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GTE Resource Assessment and Renewal Software

Konstantin Rizvanov*
Department of Automated Control Systems
Ufa State Aviation Technical University
Ufa, Russian Federation
rizvanovk@bk.ru

Gennady Kulikov
Department of Automated Control Systems
Ufa State Aviation Technical University
Ufa, Russian Federation
gennadyg_98@yahoo.com

Dmitry Rizvanov
Department of Computational Mathematics and Cybernetics
Ufa State Aviation Technical University
Ufa, Russian Federation
ridmi@mail.ru

***Abstract*—In the proposed article, the GTE resource extension software is considered. System models for the extension of the GTE resource during the formation of the digital twin of the GTE have been developed. The stages of the life cycle of a gas turbine engine are tested and operated. The use of various BI / ERP / PLM systems in the formation of a digital twin of GTE is proposed. It is proposed to use the relationship between the organization's business processes and the content of the information space in the digital twin of GTE. The structure of an automated workplace for monitoring and diagnosing gas turbine engines is described. It is proposed to use the database structure of the GTE resource expansion parameters for use in the GTE digital twin. It is proposed to use Oracle DBMS to integrate information obtained as a result of resource tests with the Teamcenter PLM system.**

***Keywords*—digital twin, aviation gas turbine engine, life cycle, gate system**

I. INTRODUCTION

Currently, in the aircraft engine industry, an urgent task is the transition to the concept of designing and manufacturing gas turbine engines using digital twins. To determine the structure of the digital twin of an aircraft gas turbine engine, we describe the main stages of the life cycle of a real gas turbine engine [1-4].

Consider the stage of the life cycle GTE functional design. At this stage, a 0D model of a gas turbine engine is created using various CAD / ERP / PLM systems, which includes the main characteristics of a gas turbine engine, such as mass, dimensions, cost, etc. At the end of this stage, the terms of reference for the gas turbine engine are formed, its development begins, and a virtual gas turbine engine model is created. At the following design and manufacturing stages, a full 3D solid-state gas turbine engine model based on CAD / PLM systems, a 3D aerothermodynamic and strength model using CAE / PLM systems are developed, production technologies based on CAM / PLM systems are developed, and the cost of creation in ERP system [5-7].

At the end of the design, an electronic model of the gas turbine engine is created, and its virtual certification is carried out. At the end of manufacturing, a real gas turbine engine appears, ready for bench tests. At the testing and certification stage, a complete gas turbine engine model is formed on the basis of identifiable nodes. At the next stages, serial production and operation begins the serial production of gas turbine engines, virtual manuals, a diagnostic model of gas turbine engines and the support of a specific gas turbine engine are developed. All the information obtained at the stages considered in the GTE liquid engine falls into the DB of the GTE digital twin. The analysis of the considered scheme shows that the digital twin of a gas turbine engine should dynamically develop throughout its life cycle. It is advisable to develop a gate system for it.

II. GTE RESOURCE EXTENSION SYSTEM MODEL

The extension of the GTE resource is one of the last stages of the gate system, which is called the GTE test. In aircraft engine manufacturing, it is customary to extend the life of a gas turbine engine to conduct tests on a standard gas turbine engine for the number of hours by which the resource is extended. If the tests pass without comment, the developer of the gas turbine engine decides to extend the life. The development of a system model includes the development of functional, informational, dynamic and mathematical models.

The IDEF0 methodology is a set of methods, rules, procedures designed to build a functional model. It is intended to represent the functions of the system and analyze the requirements for systems and is one of the most famous and widely used methodologies for designing control systems. The functional model is intended to describe the existing system in the enterprise (AS-IS model) and the proposed one - the one to strive for (TO-BE model), which in the future will be the basis for developing control system algorithms.

IDEF0 prescribes the construction of a hierarchical system of diagrams - single descriptions of fragments of the system [8-10].

The construction of a functional model begins with setting a goal for judging the subject area under consideration and choosing the point of view from which we will consider it. In order to carry out the transformations, first of all, it is necessary to understand how the functioning of the system occurs and to build a functional model of the existing system.

The goal is a pre-design survey of the functioning of the existing system, the point of view is the developer of the gas turbine engine. Secondly, it is necessary to build a functional model of the proposed system [11-14].

The goal is to improve the existing system for extending the resource of a gas turbine engine, the point of view is the developer of a gas turbine engine. Classification can be performed using information retrieval systems. In this case, the search index will play the role of the classifier.

When referring to the query to the classifier, it is possible to extract pointers to information resources from different systems uniformly. Fig. 1 shows the relationship between the organization's business processes and the content of the information space.

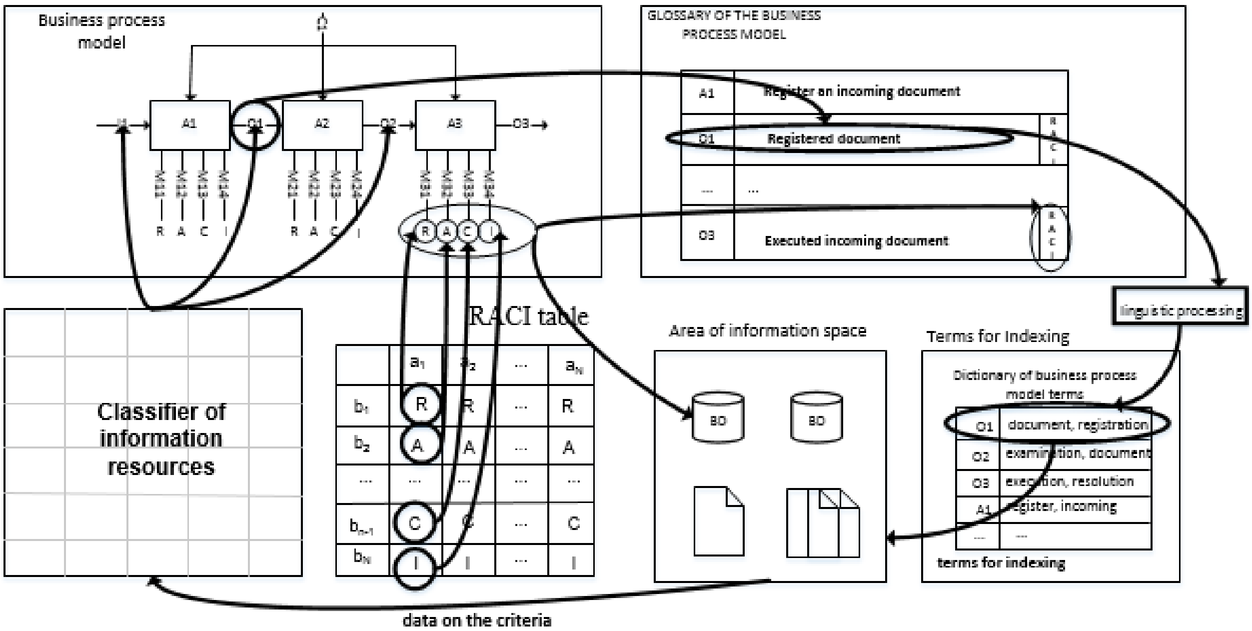

Fig. 1. The relationship between the organization's business processes and the content of the information space

The presence of a structured and formalized information model allows you to automate the design and technological tests, including tests to extend the life and analysis of test results according to the following scheme:

1) organize the search and collection of necessary documentation, including methodological support for the preparation of tests in an automated mode:

- development of technical conditions for testing;

- development of a calendar plan and resource and information support for testing;

2) provide information support for testing, filling the database of tests;

3) to organize access to the database and data processing using automated techniques and algorithms;

4) provide informational support in a collective analysis of the results.

The results of the analysis are recorded in the database. At the decision-making stage, access to the results is provided.

III. Functional Structure of a Workstation for Gas Turbine Engine Control and Diagnostics

An automated workstation for gas turbine engine monitoring and diagnostics provides:

- registration and display of information received from the electronic control system (ECS), in stationary and variable modes in real time;

- printing of tables, graphs, visualization of devices in real time;

- tuning and control of the ECS on the engine;

- information support for the operation of the ECS when testing the engine at the bench;

- imitation of information interaction with the aircraft's onboard systems;

- transfer of information to an automated information system for organizing a single protocol in real time;

- receiving, converting and recording information received from ECSs through real-time information exchange channels;

- the formation and storage in the database of information received from the ECS during testing, the results of its processing for analysis of engine operation and diagnostics;

- output of information on the results of the built-in ECS control system to indicating and documenting in the form of electronic protocol and form.

In fig. 2 shows the structure of an automated workstation for the control and diagnosis of gas turbine engines.

In fig. 3, for example, the process of starting a gas turbine engine with an electronic control system is shown, obtained using a technological automated workstation for monitoring and diagnostics in real time, including only standard parameters from more than 100 parameters registered for analysis, including the parameters of the built-in control of the self-propelled guns and the engine. Test data are placed in a heterogeneous test database, to which access is granted to design services for their detailed analysis.

An automated workstation for monitoring and diagnosing a gas turbine engine is designed to assess its technical condition during operation, to identify and prevent engine failures and its main functional systems in flight. Analysis of flight information allows you to classify engines as “good” and “suspicious as faulty”, to identify irregularities in the functioning of the engine’s functional systems and failures of the parameter monitoring and registration system, make reasonable decisions about the engine's technical condition, necessary replacements, inspections and adjustments, and conduct automated search malfunctions [15].

The technical condition of the engine is determined by the following parameters:

- according to the compliance of the engine parameters with the operating manual;

- to change the parameters of the working process according to the operating time;

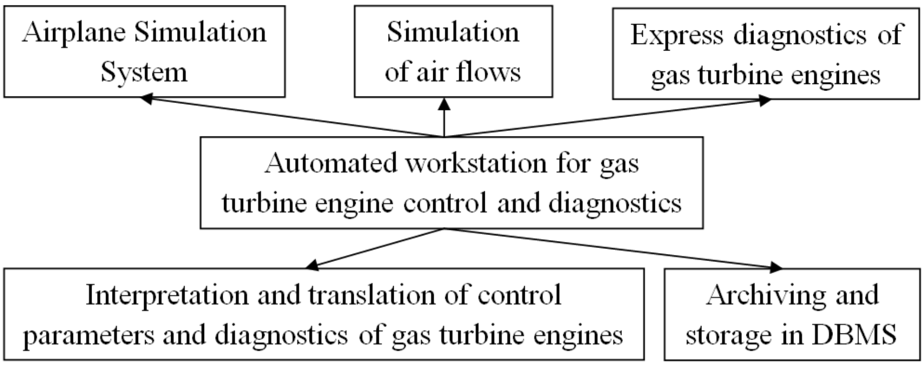

Fig. 2. The structure of an automated workstation for the control and diagnosis of gas turbine engines

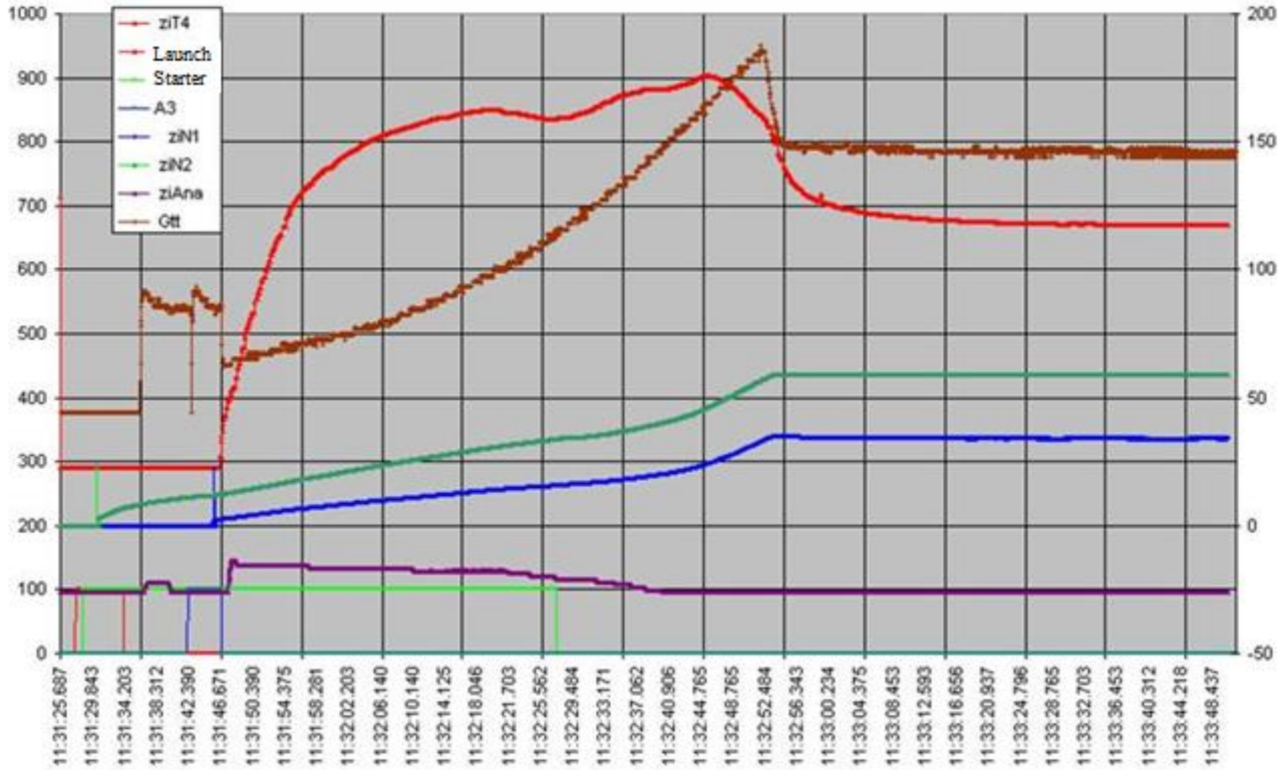

Fig.3. GTE Test Example

- according to the results of calculating the damage to parts and determining the residual life of the engine;

- to change the vibration state of the engine;

- according to the results of instrumental control of the engine;

- by changing the concentration of metallic impurities in the oil.

In aviation gas turbine engines, the main types of loading that determine the resource are operating time in modes, which leads to accumulation of damage by long-term static strength, and cyclic loads, which lead to accumulation of damage by low-cycle fatigue. Analysis of the operation of the gas turbine engine shows that, depending on the purpose of the aircraft and the tasks performed, there is a large spread in the accumulation of damage to the main parts. Most gas turbine engines do not produce proven damage. The creation and implementation of the methodology for developing the resource of exploited gas turbine engines makes it possible to keep track of the actual engine load, their main parts and increase the allowable resources for the total operating time [16-19].

IV. DBMS STORAGE OF PARAMETERS FOR TESTING THE EXTENSION OF THE RESOURCE GTE

Choosing a DBMS is a complex multi-parameter task and is one of the important steps in developing database applications. The selected software product should satisfy both the current and future needs of the enterprise, while taking into account the financial costs of acquiring the necessary equipment, the system itself, developing the necessary software based on it, as well as staff training. In addition, you need to make sure that the new DBMS is able to bring real benefits to the enterprise.

The simplest approach to choosing a DBMS is based on an assessment of the extent to which existing systems satisfy the basic requirements of an information system project being created. The list of DBMS requirements used in the analysis of a particular information system may vary depending on the goals. There are several groups of criteria:

- data modeling;

- architecture features and functionality;

- control of the system;

- Features of application development;

- performance;

- reliability;

- requirements for the working environment;

- mixed criteria.

Oracle DBMS provides enterprise data processing and analysis applications with enhanced security, scalability, and availability, making it easy to create, deploy, and maintain. It provides integrated data processing and analysis, which allows enterprises of any scale to perform the following tasks:

- the construction, deployment and management of enterprise applications with increased security, scalability and reliability;

- maximizing the productivity of IT personnel by reducing the complexity of developing and supporting database applications;

- data sharing between different platforms, applications and devices, which facilitates the integration of internal and external systems;

- limiting costs without compromising performance, availability, scalability, and security.

Oracle provides enterprise data infrastructure development in three key areas: enterprise data management, development productivity and enterprise intellectual resources.

The Oracle data platform provides organizations of all sizes with a profitable investment, increased productivity, and reduced IT complexity.

In addition to all these advantages, we can also name the fact that the selected DBMS is supported by the Teamenter PLM system. It is also important that Oracle has a large set of tools for building applications for the Web. This is necessary for the possible further development of this system on the Internet, for example, remote diagnostics of gas turbine engines or transmission of test results.

In fig. 4 shows the structure of the database parameters of the extension of the resource GTE.

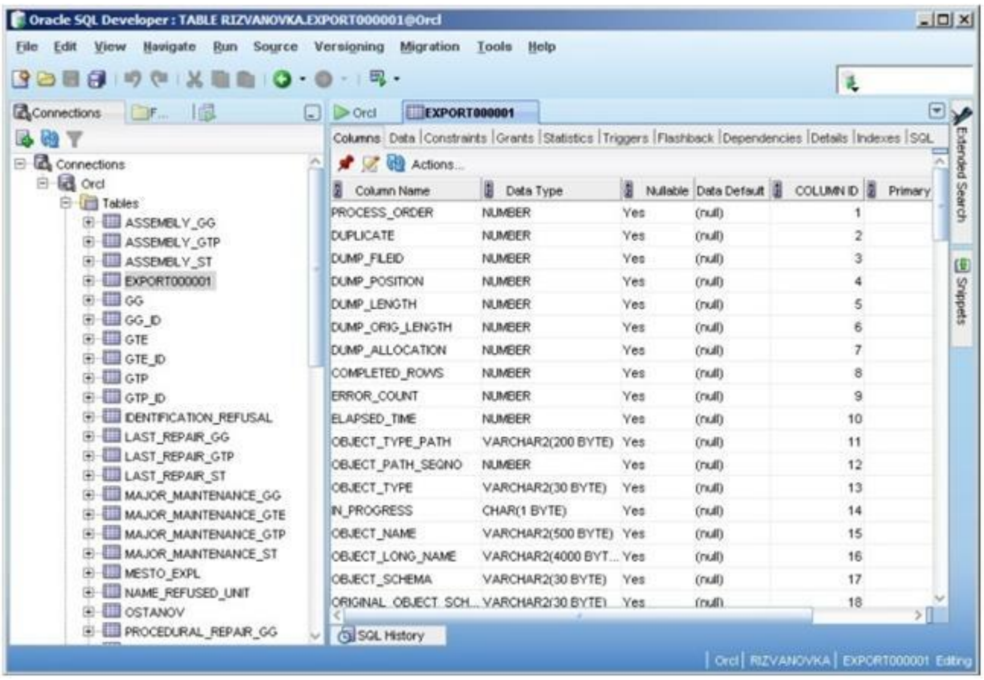

Fig.4. The structure of the database parameters of the extension of the resource GTE

V. Conclusion

The developed system models and software in accordance with the requirements of system engineering standards allow us to move to a new level of design, production and operation of gas turbine engines through the use of digital twins. This allows you to simulate various situations on the digital twin of the gas turbine engine, to clarify system models on it, which allows you to reduce the time and financial costs of eliminating various production, operational and other defects.

Acknowledgment

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