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Definitions of dependability

Anatoly S. Alpeiev, *Scientific and Engineering Center for Nuclear and Radiation Safety, Moscow, Russia, e-mail: alpeev@yandex.ru*

Anatoly S. Alpeiev

Abstract. *The article analyzes dependability-related definitions that have been used so far in a number of regulatory documents, the majority of which have been borrowed into Wikipedia. The analysis shows the shortcomings of said terminology, while more correct definitions of primary dependability-related terms are suggested for dependability, reliability, maintainability, durability, survivability, storageability, operation time, limit state. For instance, the generic term "science" instead of "property of object" is suggested for the definition of "dependability", as the former better complies with the modern understanding of the term "dependability", as it has a subject matter, research methods and quite specific goals. It is also shown that this definition of "dependability" may be taken as a basis and then all dependability characteristics should be defined not as "properties of objects", but rather as dependability indicators, while specifying what properties they characterize. For example, reliability is a dependability indicator that characterizes the time from the start of object operation to its expected failure. Another example: storageability is a dependability indicator that characterizes the time during which an object can be stored under certain storage conditions with no loss of required quality. It is suggested to define in this manner all the required dependability characteristics. Further it is shown that there is an error in the dependability-related definitions with the generic term "property of object", as the definition in those notions is incorrectly associated with the term it refers to. For instance, the existing definition of dependability: "property of an object to maintain in time and within the set limits the values of all parameters that characterize the ability to perform the required functions in specified modes and conditions of operation, maintenance, storage and transportation" should be associated with the term "dependability of object", but not "dependability", as it implies a wider notion. Additionally, the article suggests a number of new terms, such as dependability of object, reliability of object, maintainability of object, etc. that are directly related to the dependability indicators of a specific facility a user is concerned with. In the conclusion examples are given of construction of terms and definitions for such technical objects as control systems. The distinctive feature of such objects is that they are usually multifunctional and it is not correct to set dependability requirements for the system as a whole, as that is impossible. In such cases it is believed that the system's dependability has been identified when the dependability indicators of all the functions it performs are known.*

Keywords: *aspect, safety, time, reliability, time, longevity, survivability, quality, operation time, science, object, definition, limit state, mode, maintainability, property, storageability, term, operational application.*

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In today's world, dependability is one of the primary characteristics that define the quality of any product. Therefore, the matters of dependability have been and still are the focus of attention, especially in the high-technology industry, as well as in the context of regulatory documentation development, specifically when it comes to the terminology that covers practically all required technical aspects of products that ensure their normal operation over the specified period of time.

This article questions the current dependability-related terminology, as it has significant shortcomings that will be identified below.

We will begin with a list of notions that are criticized in this article and that are taken from [1].

Dependability is the property of an object to maintain in time and within the set limits the values of all parameters that characterize the ability to perform the required functions in specified modes and conditions of operation, maintenance...

Reliability is the property of an object to continuously maintain its operability over a certain time of operation.

Maintainability is the property of an object that consists in its ability to maintain and recover operability through maintenance and repair.

Longevity is the property of an object to continuously maintain its operability from the beginning of operation to the onset of the limit state, i.e. a condition at which the object is removed from operation.

Storageability is the property of an object to maintain its operability over the period of storage and transportation.

Survivability is the property of an object to maintain its operability after the failure of individual functional units.

Time to failure is the value (time or volume of work) used for measurement of equipment operation time.

Service life total time from the beginning of operation to the onset of the limit state.

Let us begin with the term "dependability" that is used in many documents, for example in [1, 2], where it has a similar definition:

Dependability is the property of an object to maintain in time and within the set limits the values of all parameters that characterize the ability to perform the required functions in specified modes and conditions of operation, maintenance, storage and transportation.

As we see from those examples, the generic term for "dependability" is "property of object".

According to another opinion, e.g. in [3], "it is only since very recently that the dependability theory is a stand-alone science. It happened at the beginning of the technological revolution, i.e. in the middle of the XX century. That period was marked with a new qualitative leap in the technological development, widespread deployment of large and small-scale automated control systems (ACS) of various purposes. The development and application of such technology without the use of special measures to ensure its dependability is meaningless. The problem of dependability of automated control systems was first encountered by the scientists of the Nazi Germany who created the first of its kind unmanned airplane, the V-1 cruise missile."

Besides that, in [4] it is also noted that "the dependability theory is a science that deals with the failure patterns of technical systems and possesses the methods that allow using the analysis of statistical data on populations of identical objects to identify the probability of failures of objects in operation."

Therefore, as shown above, according to an opinion the word "science" can be used as the generic term for "dependability", and the former, in my opinion, is preferable due to the following reasons:

First, like any science, dependability has a subject matter, i.e. the failure patterns of technical objects;

Second, like any science, dependability has its methods, i.e. deterministic, stochastic and physical;

Third, like any science, dependability has its pragmatic goals, i.e. development of regulatory documents that set forth the methods and ways of identifying such special properties of technical systems as reliability, maintainability, storageability, longevity, survivability, service life, etc.

The above allows defining "dependability" as follows:

Dependability is a science that deals with failure patterns of technical systems for the purpose of identifying the causes of failures, their prediction, as well as preparation of regulatory documents that set forth the definitions, requirements, rules, assumptions and exceptions of which the observance enables the development of products with required time and quality of operation.

This definition of dependability allows for different definitions of its indicators, i.e. reliability, maintainability, storageability, survivability, longevity, etc. that are different from those given in regulatory documents.

For example:

Reliability is a dependability indicator that characterizes the time from the start of object operation to its expected failure.

Maintainability is a dependability indicator that characterizes the time required for object recovery after failure.

Storageability is a dependability indicator that characterizes the time during which an object can be stored under certain storage conditions with no loss of required quality.

Longevity is a dependability indicator that characterizes the time during which an object can maintain its operability.

Now let us go back to the existing dependability-related definitions with the generic term "property of object" that are widely used today. In my opinion, the error is that the definition in those notions is incorrectly associated with the term it refers to. For example, when defining the term "dependability", if the definition is referred to the term "dependability of object" everything falls into place:

"Dependability of object" is the property of an object to maintain in time and within the set limits the values of all parameters that characterize the ability to perform the required functions in specified modes and conditions of operation, maintenance, storage and transportation.

As we see, the term is easily associated with the definition.

In the same manner, the term "maintainability" from [1] should be replaced with a term associated with the object:

Maintainability of object is the property of an object that consists in the adaptation to prevent and detect the causes of failures, defects and eliminate their consequences by means of maintenance and repair.

Similarly, it is suggested to replace the remaining terms for dependability indicators from [1] with object-related terms:

Reliability of object is the property of an object to continuously retain operability with a specified operation time.

"Operation time" should also be understood as a term related to the object of which the operating time we deal with:

Operation time of object is the duration or amount of work.

Longevity of object is the property of an object to maintain operability until the limit state.

Here the term "limit state" should also be associated with the object:

Limit state of object is the condition of object under which its further operation is inacceptable or impractical, or recovery of operability is impossible or impractical.

In this case the equipment is not repairable and is removed from operation.

Storageability of object is the property of an object to maintain operability during the whole storage and transportation period.

Survivability of object is the property of an object to maintain operability after failure of individual functional units.

Service life of object is the object's operation time from the beginning of operation till the onset of the limit state.

Lifetime of object is the total time from the beginning of operation till the onset of the limit state.

Thus, the existing definitions of dependability indicators fit in well with the above proposals. In order to maintain the conformity of terms and definitions if referring to a product or equipment rather than an object, it is recommended to replace the word "object" in the term and definition accordingly. For example:

Reliability of product (equipment) is the property of a product (equipment) to continuously maintain operability with the specified operation time.

For further considerations let us note that currently calculations of dependability indicators are predominantly associated with only artificial objects with known structure, components and their connections. This is especially the case with control systems that perform a number of functions in operation. For example, protection function, information display function, information registration function, diagnostics function, etc. In such cases there is no reason to talk about the dependability of a control system that implements several functions, as each of the implemented functions has its own set of dependability indicators. In other words, the dependability of a control system is known if the dependability indicators of each implemented function have been identified.

As is well known, a function is the sum of actions of a control system aimed at the implementation of a specific control objective. As the control systems actions are performed by means of automation facilities each of which has its own dependability indicators, in [5] functional groups were introduced as elements for dependability evaluation and safety classification.

As defined in [5]: "Functional group is a designed part of a control system representing the sum of automation facilities that perform the specified function of the control system".

Thus, it is recommended to use the following terms when dealing with control systems dependability.

Dependability of functional group of control system power level protection is the sum of dependability indicators of the functional group of control system power level protection that are specified in the respective regulatory document or control system performance specification. For example [6].

Reliability of functional group of control system power level protection is the property of the functional group of control system power level protection to continuously maintain operability within a specified operation time.

Maintainability of functional group of control system power level protection is the property of the functional group of control system power level protection that consists in the adaptation to prevent and detect the causes of failures, defects and eliminate their consequences by means of maintenance and repair.

Longevity of functional group of control system power level protection is the property of the functional group of control system power level protection to maintain operability until the onset of the limit state.

Similarly, we can continue defining terms for various functional groups of control systems, but it is not required for the purpose of this article, as the method is clear and simple.

In conclusion, we should note the systemic nature of the proposals in respect to the whole dependability terminology that fits in well with all the previous research in this area. The author hopes that the proposals above will find wide application both in regulatory and design documentation.

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About the author

Anatoly S. Alpeiev, Candidate of Engineering, Lead Researcher, Scientific and Engineering Center for Nuclear and Radiation Safety, Moscow, Russia

tel.: +7 (916) 373 61 00

e-mail: alpeev@yandex.ru

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