 Original article
https://doi.org/10.21683/1729-2646-2020-20-2-24-27

On the terminology of dependability

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Abstract. Aim. *Currently, there is a fully-fledged system of Russian dependability standards, the GOST R 27.xxx series. However, due to the suspension of the terminology standard (GOST R 27.002-2009) this system is now incomplete. In this situation, a compromise solution can be found with dual designation in the current dependability standard in Russia. The aim of the paper is to define the proposals for improved basic terminology in dependability.* **Methods.** *The paper uses methods of system analysis in respect to dependability terminology. The last decade was marked by active discussions regarding dependability terminology. Not only particular definitions, but the definition of the term "dependability" itself are addressed. The dependability terminology in the Russian Federation is currently represented in two standards: the Russian GOST R 27.002-2009 (suspended indefinitely) and the interstate GOST 27.002-2015. This paper continues the discussion regarding a limited set of concepts and terms that interest the author most. Such concepts as item, entity, failure, property, ability, calculation, estimation, prediction, requirements for dependability are examined. It is noted that the concept of technical entity is based on the product, the study object as a finished result of some technical activity, i.e. to make and at the same time provide the product with the ability to perform certain functions. It is shown that a product's properties characterize its abilities, therefore, while identifying, the focus should be on the ability of a product provided with properties (features) required for the performance of certain functions. The features (properties) themselves are primary only for the purpose of identification of the entity's required ability and are secondary for the purpose of dependability identification. It is demonstrated that there is no need to substitute the concepts of "calculation" and "estimation". The correctness of the definition of "prediction" in the Russian standard GOST R 27.002-2009, i.e. a computational process aimed at predicting the values of quantitative characteristics, is noted.* **Conclusions.** *Based on the terminological analysis performed in the paper, the following proposals were developed. Dependability terminology should be complemented with the definition of entity. An entity should be understood as a functional unit provided with abilities defined by the required properties. A failure should be understood as an event consisting in the disruption of the product's up state. The concept of item should be interpreted as in GOST R 27.001-2009: an item (entity, system) that is considered individually in terms of dependability, that consists of hardware and software or their combinations. The terms of dependability, reliability, durability, etc. should be defined as the identified ability of the product to perform the required function in the given circumstances. The term "requirements for dependability" should be specified in the dependability standards. The term "dependability estimation" should not be introduced in the interstate standard GOST 27.002-2015.*

Keyword: *item; entity; failure; property; ability; calculation; estimation; prediction; requirements for dependability.*

For citation: *Mikhailov V.S. On the terminology of dependability. Dependability. 2020;2: 24-27. https://doi.org/10.21683/1729-2646-2020-20-2-24-27*

Received on: *21.12.2020 /* **Upon revision:** *16.04.2020 /* **For printing:** *17.06.2020.*

Introduction

The last decade was marked by active discussions regarding dependability terminology [1 – 6]. Not only particular definitions, but the definition of the term "dependability" itself are addressed [1 – 6]. Due to the fact that the Russian standard GOST R 27.002-2009 [7] is suspended indefinitely dependability terminology in the Russian Federation is currently based on the interstate standard GOST 27.002-2015 [8]. GOST 27.002-2015 was adopted by the Interstate Council for Standardization, Metrology and Certification (proceedings of December 28, 2015 no. 83-P). It was voted for by Armenia, Kazakhstan, Kyrgyzstan, Moldova and the Russian Federation. The list of voters does not include Belarus who is the founder of the Customs Union.

This paper continues the discussion regarding a limited set of concepts and terms that interest the author most.

GOST 27.002-2015 or GOST R 27.002?

Currently, there is a fully-fledged system of Russian dependability standards, the GOST R 27.xxx series. However, due to the suspension of the terminology standard (GOST R 27.002-2009) this system is now incomplete. In this situation, a compromise solution can be found with dual designation in the current dependability standard in Russia. When applied in Russia, the standard is designated GOST R 27.002-2015, while for the purpose of interstate relations it is designated GOST 27.002-2015. While the national dependability standard GOST R 27.002-2009 is suspended, such solution would allow solving many problems.

Item, entity and failure

The concept of technical **entity** (hereinafter referred to as entity) is based on the product, the study object as a finished result of some technical activity that consists in making and at the same time providing the product with the ability to perform certain functions. For instance: a microscope has a high resolution, a diode is able to withstand high reverse voltage, an instrument is able to equalize voltage, a surface with a high reflective power. For that reason, an entity should be understood as a functional unit out of a produced set of products provided with required abilities defined by the necessary properties. That complies with the definition of entity per GOST R 27.002-2009 [7].

In accordance with Item 49 of GOST R 27.002-2009, a **failure** is the loss by an entity of the ability to perform the required function. The note to Item 49 states that "a failure is an event that causes a fault". On the other hand, in accordance with the interstate standard GOST 27.002-2015 a **failure** is "an event that consists in the disruption of operability of an **item**". Given that a fault does not always cause a failure (for example, minor chipping or dent on the surface of equipment, broken cap of a signal light, etc.), the definition according to the interstate standards GOST 27.002-2015 is preferable. GOST R P 27.002-2009 does not define item. Let us clarify what the concept of item consists in.

N.E. Yatsenko: "Item: 1. In philosophy, any phenomenon existing independently from human consciousness. 2. In a general sense, an object, phenomenon that people try to get to know and the human activity is directed at". "Object: 1. Any material phenomenon, a thing. 2. Something the thought, an action or a feeling is directed at" [9].

An item is a process or a phenomenon that causes a problem situation and that a researcher chose to examine. An object is something that is within an item. An item is the part of scientific knowledge a researcher is dealing with. The study object is the aspect of the problem, researching which we get to know a whole item by identifying its primary, most significant features. As scientific categories, item and study object are the general and the particular [9].

Dependability studies the quality of an item or, ultimately, quality as a property of an object, i.e. the feature that constitutes the identifying characteristic of the object of cognition. Therefore, the dependability terminology should include the concept of "**entity**" as study object, as the particular and the specific.

GOST 27.002-2015 introduces the definition of "technical item": "The subject matter covered by the terminology of dependability in engineering." Such definition of item is not universally accepted and raises a few questions:

- what should be the scope of the terminology of dependability in engineering;
- if the coverage is not to be complete, what should it encompass.

The concept of item is best defined in GOST R 27.001-2009 [10]: an item (entity, system) that is considered individually in terms of dependability, that consists of hardware and software or their combinations.

A developer must make a choice as to which term to use, item or entity, based on the need for a terminology.

On the term "dependability requirements"

Despite the fact that the term "requirements for dependability" [11] has established itself, the term "dependability requirements" can be frequently encountered [12]. According to [11], the dependability characteristics (requirements for dependability) can be specified (raised) by a supplier or a consumer. However, out of term "dependability requirements" follows that the requirements for the dependability of an entity are raised by the entity itself, which is nonsense. A supplier, by specifying requirements for dependability in the form of specified qualities (properties, indicators) as part of the entity's design, may expect from such entity the required ability to perform certain functions. Therefore, the concept and term "requirements for dependability" should be specified in the section dedicated to development.

Property or ability

A **property** is a feature [13, 14] that constitutes the identifying characteristic of the object of cognition [9]. An entity's properties characterize its abilities, therefore while identifying the dependability the focus should be on the **ability** of the entity provided with properties (features) required for the performance of certain functions. The features (properties) themselves are primary only for the purpose of identification of the entity's required ability and are secondary for the purpose of dependability identification. Therefore, the terms dependability, reliability, durability, etc. should be defined as the **ability** of the product to perform the required function in the given circumstances, which is in compliance with GOST R 27.002-2009. It should be noted that the interstate standard GOST 27.002-2015 defines the terms dependability, reliability, durability, etc. as the **property of an item**, which is incorrect due to the secondary status within the hierarchy of definitions. Let us give an example of how certain definitions of abilities are built.

Reliability is the identified ability of an entity to continuously perform the required function within the defined period of time (operation time) under the given conditions. This ability is defined by the entity's properties that are characterized by the following indicators: mean time between failures, mean time to failure, probability of no-failure, gamma-percentile time to failure, gamma-percentile time between failures, failure rate, assessed failure rate.

Availability is the identified ability of an entity to perform the required function under the given conditions assuming that the required external resources are provided. This ability is defined by the entity's properties that are characterized by composite indicators of availability.

Durability is the identified ability of an entity to perform the required function until the onset of the limit state under the given conditions of operation and maintenance. This ability is defined by the entity's properties that are characterized by the following indicators: average operating life, gamma-percentile life, mean lifetime, gamma-percentile lifetime.

Dependability is the ability of an entity to perform the required function in the given circumstances. An entity's ability is defined by particular abilities: availability, reliability, durability, maintainability and storability.

The list goes on. Thus, the following hierarchical structure is shown: dependability, ability, property, indicator.

Calculation, estimation and prediction

The concept of "dependability estimation" introduced in the interstate standard GOST 27.002-2015 as the identification of the numerical values of the indicators of an items' dependability, is broad and requires additional specifications in the standard. Dependability estimation implies that the identification of the numerical values of the dependability indicators is performed through either **calculation** based on reference data, or **estimation** based on the results of testing, where estimation means statistical estimation. According to GOST R 50779.10-2000, statistical estimation (the word "statistical" is always omitted) is understood as the statistics used for the purpose of estimating the population parameter. Statistics is the function of selective values [13]. The population parameter is some dependability indicator. Since in the dependability theory the word "estimation" is reserved to statistical estimation, the interstate standard GOST 27.002-2015 should not feature the term "dependability estimation". In the last resort, the term "Identification of numerical values of dependability indicators" should be introduced to imply the identification of the numerical values through calculation based on reference data or estimation based on test results. In the Russian standard GOST R 27.002-2009, there is no such term as "dependability estimation", since there is no need to substitute the concepts of "calculation" and "estimation".

The Russian standard GOST R 27.002-2009 sets forth a correct definition of "**prediction**", i.e. a computational process aimed at predicting the values of quantitative characteristics. Given the above, the concept of "**prediction** of dependability" introduced in the interstate standard GOST 27.002-2015 as the preliminary **estimation** of dependability based on prior experience or statistics should be modified in accordance with the Russian standard GOST R 27.002-2009.

Conclusions

1. Dependability terminology should be complemented with the definition of entity.

2. An entity should be understood as a functional unit provided with abilities defined by the required properties.

3. A failure should be understood as an event consisting in the disruption of an entity's up state.

4. The concept of item should be interpreted as in GOST R 27.001-2009: an item (entity, system) that is considered individually in terms of dependability, that consists of hardware and software or their combinations.

5. The terms of dependability, reliability, durability, etc. should be defined as the identified ability of the product to perform the required function in the given circumstances.

6. The term "requirements for dependability" should be specified in the dependability standards.

7. The term "dependability estimation" should not be introduced in the interstate standard GOST 27.002-2015.

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The author's contribution

The author analyzed the current interstate and Russian dependability terminology standards. Based on the analysis, the author proposed the following: within the dependability terminology, the definitions of entity, failure, item (per GOST R 27.001-2009), as well as of the term "requirements for dependability" are to be made more specific; the terms dependability, reliability, durability, etc. are to be defined as the identified ability of an entity to perform the required function in the given circumstances; the term "dependability evaluation" is not to be introduced into the interstate standard.