Analysis of Russian software supporting onboard systems development lifecycle in context of import substitution policy

Natalia Gorelits
Department 2100: Advanced Systems and Avionics Integration
State Research Institute of Aviation Systems (GosNIIAS)
Moscow, Russia
nkgorelits@2100.gosniias.ru

Aleksandra Gukova
Department 2100: Advanced Systems and Avionics Integration
State Research Institute of Aviation Systems (GosNIIAS)
Moscow, Russia
asgukova@2100.gosniias.ru

Dmitry Krasnoshekov
Department 2100: Advanced Systems and Avionics Integration
State Research Institute of Aviation Systems (GosNIIAS)
Moscow, Russia
dvkrasnoshekov@2100.gosniias.ru

***Abstract*—Avionic industry in Russian Federation faces difficulties in organizing the reliable instrumental support of development processes. State-wide active direction on digitalization of the economy doesn't facilitate the issue solving. The choice of software tools is an important component of success while developing complex certifiable software such as aircraft onboard systems. The same situation could be observed in other industries as well. Nowadays the Russian IT-market provides a sufficient amount of different software that can cover the development lifecycle processes of complex certifiable software for avionics in a varying degree. This article analyses the current situation on Russian software market and the impact of import substitution policy of Russian Federation on software developers and consumers – industrial enterprises. Details of regulation document DO-178C for onboard software development are considered to show the importance of correct choice of project's instrumental landscape. Certain types of specialized software tools for development processes automating are considered. Authors identified the basic groups of tool functionality that provide support for the development lifecycle of onboard software. The Russian and foreign PLM (Product Lifecycle Management) and PDM (Product Data Management) systems and other software were examined for compliance with the necessary functionality. For comparative analysis the method based on additive verification of software by criteria was proposed. Research results allowed authors to make a conclusion about current Russian software level in comparison with worldwide analogues. Also some prospects of Russian software further evolution have received justification based on results of this research. Recommendations for the directions of software development and completion are given. The analysis, presented in the article, can be useful for avionic and other industries enterprises which need to choose some software for support the development lifecycle processes in new and ongoing projects of complex systems development. Also specialists who are interested in the current state of Russian IT industry can find some valuable information in this article.**

***Keywords*— software, software analysis, software comparison, Russian software, lifecycle, development lifecycle, onboard systems, onboard software, import substitution, certification, PLM, PDM, complex systems, DO-178C, additive method**

I. Introduction

In addition to the high requirements for the reliability and safety of developing software and products, another huge problem in the production of certified products for domestic avionics is the modern governmental policy on technological independence.

Import substitution and digitalization become two main factors in the development of the Russian economy today [1]-[3].

According to the Federal State Statistics Service (Rosstat), if the import substitution policy implemented, the civil aircraft industry expected in 2020 to reduce import dependence from the level of 60-80% to the level of 50-40% [4].

Developers who recently started to automate processes using foreign software are now forced to seek for adaptable software again among Russian products. However, there is no credible information – if there are fully functional qualified analogues of foreign-made software on the Russian market in the form familiar to the user or not. Is the quality of the product or service that provides it sufficient to develop safety-critical products?

Accordingly, the problem of developing certified software, in addition to meeting the requirements and recommendations of numerous aviation documents (international standards, national standards, guidelines, and qualification requirements acting in the industry), has significantly expanded by the need to comply with the course of technological independence in the Russian Federation.

This article provides an actual overview and analysis of Russian software tools for lifecycle management in the development of certified software. As well there is shown the comparison of Russian software with foreign-made analogues traditionally used in the avionic industry in the Russian Federation and abroad (such as Siemens, IBM, etc.).

The article also provides recommendations that may be in demand by enterprises from different industries that need to migrate from foreign to domestic tool platforms, but first of all avionic industry is main interest for this research.

II. Related work & Background

A. Related Work

Software analysis interests a large number of researchers throughout the Russian Federation and affects different field of activity.

There are not many reviews of software for the avionic industry in the scientific sources available to the general

XXX-X-XXXX-XXXX-X/XX/$XX.00 ©20XX IEEE

public - that is why the appearance of this review was influenced.

Among the scientific works devoted to the topic of comparative analysis of software, we can distinguish the works of Khubaev G. N. [5][6], Shcherbakov S. M. [7], Boikov S. A. [8], Shirobokova S. N. and Serikov O. N. [9], Lisetsky Yu. M. [10], Maslov Yu. G. [11], Zhukov A. G. [12], Krakovskaya T. A co-authored with Tyurnev A. S. [13], Mukhina E. R. [14], Dzyuba E. A. co-authored with Shibanov S. V. and Gerasina A. I. [15], Ozerkova A.V. co-authored with Trubaeva A. L. and Lebedeva M. Yu. [16].

In their work, the authors used three types of methods for software analysis: methods of comparative analysis of software using absorption matrices and graphs [5]-[9], methods of comparison based on binary tables [11]-[13] and simple text reviews [14]-[16]. Separately we would like to highlight the work [10], where author presented the algorithm for selecting the most optimal method for software analysis based on the approach of pairwise comparison of methods.

Our article uses a method of comparative analysis based on additive verification by criteria for selecting software, similar to the one proposed in [11] and adapted for the purposes of this work. The choice of this method is due to the fact that in the case of analyzing tool samples for a small list of parameters, it is quite visual, but at the same time it is not a labor-intensive method to reflect the functional features of the software.

The data obtained as a result of the analysis should first of all be of practical significance for direct users of software (developers, project managers, etc.). In the future, the authors would be interested to develop this topic deeply and to compare software using the method proposed by G. N. Khubaev [5] and his followers, in order to obtain results for comparing both approaches to analysis and draw conclusions about the applicability of different types of analysis methods.

B. Background

Work described in this article was started in GosNIIAS in 2018 in the scope of one of the research and development projects.

First step was made in 2018 and consisted in identification and justification of criteria, which configuration management process puts forward as a requirements for IT-landscape of certifiable product development (especially in avionic industry) [17]. Set of selected criteria was used for analysis of popular requirements management instruments. Results were published and reported during SYRCoSE 2018 conference and some other scientific and practical events.

Next step touched upon the topic of requirements management and its importance for projects in avionic industry [18].

Cursory review of lifecycle management software for certifiable aviation software development was made by authors in 2018 and reported on conference III All-Russian Scientific and Technical Conference "Modeling of aviation systems" [19].

Then special review of requirements management tools for development of safety-critical systems was made by one of the authors and specialists from ISP RAS and published in 2019 [20]. Analytic work was continued and its approach, details and results are described in this article.

III. Research Method

In this paper the analysis based on additive comparison was chosen as the research method in order to compare Russian and foreign software. Analysis consisted of the following steps:

1) Formulation of the problem. At this step some aspects and reasons of tools choice complexity were formulated,

2) Overview of software and selection of two sets – Russian software and foreign software. Software sets were based on the current state of the IT market, available for estimation from open sources data in the Internet, and the authors' knowledge on the current situation at some domestic manufacturing enterprises, which were accumulated as a result of their professional activity. During the software choosing main preferences were given to the software, which is often used in avionic industry enterprises.

3) Selection of a list of functions for software examination. Functions for software examination were chosen based on requirements, regulations and recommendation of industry standards and best practices.

4) Analytic research publicly available from open sources data about software, empirical test of tools which were available for authors. An analysis of the compliance of the tool with the tested features was performed with:

- Analytical research of information published in open sources available for everyone in the Internet - websites of software developing companies, reference and help materials,
- Interaction with software providers,
- Attraction authors' own practical experience with some of selected software.

Found results for both sets were added into the table. Table consists of tools in rows and functions in columns. The following notation was chosen in the table:

- + - function is supported by tool,
- – - function is not supported by tool,
- –, I - function is not supported by tool, integration with third-party tools is required.

5) Counting the formulas for analysis and visualization of data on the diagrams. For counting and visual analysis "+" value was taken as 1, "–" value was taken as 0, "–, I" value was taken as 0.5. Data from the table was examined in two projections with formulas (1) and (2):

$$\forall j = \overline{1, m}: function_j = \sum_{i=1}^{n} x_{ij} \quad (1)$$

$$\forall i = \overline{1, n}: tool_i = \sum_{j=1}^{m} x_{ij} \quad (2)$$

Where:

- n is a size of tools set (with letter ***i*** as index),
- m is a size of functions list (with letter ***j*** as index),
- x_{ij} are values from the table cells,

- $tool_i$ is summed value for each tool,
- $function_j$ is summed value for each function.

6) Fixing conclusions and recommendations.

IV. COMPARATIVE ANALYSIS OF SOFTWARE

A. Formulation of the problem

Before considering the tools for managing the software development lifecycle it is necessary to refer to the aviation regulation document DO-178C [21] and its Russian analogue Qualification requirements part 178C [22] as an example of tools choice complexity.

DO-178C defines the rules for the organization of onboard aviation software development processes which are necessary for successful achievement an acceptable level of confidence in product safety and to confirm this level by passing certification and obtaining special aviation certificate. DO-178C defines such important goals like change management and quality management for all of the lifecycle phases.

Regulation document DO-178C specifies the processes of onboard development lifecycle: their definition, input and output data, recommended activities, criteria for the transition between them and many other useful details. But DO-178C does not prescribe the developers of certified software the preferred models of software development lifecycles and the interaction between them. Perhaps this is the reason why the choice of tools becomes such a time-consuming decision for airborne systems software developers, causing numerous disputes, questions and consequences [23]. In the case of the wrong choice of tool, the cost of resources for changing the IT-landscape and subsequent changes in the project can be very significant especially on the last stages because of the need for certification to start the whole project from almost the very beginning with new set of software. This inevitable decision will cause the loss of pace and the competitive advantage in the market as a result.

In this work we wouldn't analyze tools for compliance with DO-178C requirements. Partly this work was done in other articles of authors [17][18][20].

The next sections of this article describe some packages of Russian software that partially or fully cover the entire software development lifecycle. As well there is maid a comparison of chosen software tools functionality on a set of features with foreign analogues.

For the other parts of aircraft processes such as level of hardware or level of the whole system the developer should analyze lifecycle processes by himself. All of conclusion from this article could be applicable for other levels of processes after some analysis and adaptation if it needs. For example, lifecycle processes for airborne hardware with regulation document DO-254 [24][25] aren't significantly differ from software lifecycle processes.

Product lifecycle management systems (managing product data) support the full cycle of product and software development and have advanced functionality compared with single-process targeted tools.

Systems, supporting the full cycle of product and software development, include such software groups as Product Data Management systems – PDM systems, Product Lifecycle Management systems – PLM systems, and Collaborating Lifecycle Management systems – CLM systems.

During the analysis two sets of domestic and foreign PLM/PDM systems were formed. Chosen systems cover a similar functional basis of the lifecycle processes. And also a list of functions was selected, which must be automated by tools. The results of the analysis are given below (Table 1).

B. Overview of software & sets selection

This chapter contains briefly overview of some CIS-made but in general Russian systems. Complete description could be found on developers sites. These systems will be analyzed below.

1) T-FLEX DOCs PLM

T-FLEX DOCs software is a scalable solution for product lifecycle management (PLM) and enterprise organization [26]. The solution is based on a set of software T-FLEX CAD/CAM/CAE/CAPP/PDM/CRM/PM/MDM/RM/ - a set of software supplied by one manufacturer – Russian company "Top Systems". It makes possible to organize a single environment for design and technological document flow, design and production preparation.

The solution "T-FLEX DOCs" includes the following capabilities:

Engineering Processes and Design Management; General Office and Desk Workflow; Enterprise Knowledge Management and Archive; Project Management, Cost and Resource Planning; Mail and Tasks, Workflow Management; Integration with ERP Systems; Managing Company Product Range, Corporate Data and Classifiers; Product Structure Management, Bill of Materials, Configurations and Versions; Integration with Major MCAD Systems; Customized Information Systems.

2) Full Lifecycle Management System: "Digital enterprise" (TIS: Digital enterprise)

It is domestic protected system for managing the full lifecycle of products "Digital enterprise", developed by Russian Federal Nuclear Center – «Rfyats-Vniief» [27].

The software product «Digital enterprise» includes:

Complex of software for digital enterprise resource management, digital enterprise personnel management, production management system, performance management system based on BI-solutions, project and program management, integration platform, regulatory and reference information management, portal services, product lifecycle management, PDM system, protected operating system «Synergy 1.0».

3) Soyz PLM

Soyuz-PLM is a system for managing engineering and technical information throughout the product lifecycle, developed by Russian company – «Programsoyuz» [28]. Soyuz-PLM is a software package designed to solve various problems of engineering data management in the field of mechanical engineering, instrumentation, architecture, construction and related fields.

The main features are dynamic configuration of the data model as the enterprise develops, the ability to work in a geographically distributed environment, access differentiation and management, and the design of text-based technical documentation for PLM data, integration with external applications, management of processes and regulated procedures, document management, secure storage of engineering data.

4) IPS PLM (Intermech Professional Solutions)

A universal information system for product lifecycle management based on enterprise-level INTERMECH solutions designed to manage engineering data and provide information support for a product at various stages of its lifecycle [29]. Currently, IPS PLM is used in various industries – mechanical engineering, instrumentation, industrial and civil construction, nuclear industry, and the military-industrial complex. The software was developed by Belorussian company «Intermech».

5) Appius-PLM

Integrated information system for product lifecycle management and ERP regulatory framework on the 1C platform: Enterprise 8.3, developed by Russian company «Appius» [30]. Appius-PLM - the solution for managing entire enterprise as a single complex, created based on experience in the development and implementation of CAD/CAM/CAPP/PDM/PLM systems, which allows including design and technological divisions in a single information space of the enterprise, with a single database.

C. Selection the PLM/PDM tools for comparison

Among Russian systems, supporting the full cycle of product and software development – PLM/PDM systems we can distinguish the following set: T-FLEX DOCs, Full lifecycle management system "Digital Enterprise" (TIS: Digital Enterprise), APPIUS PLM, Lotsman PLM, Lotsia PLM, Soyuz PLM etc. Also it was decided to include in the analysis the Belorussian software IPS PLM, as the most common system in the CIS countries. The following tools were chosen for the set **TOOLS 1**: T-FLEX DOCs [26], Full lifecycle management system "Digital Enterprise" [27], Soyuz PLM [28], IPS TDM| PDM| PLM | Workflow (Automated Control Systems for Design and Technological Preparation of Production) [29], APPIUS PLM [30].

Among foreign systems with similar functions for the full cycle of product and software development the following systems were chosen for analysis: Siemens Team Center PLM [31], PTC Windchill PLM [32], Dassault Systemes Enovia [33], SolidWorks Enterprise PDM [34]. Also it was decided to include integral solution from IBM - IBM Rational Collaborating Lifecycle Management [35] to the foreign set. Because some components of this solution (such as DOORS / DOORS NG, Change / Synergy, Team Concert, Rhapsody, Test RealTime and others) are most often used at aviation enterprises in the Russian Federation either in separate way of using or in some varies of integration (more rarely). These tools put together a set **TOOLS 2**.

D. Selection the list of functions for comparison

Industry regulations [21][22][24][25][37]-[41], national and international standards [42]-[45], best practices and requirements from enterprises and users for PLM/PDM systems and separate types of tools, accumulated by authors during their work way, were analyzed and gave a huge list of useful and necessary functions for tools for the full lifecycle coverage. Some functions were chosen to make a comparative analysis of systems in sets **TOOLS 1** and **TOOLS 2** – necessary features for automation or support the full cycle of product and software development. These features made up a list of parameters **PLM/PDM PARAMS** (short name of parameter for diagram put in braces):

- Ability to integrate with CAD systems (short: CAD),
- Reference data management (short: RDM),
- Ability to make custom agreement processes with electronic signature and other types of workflows (short: Workflow),
- Technological support of production (short: Support),
- Requirements management (short: RM),
- Quality management (short: QM).

E. Comparative analysis

TABLE I. COMPARATIVE ANALYSIS OF PLM/PDM SYSTEMS: FUNCTIONS

Name of software	Russian software	Integration with CAD systems	Reference data management	Workflow, e-signature, agreement	Technological support of production	Requirements management	Quality management
Set TOOLS 1: Russian/CIS software							
T-FLEX DOCs	+	+	+	+	+	+	–
Full lifecycle management system "Digital Enterprise" (TIS: Digital Enterprise)	+	+	+	+	+	+	–
Soyuz PLM	+	+	+	+	+	+	–
IPS TDM| PDM| PLM | Workflow	+	+	+	+	+	–	–
Appius PLM	+	+	+	+	+	–	–
Set TOOLS 2: foreign software							
SolidWorks Enterprise PDM	–	+	+	–, I	+	–	–
IBM Rational Collaborating Lifecycle Management	–	–	–	+	–	+	+
Dassault Systemes Enovia	–	+	–, I	–, I	+	+	–
PTC Windchill PLM	–	+	–, I	+	+	+	+
Siemens Team Center PLM	–	+	+	–, I	+	+	+

F. Counting and visualization

Then in first case tools score from each set was summed up for each parameter from the set of functions. Here the formula (1) was used. On the Fig. 1 there is a comparison between two sets **TOOLS 1** and **TOOLS 2** by **PLM/PDM PARAMS** – how many tools from each set have selected functions. Fig. 1 shows that there are some more attractive features for product developers, whereas other features are very important as well.

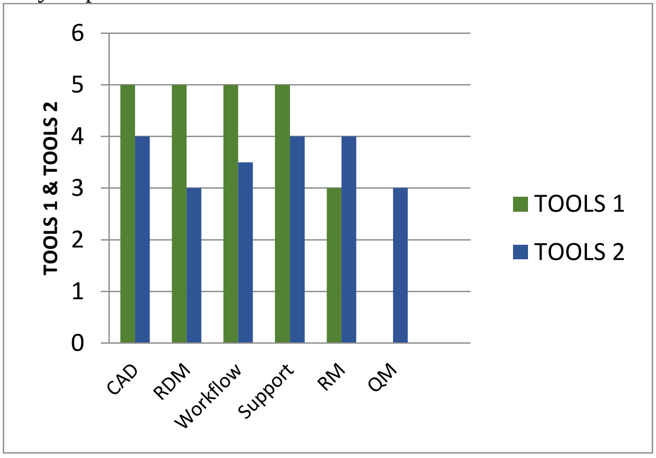

Fig. 1. How many tools from sets TOOLS 1 and TOOLS 2 have functions from PLM/PDM PARAMS list

In the second case values of features for each software were summed. Both sets **TOOLS 1** and **TOOLS 2** were compared between each other and with some hypothetical Reference tool – how many functions from **PLM/PDM PARAMS** list has each software from sets **TOOLS 1** and **TOOLS 2**. Reference tool has all features - 6. Here the formula (2) was used. Fig. 2 shows that no one tool from both sets has all features. And also it is seen on both Fig. 1 and Fig. 2 that in set **TOOLS 1** (Russian software) more instruments have necessary functions than in set **TOOLS 2** (foreign software).

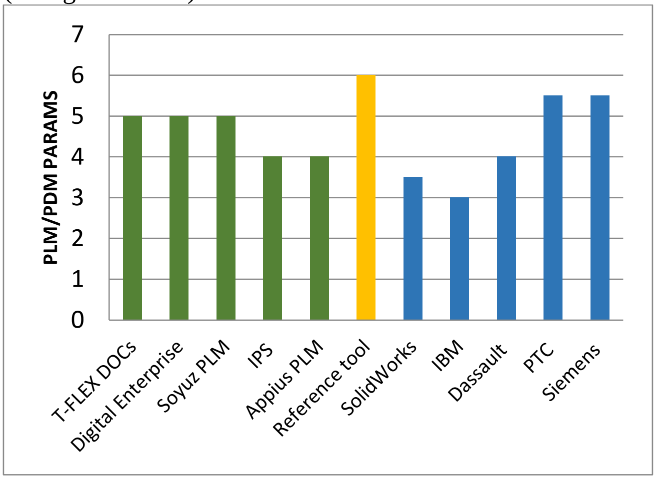

Fig. 2. How many functions software from sets TOOLS 1 and TOOLS 2 covers

G. Intermediate conclustion

All of the listed software products have much in common by functionality. Foreign software, unlike Russian, does not take into account the existing mentality and work culture of specialists in the post-Soviet space and enterprises. Domestic software was created to solve problems and based on the needs of only Russian enterprises, considering their specificity and the established regulatory framework.

Because of this fact the functionality and technological processes in domestic PLM and PDM systems are developed with better attention to local needs and rules. The built-in processes, document flow, data formats, reports and etc. more closely correspond to Russian standards.

In order to support processes, which are common to all developers, and also domestic-specific Russian processes, software from foreign vendors must either be integrated with Russian modules or develop add-ons with similar functionality. All of these additional activities will lead to extra costs and time losses during implementation of software that is already very expensive.

Nowadays Russian aviation enterprises solve the problems of supporting the full lifecycle of their products. And these problems go beyond the design and technological preparation of production. That is why Russian PLM systems are also growing dynamically. However, they are moving after Russian enterprises - their development takes place and has a direction depending on the needs of specific customers. The solutions of foreign vendors such as DASSAULT Systemes, Siemens PLM, PTC, IBM and other foreign developers contain the experience of Western industrial enterprises, which are much more advanced than domestic ones due to the earlier and balanced implementation of approaches and practices of systems engineering [42][46][47].

Nevertheless, the teams of domestic developers deeply understand the need to automate the processes of lifecycle and the provision of end-to-end technologies in their software. Today developers already add to their product lines such modules as, for example, requirements management (T-FLEX DOCs, Soyuz PLM) or complaint management (T-FLEX DOCs). Also it makes sense to highlight the software product 8D from ASCON [48]. 8D wasn't included to the set **TOOLS 1** but nevertheless 8D is one of the few products in the Russian Federation in which quality management support has appeared.

All these facts allow us to surely conclude that domestic PLM and PDM systems are ready to correspond foreign analogues, and even bypass them according to a number of criteria. Moreover, Russian software is closer to Russian production realities, which probably makes the introduction of such software less "traumatic" for users.

V. Recommendations for choosing software

In the context of the import substitution policy in Russian Federation, it is necessary to consider additional parameters besides to functionality when choosing software. The same additive method as proposed in this article was used for analyzing and visualizing the result.

Some characteristics were chosen to estimate the readiness of Russian software to replace foreign analogues from the point of view of the import substitution program for increasing technological independence of Russian Federation. These characteristics made up a list of parameters **SUBSTITUTION PARAMS**:

- Registration in the Russian Register (Unified Register of Russian programs for electronic computers and databases) [49];
- Earning the certificate of FSTEC of Russia (Federal Service for Technical and Export Control) [50];
- Integration with other software tools or built-in software functions (CAD/ECAD systems, workflow systems, configuration management systems, master data management systems, ERP systems, etc.)
- Russian-speaking technical support;
- Compliance with the statement of the problem – providing functions which cover necessary aspects of lifecycle processes and features of foreign analogues;
- Successful implementation to the aviation industry enterprises;
- Successful implementation to the other industries enterprises.

Just to show the example of these recommendations applying here will be given one more analysis - software tools from the set **TOOLS 1** were taken for analysis with **SUBSTITUTION PARAMS**.

The results of the analysis are given below (see Table 2, Fig. 3 and Fig. 4).

TABLE II. COMPARATIVE ANALYSIS OF RUSSIAN SOFTWARE: IMPORT SUBSTITUTION

Name of software	Registration in the Russian Register	Certificate of FSTEC of Russia	Compatibility/ integration	Russian-speaking technical support	Implementation to the aviation	Implementation to the other industries
T-FLEX Docs	+	–	+	+	+	+
Full lifecycle management system “Digital Enterprise” (TIS: Digital Enterprise)	+	+	+	+	–	+
Soyuz PLM	+	–	+	+	–	+
IPS TDM| PDM| PLM | Workflow	–	+	+	+	+	+
Appius PLM	+	–	+	+	+	+

The following notation is used in the table:

- + - parameter is supported by software developer or distributor (this value was taken as 1),
- – - parameter is not supported by software developer or distributor (this value was taken as 0).

Similarly with the previous analysis Fig. 3 and Fig. 4 were formed. Fig. 3 shows how many tools from set **TOOLS 1** automate each feature from **SUBSTITUTION PARAMS** list. It is seen that not all instruments satisfied all parameters - some parameters are more difficult to satisfy than others. Here the formula (1) was used.

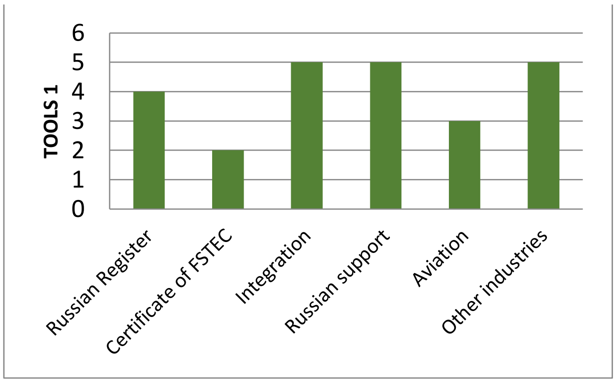

Fig. 3. How many tools from set TOOLS 1 have features from SUBSTITUTION PARAMS list

Fig. 4 shows how many features from **SUBSTITUTION PARAMS** list has each software from set **TOOLS 1**. Instruments were compared between each other and with some hypothetical Reference tool. It is seen that there is no real instrument in set **TOOLS 1**, which could satisfy all import substitution parameters like Reference tool with 6 score. Here the formula (2) was used.

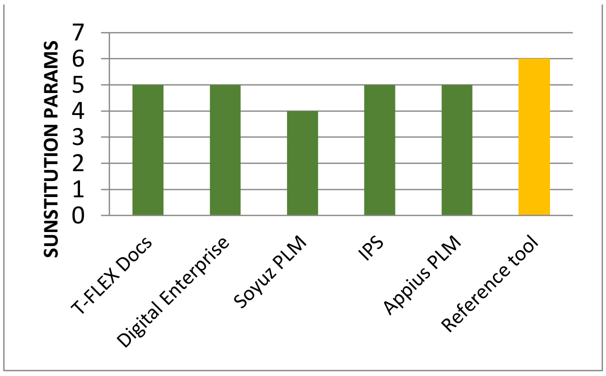

Fig. 4. How many features software from set TOOLS 1 covers

Some more facts should be carefully checked out and used as potential parameters for comparison during choosing software: comparison with analogues, geographical location, staff for implementation and history of successful implementations. Here is a short description of these facts below as text just not to complicate the table and figures.

It is important to know during choosing a software if any comparisons with foreign analogues were carried out. For example, what percent of the functions of a foreign analogue are covered by software under review? And what plans for further development are existed — whether it is planned by developer to cover 100% of the functions in the near future?

For nowadays situation with import substitution the aspect of geographical location is very important as well. Enterprises should pay attention on it – if developer's servers and software development itself are located on the territory of the Russian Federation. For example, if the software was developed by a foreign company, and then a company in the Russian Federation bought it – presently software's origin may become an obstruction to its implementation in Russian governmental enterprises in the boundaries of import substitution.

Additional advantages to software developer while choosing software are a pool of partners or their own experienced staff for implementation and training and a history of successful implementation in the avionic industry or related industries.

VI. Conclusion

In Russian Federation not only avionic industry but also aerospace, nuclear, railway, automobile, shipbuilding, medical and other industries have difficulties in automating development processes, despite the active digitalization course of the state.

Choosing the toolset that will be used throughout the project is an important element in planning the development of complex certified software. IT-landscape has a significant impact on the success and cost of the entire project.

Software developers in the aviation sector do not have a common opinion about what should be an ideal tool for managing the processes of software and product development and its entire lifecycle. Some developers want to see a single platform to support development lifecycle and complete automation of all processes. Another part of developers insists that more processes should be controlled manually, because not all processes can be properly automated at the moment for various reasons.

There is no consensus on this issue - regulatory documents usually do not impose the development process or preferred lifecycle models by the developer, but only provide recommendations for the organization of this process and its limitations.

At the time of writing this article, there is no ideal tool for solving problems of automation the development processes in the industry, which has proven itself in practice in the Russian Federation - the concept of unity of digital platforms is only at the beginning of its path.

But it is already being discussed at the state level, so we have chance to see its successful implementation in the future.

As in the case of foreign software – it is not enough just to buy and install "boxed" Russian software– it also requires huge labor costs for adapting processes, methodology, implementation and training of enterprise personnel.

There is bit public information about the successful implementation of Russian systems in aviation. There is only information published on the official websites of vendors that indicates the fact of purchasing software. The last decade authors' experience of interaction with Russian industrial enterprises and software suppliers has shown that the purchase of software licenses does not guarantee the use and successful implementation on the enterprise. Despite it at the same time the project can be listed on the developer's website as an example of successful implementation because of business interests.

However today there is a sufficient amount of software available on the Russian market that can cover part of the software lifecycle processes in the development of complex certified software. Many software developers are open to interaction with enterprises and users and, reviewing the trend of recent years, are ready to refine their software in accordance with industry requests. For example, important modules for requirements management and quality management have already appeared in some Russian systems although previously these modules were missing.

Based on the results of the analysis, we can make a conclusion about the active development and use of domestic Russian systems and tools with an insufficient level of integration between them. The effectiveness of using an isolated tool decreases due to the need to convert, and sometimes re-enter existing (in another system) source data. The same output can be noted for using the results of work that require additional actions to transfer data to the system for further use.

Russian software covers the automation of technological processes of domestic Russian enterprises better than foreign software. And today Russian software is not inferior to foreign manufacturers in integration with design data. And it is pleased to note that some Russian analogues of CAD and ECAD systems have been developed already.

The results of the analysis and suggested recommendations given in this article should help enterprises and organizations from various industries at the initial stages of choosing import-substituting tools for automating enterprise development processes.

References

[1] Decree of the Government of the Russian Federation of April 15, 2014 N 328 "On approval of the state program of the Russian Federation" Development of industry and increasing its competitiveness" http://ivo.garant.ru/#/document/70643464/paragraph/1:0 (in Russian)

[2] Decree of the Government of the Russian Federation of March 2, 2019 N 234 "On the system for managing the implementation of the national program" Digital Economy of the Russian Federation" http://ivo.garant.ru/#/document/72190034/paragraph/1:0 (in Russian)

[3] Shelomanova P.A., Kuzmin R.A., The state program of import substitution in the Russian economy until 2020. Development and current issues of modern science, Magnitogorsk, vol. 5, 2017, pp. 72-76, (in Russian)

[4] Federal State Statistic Service (Rosstat) https://www.gks.ru/

[5] Khubaev G.N. Comparison of software by «Functional completeness» criterion. Programmnye produkty i sistemy (Software & systems). 1998. No. 2. pp. 6-9 (in Russian)

[6] Khubaev G. N. Comparison of software by «Performance» criterion. Programmnye produkty i sistemy (Software & systems). 2008. № 4. pp. 27—33 (in Russian)

[7] Shcherbakov S.M. The method of analysis of complex systems by the criterion of functional completeness: expansion and adaptation. System Management. 2010. №2(8) (in Russian)

[8] Boykov S. A. Models and valuation methods of the functional completeness of information systems for the state institutions in the social sphere. Business. Education. Law. Bulletin of Volgograd Business Institute, 2014, november № 4 (29), pp. 231-235 (in Russian)

[9] Shirobokova S.N., Serikov O.N. Formal analysis of functional completeness of a system of video analytics. Electronic scientific journal «Engineering journal of Don». 2019. №1 (52). pp.33-47 (in Russian)

[10] Lisetsky Yu.M. Algorithm comparison of methods of complex quantitative quality evaluation of the complex systems. Programmnye produkty i sistemy (Software & systems) 2012. №4, pp.153-156 (in Russian)

[11] Maslov Yu.G. About the methodology for software products comparison. Electronic journal «Information Security». 2007. №2, pp.56-57 (http://lib.itsec.ru/articles2/control/o_metodike_sravneniya_programmnih_produktov, 18.05.2020)

[12] Zhukov A.G. Comparison of software products based on the analytic hierarchy. European researcher. 2011. № 6 (9), pp.934-935 (in Russian).

[13] Krakovskaya T. A., Tyurnev A.S. Comparative analysis of software products for marketing research. Modern technologies, System analysis, Modeling. 2007. №1(13), pp.120-126 (in Russian)

[14] Mukhina E.R. Comparative characteristics of software products allowing management accounting. Actual problems of humanitarian and natural sciences. 2014. №9, pp.160-163

[15] Dzyuba E.A., Shibanov S.V., Gerasina A.I. Comparative analysis of modern instruments supporting the life cycle of information systems. Proceedings of International Symposium «Reliability and quality»2012. №1, pp. 420-426

[16] Ozerkova A.V., Trubaeva A.L., Lebedeva M.Yu. Comparison of software products that can be used in the organization MUP KH "CHISTIC". New science: from idea to result. 2016. №4-1, pp. 65-68

[17] Gorelits N.K., Gukova A.S., Peskov E.V. Criteria for software to safety-critical complex certifiable systems development. Trudy ISP RAN/Proc. ISP RAS, vol. 30, issue 4, 2018, pp. 63-78

[18] Krasnoshekov D.V., Gorelits N.K., Peskov E.V., Requirements management for software development in the aviation industry. IT-Standard, vol. 2(15), 2018, pp.12-17 (in Russian)

[19] Gorelits N.K., Gukova A.S. Overview of lifecycle management software for certifiable aviation software development. Thesis of III All-Russian Scientific and Technical Conference "Modeling of aviation systems", 2018, p. 223 (in Russian)

[20] Gorelits N.K., Kildishev D.S., Khoroshilov A.V. Requirements management for safety-critical systems. Review. Trudy ISP RAN/Proc. ISP RAS, vol. 31, issue 1, 2019. pp. 25-48 (in Russian)

[21] Software Considerations in Airborne Systems and Equipment Certification (RTCA DO-178C), 2011.

[22] Qualification requirements part 178C. Software requirements for onboard equipment and systems for certification of aviation equipment. M., AR MAK, 2016, 131 p. (in Russian).

[23] Solodelov Yu.A., Gorelits N.K. Certifiable onboard real-time operation system JetOS for Russian aircrafts design. Trudy ISP RAN/Proc. ISP RAS, vol. 29, issue 3, 2017, pp. 171-178. (in Russian)

[24] Design Assurance Guidance for Airborne Electronic Hardware (RTCA DO-254), 2000

[25] Qualification Requirements part 254. Guidance on the warranty design of onboard electronics. M., IAC, 2011 (in Russian)

[26] T-FLEX DOCs PLM https://www.tflex.com

[27] Full lifecycle management system “Digital Enterprise” http://vniief.ru/en/, http://vniief.ru/researchdirections/tisjaok/

[28] Soyuz PLM http://www.programsoyuz.ru/products/system-soyuz-plm/, https://www.xn--g1ahdico6g.xn--p1ai/platform

[29] IPS TDM| PDM| PLM | Workflow https://intermech.ru

[30] APPIUS PLM http://www.appius.ru

[31] Siemens Team Center PLM https://new.siemens.com

[32] PTC Windchill PLM https://www.ptc.com/en

[33] Dassault Systemes Enovia https://www.3ds.com

[34] SolidWorks Enterprise PDM https://www.solidworks.com

[35] IBM Rational Collaborating Lifecycle Management https://jazz.net, https://www.ibm.com

[36] Aerospace recommended practice. Guidelines for development civil aircraft and systems (SAE ARP 4754A), 2010

[37] Guideline R-4754A on the development of civil aircraft and systems. M., IAC, 2016, 131 p. (in Russian)

[38] Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment (SAE ARP 4761), 1996

[39] Guidelines R-4761 for Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment, IAC, 2011 (in Russian)

[40] Integrated Modular Avionics Development Guidance and Certification Considerations (RTCA/DO-297), 2005

[41] Guidelines R-297 for integrated modular avionics development and qualification, 2015 (in Russian)

[42] ISO/IEC/IEEE 15288 System engineering — System life cycle, 2015

[43] ISO 10007 Quality management — Guidelines for configuration management, 2017

[44] ISO/IEC 12207 Systems and software engineering – Software life cycle processes, 2008

[45] ISO/IEC/IEEE 29148 Systems and software engineering – Life cycle processes – Requirements engineering, 2011

[46] Koverninskiy I.V, Kan A.V., Volkov V.B., Popov Yu.S, Gorelits N.K. Practical experience of software and system engineering approaches in requirements management for software development in aviation industry. Trudy ISP RAN/Proc. ISP RAS, 2016, vol. 28, no 2, pp.173-180.

[47] Gorelits N.K., Peskov E.V. Analysis of system engineering approaches for complex systems development in aviation industry. Thesis of III All-Russian Scientific and Technical Conference "Modeling of aviation systems", 2018, p. 231 (in Russian)

[48] Ascon 8D.Quality management https://ascon.ru/products/1248/review/

[49] Unified Register of Russian programs for electronic computers and databases https://reestr.minsvyaz.ru

[50] Federal Service for Technical and Export Control https://fstec.ru