Method for estimating the reliability index of automated system software for aircraft control data preparation

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The most complicated component of automated system for aircraft control data preparation is software. The likely reason for the interruption of the data preparation process is the presence of errors in the software, which may take a long time to resolve. Early elimination of these errors is an extremely important task. The degree of error elimination is determined by the value of the reliability index. The problem of assessment of the software reliability index is up to date, since there is no generally accepted technique for estimating this indicator. Based on the results of the analysis of existing software reliability models, it is shown that none of them can be used to estimate the software reliability index of an automated data preparation system. The proof of the correctness of using the methods of probability theory for the estimation of the indicator under consideration is presented. The theorem about a bijection (one-to-one correspondence) between the set of variants of input data and the set computational trajectories is proved. The possibility of applying the method of probability theory in the geometric interpretation of the probability of occurrence of an event (error) for estimating the software reliability index follows from the theorem. The use of this method is correct, but it requires infinite time resources, which makes it unsuitable for practical application. A fundamentally different method for estimating the software reliability index is proposed. Using this method it is necessary to have a documentary evidence of the coverage level by test variants of the entire input data area from the permissible region. The advantage of the proposed method is that it does not require any assumptions, and the initial data for estimating the software reliability index have a clear physical meaning and can be obtained in practice.

Keywords: *computational branch, computational path, reliability, error, software, reference result*

REFERENCES

[1] Podlovchenko R.I. *Programmirovanie — Programming and Computer Software*, 1981, no. 2, pp. 3–14.

[2] Letichevsky A.A. *Kibernetika — Cybernetics*, no. 2, 1969, pp. 5–16.

[3] Yevstigneyev V.A. *Primenenie teorii grafov v programmirovanii* [Application of the graph theory in programming]. Moscow, Nauka Publ., 1985, 352 p.

[4] Myers G.J. *Software Reliability: Principles and Practices*. New York, John Wiley Publ., 1976, 275 p. [In Russ.: Myers G. Reliability of the software. Moscow, Mir Publ., 1980, 360 p.].

[5] Jelinski Z., Moranda P.B. Software Reliability Research. In: *Statistical Computer Performance Evaluation.* Freiberger W., ed. New York, Academic Press Publ., 1972, pp. 465–484.

[6] Boehm B.W., Brown J.R., Kaspar H., Lipow M., MacLeod G.J., Merritt M.J. *TRW Series on Software Technology. Volume 1: Characteristics of Software Quality.* Amsterdam, North-Holland Publ., 1978 [In Russ.: Boehm B.W., Brown J.R., Kas-

par H. i dr. Kharakteristiki kachestva programmnogo obespecheniya. Moscow, Mir Publ., 1981, 208 p.].

[7] Kazakov G. V. *Dvoynye tekhnologii* [Double-Purpose Technology]. 2014, no. 3, pp. 59–63.

[8] Mills H. D. *On the Statistical Validation of Computer Programs. FSC-72-6015,* Gaithersburg, Md., IBM Federal Systems Div. Publ., 1972.

[9] Halstead M.H. *Elements of Software Science.* Amsterdam, Elsevier North-Holland, Inc. Publ., 1977, 128 p. [In Rus.: Halstead M.H. Nachala nauki o programmakh. Moscow, Finansy i statistika Publ., 1981, 128 p.].

[10] *GOST P ISO/IEC 9126-93. Informatsionnaya tekhnologiya. Otsenka programmnoy produktsii. Kharakteristiki kachestva i rukovodstva po ikh primeneniu* [RF standard P ISO/IEC 9126-93. Information technology. Assessment of program production. Characteristics of quality and a manual on their application]. Moscow, Gosstandart Russii Publ., 2004, 9 p.

[11] GOST P ISO/IEC 15408-3–2013. *Informatsionnaya tekhnologiya. Metody i sredstva obespecheniya bezopasnosti. Kriterii otsenki bezopasnosti informatsionnykh tekhnologiy. Chast 3. Komponenty doveriya k bezopasnosti* [RF standard GOST P ISO/IEC 15408-3–2013. Information technology. Methods and means of ensuring security. Criteria for assessing the security of information technology. Part 3. Components of trust in security]. Moscow, Standartinform Publ., 2014, 267 p.

[12] *GOST 28195-89. Otsenka kachestva programmnykh sredstv. Obshchie polozheniya* [USSR State standard. Software quality assessment. General provisions]. Moscow, Izdatelstvo standartov Publ., 2001, 30 p.

[13] Galaktionov V.S., Znak V.A., Znak N.E., Kazakov G.V., Kotyashev N.N., Sidorov A.V. *Strategicheskaya stabilnost — Strategic stability*, 2009, no. 3, pp. 59–66.

[14] Kazakov G.V., Znak V.A., Danilin S.B. Ob odnom podkhode k formirovaniu ratsionalnogo mnozhestva testovykh variantov na osnove metoda faktornogo analiza [On an approach to the formation of a rational set of test options based on the factor analysis method]. In: *Trudy Moskovskogo instituta teplotekhniki* [Proceedings of Moscow Institute of Heat Engineering]. Moscow, MIT Publ., 2015, vol. 15, part 1, pp. 114–119.

[15] Kazakov G. V. Metod otsenki pokazatelya nadezhnosti spetsialnogo programmnogo obespecheniya komplekcov sredstv podgotovki dannykh po rezultatam ispytaniy na etape razrabotki [Method for estimating the reliability index of special software for data-preparation facilities based on test results at the development stage]. In: *Trudy Moskovskogo instiyuta teplotekhniki* [Proceedings of Moscow Institute of Heat Engineering]. Moscow, MIT Publ., 2015, vol. 15, part 1, pp. 102–113.

[16] Bordukov M.M., Galaktionov V.S., Znak V.A., Znak N.E., Kazakov G.V., Sidorov A.V. *Dvoynye tekhnologii* [Double-Purpose Technology]. 2009, no. 4, pp. 34–38.

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