals,
   – description of diagnostic signals, their physical nature and degree of disturbance.
2. Measurements of diagnostic signals. Here, the necessary measurement systems are selected, and then a precise instruction for measurements is formulated. These instructions should apply in an immutable form over the lifetime of the object. Here, special importance should be attached to the assurance of a permanent accuracy (classes) of measurements, and repeatability (identity) of positioning measurement values in relation to the object during subsequent diagnostic tests.
3. Removal of defects from diagnostic signals. This process is accomplished by the application of appropriate filters (low pass, high pass, band, comb, Wiener, etc.) in the measuring systems, or (which is more efficient and universal) correlators for processing the measured waveforms of signals (within a dynamic t time) into the courses of correlation function (at the time of $\tau$ shift), and then into the signal spectral power density function (dependent on $\omega$ frequency). It should be noted that $\tau$ time and frequency are just another form of expression of $t$ time space. In addition, it is known that the two measured signals $x(t)$ and $y(t)$ can be converted into three correlation signals $R_{xx}(\tau)$, $R_{xy}(\tau)$ and $R_{yy}(\tau)$ and into three spectral density power signals $S_{xx}(\omega)$, $S_{xy}(\omega)$ and $S_{yy}(\omega)$ and $A^2= S_{yy}/ S_{xy}$ square of amplitude gain and $\varphi = S_{xy}/ S_{xx.}$ phase shift.
4. Formation of diagnostic signals. This activity is designed to bring all measured signals to a dimensionless form. The reference value of the measured signal is its diagnostic value resulting from the design of the object or the value determined during factory tests, or the value

determined during the transfer of the object from the production system to the system of exploitation. In this way, $\theta_0$'past' is introduced to $\theta_1$ 'present', resulting from the design of the object (e.g. the pump design provides delivery pressure of 210 at the flow rate of 10 l/s, and the manufacturer has produced the pump of 200 at and 9 l/s respectively, the relative sizes referred to the project amount to 0.95 and 0.9, which should be regarded as poor outcome). The significant fact here is that the assessment of the object is obtained at the outset of the study.

5. Database development The database includes the tables with waveform quality indicators of formed signals, correlation functions and signals spectral power density. The accepted indicators of quality should relate their physical nature to 'time adjustment' and 'overshoot value', used in assessing the quality of automatic control systems. The database can also be the matrices of parameters of mathematical models designated with the use of static and dynamic identifications. Database development constitutes the final stage of diagnostic tests and identification of the object.

Diagnostic reasoning (Fig. 3) is another important element as equally important as the diagnostic study with the element of diagnosis. It involves the conversion of the results of diagnostic tests (database) and other information about the object and surroundings (knowledge base) into diagnosis, genesis and prognosis. In diagnostic reasoning, there are several different phases:

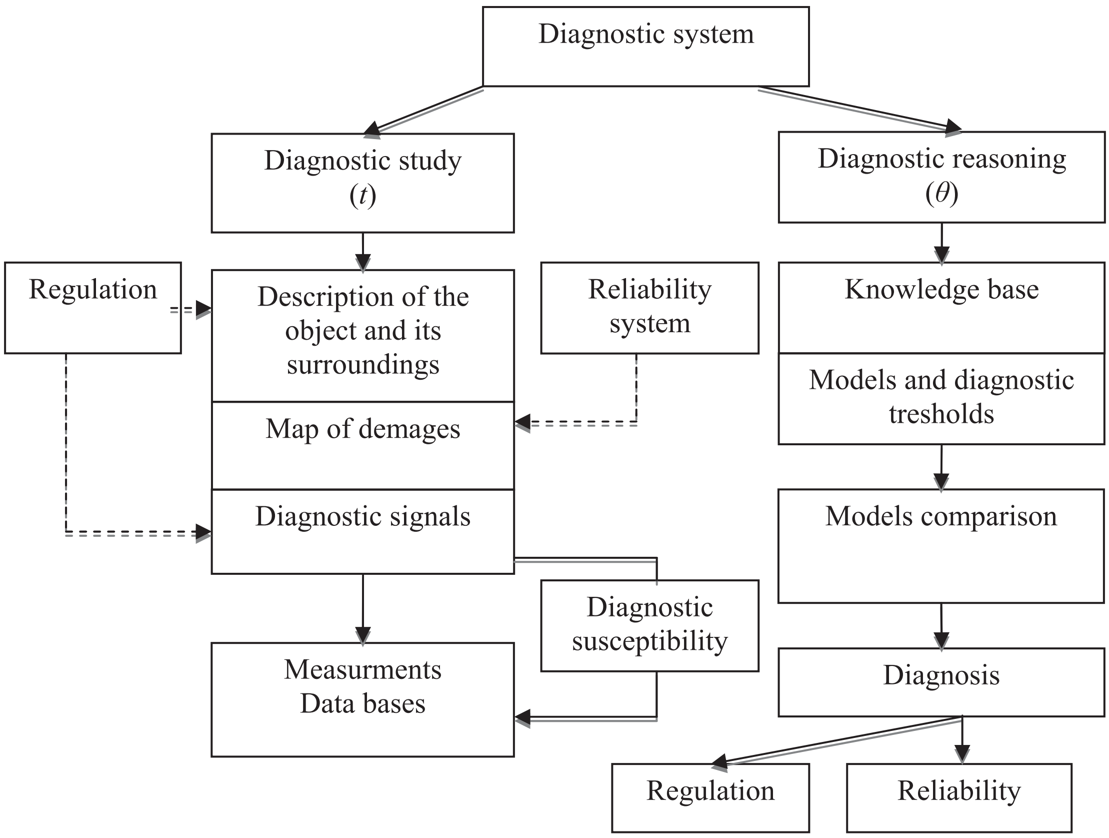


*Fig. 3. Scheme of diagnosis and its relationship to regulation and reliability systems*

1. The development of a diagnostic model. It concerns the connection (on the basis of knowledge) of diagnostic signals with the changes of technical condition (damage) of the object. The formal connection of diagnostic signals, signals waveforms quality indicators and diagnostic parameters with damage is absolutely essential in the process of diagnosis. Diagnostic model allows 'remembering' the condition of the object (constantly changing) at the current time of $\theta_0$ diagnosis and save it to the next moment of $\theta_1$, $\theta_2$, *diagnosis* etc. Therefore, without a diagnostic model, it is impossible to implement the principles of diagnosis based on comparing the current states (present) of the object with previous (past) and projected (future) states.

2. Development of algorithms for comparing diagnostic models. It includes the rules of comparing models from actual diagnosis with previous models from the life history of the object (θ time).The resulting changes in the nature and parameters of the model are converted into changes of the technical condition of the object.
3. Computer-aided diagnostic reasoning. It investigates the issue of effective elimination of diagnostician's subjective performance from the process of subjective reasoning and its replacement with an objective (always active now and many years later) expert system. It turns out (and practice confirms it) that the computer ensured identity of reasoning is much more effective than the intelligence of current time diagnostician and, following it, completely different diagnosticians.

## 4. Conclusion

It can be concluded that a significant change of the object's technical condition (signals or parameters of the state) will change its regulation state (quality indicators change) and will also change the characteristics of reliability. As it is required for the operation and reliability to be always appropriate and permanent, the settings of the steering device should be adjusted to functional needs of the object, and the use should be adapted to the current characteristics of reliability. Therefore, always-essential change of the settings of the control device (made during the handling of the object) represents the change of technical condition and state of reliability. It is presumed that, during the operation of a technical object, the selection of the settings of a control device for overly worn (damaged object) will be impossible. This fact, when predicted, becomes the basis for the prediction of reliability of the object.

Therefore, it can be concluded that any substantial change of the technical condition (diagnosis performed at t and θ times) will result in:

- change in regulatory settings according to the principles of automation ( t time),
- necessity to re-designate reliability characteristics (θ time).

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