Automated decision support system for GTU tests process

Olena Shytikova, Galyna Tabunshchyk

***Abstract*—**The paper deals with the problems of reliability and safety of the gas turbine units for terrestrial usage (GTU). Developed by the author models of GTU workflows, documents workflows and mathematical models of uncertainty in GTU tests process were put in the DSS. In the article presents main requirements for DSS, its architecture, the data storage structure, subsystems for information administration, monitoring, data visualization and analysis.

***Keywords*—**automated decision support system, gas turbine unit for terrestrial usage, tests process.

I. Introduction

The contemporary operation concept of gas turbine units for terrestrial usage (GTU) is determined by customer requirements towards qualitative reduces of their life cycle costs with simulations performance of the reliability increase. For the confirmation of the products reliability are used numerous tests.

In practice all the reliability characteristics are determined by statistical data processing, which is quite time-consuming, and therefore must be properly organized. And with the number of issued GTU the process of registration and storage of large amounts of statistical data only becomes more complicated.

One of the functions of the GTU Automatic Control System (ACS) is the formation of the back-up information about the parameters and status of GTU during functioning, including information tests collected.

However, in addition to the back-up files with the parameters GTU created by ACS, there are formed a numerous additional data, which is necessary to analyze, organize and ensure its safety during GTU life-cycle. Today, it's all stored printed on paper reports. In addition, data processing and analysis take a long time.

The transition from the huge paper archives of data towards automated decision support systems (DSS) can as significantly reduce the amount of information, but also accelerate the access process to the necessary sources, and reduce the processing time and improve the quality of the results, excluding the human factor from the process.

II. Problem definition

There are various means of lifecycle automation, such as the enterprise management system and ACS of workflows and documents flow, etc. But they did not take into account the features of the GTU tests process. Therefore, the development of the software that would take into account all the features of the GTU tests process is actual task [1-3].

The object domain analysis has allowed to design as the models of GTU test process workflows [4], which made it possible to determine the basic format and structure of electronic documents, as well a formalized model of GTU tests process (1) [5].

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$$M_И = \langle T, O, R, X, Y, Z, U, D \rangle, \quad (1)$$

where T – the set of GTU test process stages;

O – the set of objects;

R – the set of the links between objects;

X, Y – the set of input and output parameters;

Z – the set of objects states that vary according to the condition u in the set U;

U – the set of conditions to change the objects states;

D – the set of operations performed at model time t on the object $o \in O$, located in the state $z \in Z$ until a condition $u \in U$. It is defined as a set of ordered elements

$$d = \left\langle t, o, z, \widetilde{X}, u, M'_R \right\rangle,$$

where $\widetilde{X}$ – the subset of X, which includes input parameters x, necessary to perform operations d;

M'_R – risk models of GTU test process.

To improve the reliability and safety of GTU have been developed GTU risk models (Fig. 1) [6].

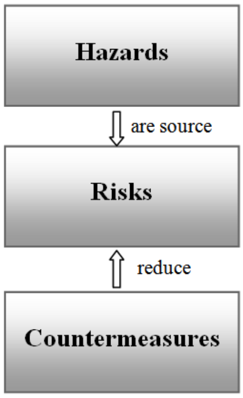

Fig. 1 GTU risk macro-model

Risk models of test process (2) [7], the method of uncertainty control in resource-limited settings [8] and the method for choice of alternative countermeasures [9] were also obtained.

$$M_R = H(D, A), \quad (2)$$

where M_R – hypercube of data from a lots of room, which correspond to the set measurements of D and a set of attributes A;

$D = \{d_1, d_2, \ldots, d_i\}$ – hypercube measurements, which correspond to the components of risk models (e.g. for GTU d_1 - "Hazards", d_2 - "Risks", d_3 - "Countermeasures");

$A = A_{d1} \cup A_{d2} \cup \ldots \cup A_{di}$;

$A_{di} = \{a_1^i,\ a_2^i,\ \ldots a_g^i\}$, where $i = 1, 2, \ldots$

These earlier models and methods will be used as a basis to develop DSS of GTU test process.

The work purpose is to design the DSS of GTU tests process, which is aimed collect and register the tests results information. It include carry out the effective storage and regulated access rights to it, and provides the analysis, in particular the risk assessment for GTU and for its test process. This requires the development of DSS architecture, storage structure, subsystem for information administration, subsystems for data visualization, monitoring and analysis

III. Software architecture

DSS architecture was designed with the following requirements:

- loading of the GTU tests data by a network directly from ACS;
- support of the centralized data archive with hierarchical storage system;
- storage of the tests results during all life cycle of GTU;
- analyzing of the possible extraordinary situations;
- differentially access to the data for various users groups (on GTU, on test, kinds of works);
- the information visualization about the GTU parameters;
- the cartographical representation of operating GTU.

As seen in Fig. 2, the DSS architecture developed using the structure "client - server", since the system must support multiplayer mode, as well, because the test objects are widely distributed geographically.

Data from ACS to database server is communicated by a protected radio channel, so for remote access to all geographically distributed GTU, the amount of which can reach up to several hundreds.

Fig. 3 is a DSS diagram of the components for the GTU test process.

The data storage system include:

- of DB for storage the necessary information from the server;
- of file structure which uses a uniform data storage format of language marking XML from the client.

At loading of data from other formats are used converters.

Also it was designed the database structure, and to provide a cross-platform database interaction - corresponding WCF (Windows Communication Foundation) services.

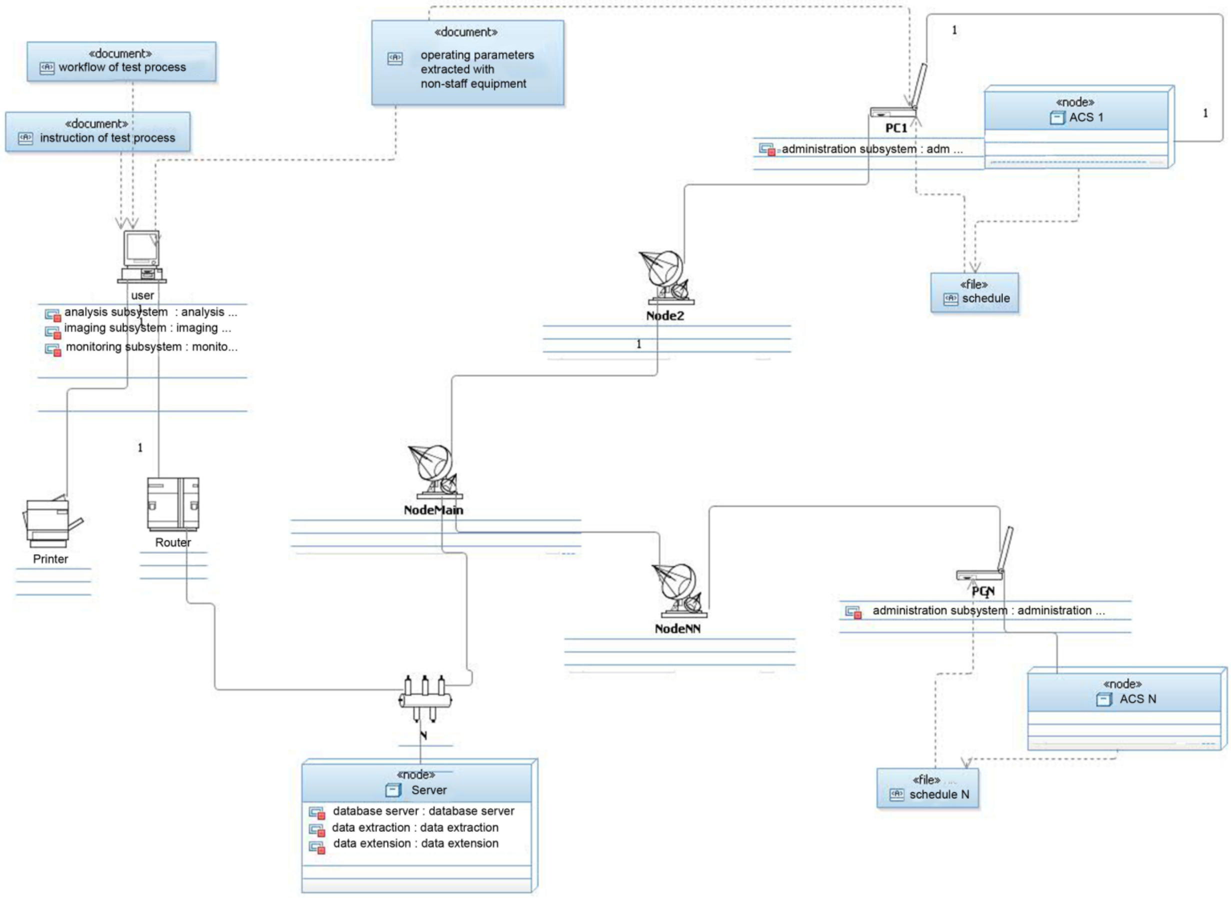

Fig. 2 DSS architecture for GTU test process

IV. Development of Subsystems DSS

A. Subsystem for information administration

Was developed subsystem for information administration that allows:

- create a new file or open an existing project for each GTU, which be stored throughout the life cycle;
- differentially access to the data for various users groups;
- to export / import data in other applications;
- provide access to all other subsystems: monitoring, data visualization, analysis, etc .;
- generate reports on user requirements with the possibility of printing and other.

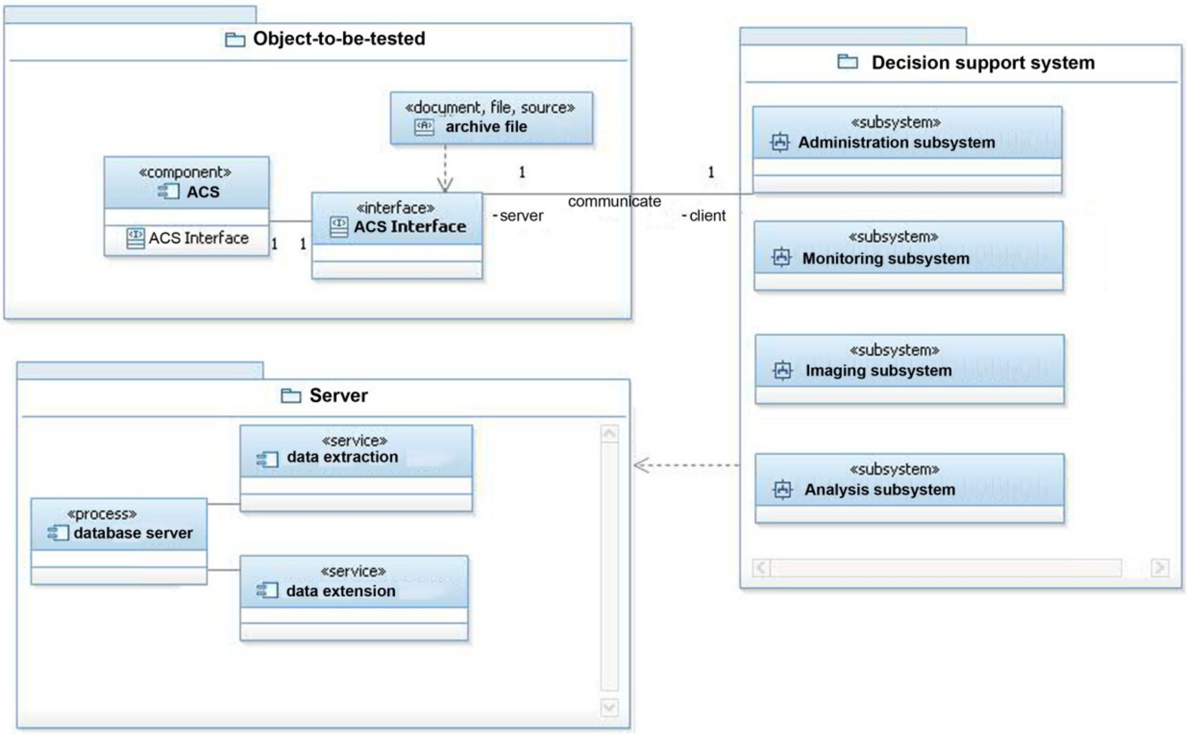

Fig. 3 DSS diagram of the components for the GTU test process

B. Monitoring subsystem

The basic idea is information integration of GTU tests process and ACS. Information integration can be carried out provided that the monitoring subsystems will operate not with traditional documents, and with the formalized documentary information models describing GTU test process.

The monitoring subsystem will boot ACS archive files containing the parameters and status of GTU during operation, including during test. It uses a specially designed converters in storage format XML.

The monitoring subsystem also provides data entry contingency equipment to download data collected manually. Loading is done with an access point PC connected to ACS, or user PC with a specially organized forms of requests.

C. Subsystem for data visualization

Based on the developed GTU test process model, as well as the electronic documents structure [4], it was designed subsystem for data visualization. This subsystem provides the correspondence between the ongoing processes and their visual presentation, focused the attention operator on the essential processes and the states with the possibility of up to the required level of detail.

Developed subsystem for data visualization allows visualizing information about the GTU parameters, as well as cartographic representation of all units in operation. Interface latter is shown in Fig. 4.

D. Analysis subsystem

In the analysis of reliability and safety of technical systems important place takes a risk-based methodology. Therefore, the developed analysis subsystem must ensure the risk assessment GTU test process, based on previously developed GTU risk models and test process [6-7], as well as the method of managing uncertainty in resource-limited settings [8] and the method for choice of alternative countermeasures [9].

Analysis subsystem performs the following functions:

- enables the identification of the research object, the assets representing the value of this object, as well as the dangers and risks that threaten;
- for the correct risk identification need to analyze the possible contingencies, so the analysis subsystem allows organization of user criteria samples for comparative analysis of parameters and operating conditions, the search for identity denials, organizes summary reports;
- not all risks are the same threat, so should be highlighted the most critical of them, so a subsystem allows a qualitative risk ranking by a group of experts;
- checked the consistency of expert opinion;
- for the most critical risks allow the identification of countermeasures if the alternatives has a mechanism of choice;
- produces a final report containing recommendations to the list of the most critical risks and the possible countermeasures that can prevent or minimize these risks.

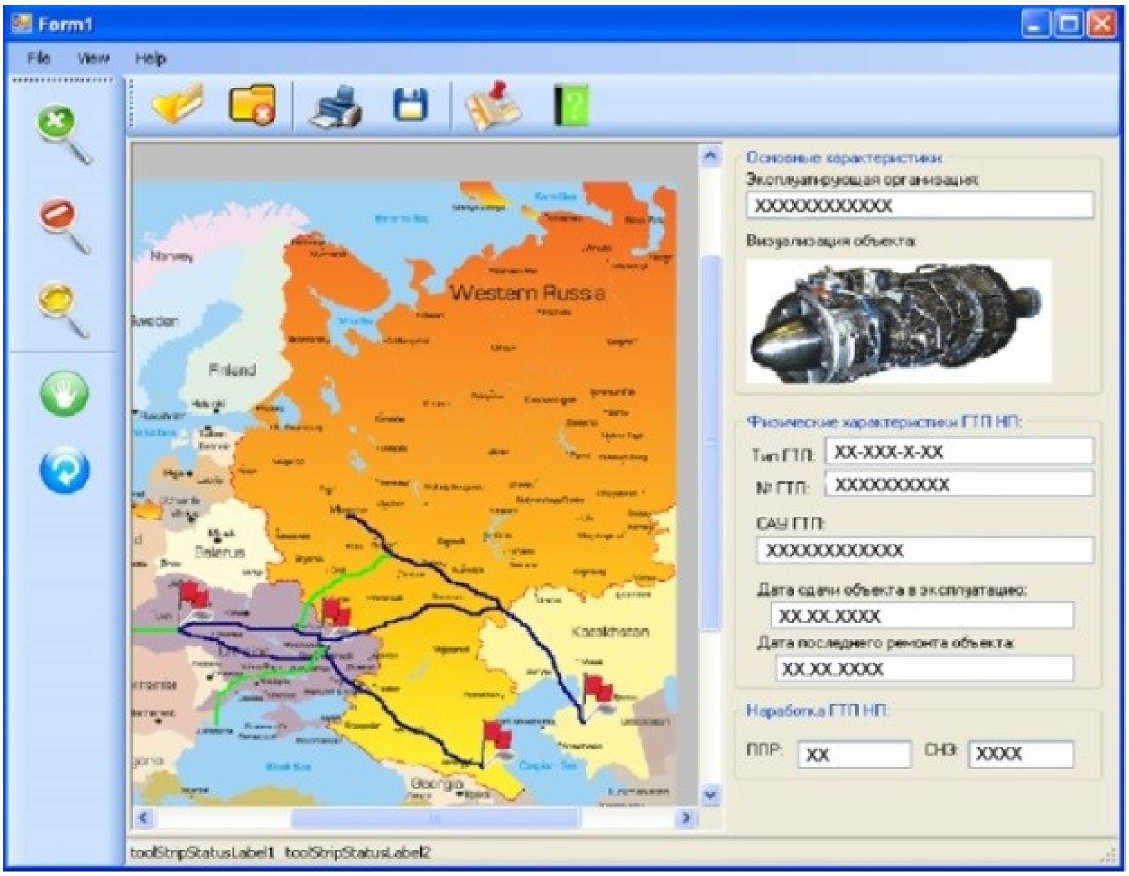

Fig. 4 Interface of Subsystem for data visualization

V. Conclusion

The DSS for GTU test process were developed by the authors. This allows to improve the manage process of test, by increasing accuracy of data collection, as well as by automate the processes of data storage and analyses.

The main requirements for DSS were designed, developed DSS architecture, the data storage structure, subsystems for information administration, monitoring, data visualization and analysis.

The developed DSS for GTU test process are passing β-testing at Motor Sich JSC, Ukraine. In the experiment data collections involved five power plants and one gas pumping stations.

The implementation of this DSS allows to improve the quality of controlled information, and to reduce the risks of incorrect information related to the human factor. Analysis subsystem of DSS allows to assess risks for the timely implementation of effective measures to improve the consumer properties of GTU and increase its reliability and safety. At the same time, the storage of this information throughout the GTU lifecycle ensure continuity of experience and formed a training base for young specialists of the enterprise.

The prospects for further development of this work are to optimize the process of collection and transmission of information from geographically dispersed GTU with regard to limitations on available resources.

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