Features of the QFD method in the development of software and hardware complexes for controlling groupings of unmanned aerial vehicles

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Abstract. In the practical implementation of projects for the development of software and hardware complexes for managing unmanned aerial vehicle groupings within the SCRUM technological system, not only issues of a systematic and logical determination of the architectural and technological aspects of the quality of the hardware platform and software being developed are important, but also the effective development of specific recommendations on quality improvement measures in the current process conditions. The method of developing recommendations on ensuring the quality of the isolated components of the software and hardware complexes for controlling the groupings of unmanned aerial vehicles, which in essence is the correct localization of the method of structuring the quality functions (Quality Function Deployment: QFD method) to the subject area of development and creation, is aimed precisely at ensuring the indicated efficiency hardware-software complexes, software within the framework of the SCRUM technological system.

1. Introduction
The objective orientation of projects to develop software and hardware systems for managing groupings of unmanned aerial vehicles for the needs and requests of potential and real customers dictates the need for constant and continuous linking of the technical capabilities of the created software and hardware complex with the needs determined by specialists in the subject area of application of aircraft groupings [1-2]. It is this fact that determines the fact of widespread use of the QFD method tools [2-4], the corresponding techniques for structuring quality functions when creating the indicated software and hardware systems, and especially within the framework of the SCRUM technological system. At the same time, the high iterability and partially empirical approach to designing and developing software capabilities within the framework of the indicated technological system imposes a number of specific features on the application of the QFD method within the framework of the SCRUM technological system.

2. The main provisions
The deployment or structuring of quality functions in the development of software and hardware complexes for managing groupings of unmanned aerial vehicles is necessary for the logical linking
(conditioning) of the technical, functional capabilities of the created hardware complex and software product with the expected needs that they are designed to satisfy. Thus, the structuring of the quality functions of the software and hardware complexes for controlling the groupings of unmanned aerial vehicles in the development is a process of sequential and purposeful identification of technical solutions, characteristics, properties and functions of the developed hardware and software platform and application software through sequential systematization, specification, localization of needs and wishes potential operator of these complexes. This process should ultimately ensure such a quality of software and hardware systems for controlling groupings of unmanned aerial vehicles as a software and hardware product that all significant needs and expectations of a potential consumer will be guaranteed to be satisfied. The essence, principles and basic approaches to the practical application of the QFD method are described in detail in the scientific and practical literature on modern qualimetry.

The basic toolkit of the QFD method is a multi-table diagram. The central element of this tabular chart is a matrix of relationships between needs, requirements of a potential consumer of software and hardware systems for controlling the groupings of unmanned aerial vehicles and the technical characteristics of the created technical components of this complex. In addition to the relationship matrix, the diagram includes a correlation matrix, as well as arrays of separately recorded formalized information according to the requirements of potential operators, labor input, alternative solutions, etc.

The process of sequential and purposeful identification of technical solutions, characteristics, properties and functions of the developed application software through sequential systematization, concretization, localization of the needs and wishes of a potential operator of software and hardware complexes for controlling groupings of unmanned aerial vehicles, as a rule, is carried out in eight main stages:

- Identification and concretization of the needs and wishes of a potential operator (consumer) of software and hardware systems for controlling the groupings of unmanned aerial vehicles. These wishes or descriptions of needs, as a rule, are not systematized, incomplete and not accurate. Obviously, such data cannot, in its original form, serve as the basis for the design and development of components of software and hardware complexes for controlling groupings of unmanned aerial vehicles. That is why at this stage not only the identification of these data is made, but also their systematization, supplemented by interviewing experts, semantic modeling, etc. The methodological and logical-mathematical basis is traditionally used to identify the needs and wishes of a potential operator (consumer) of hardware and software systems for group management unmanned aerial vehicles perform expert statistical estimation procedures. The identified requirements of the potential operator (consumer) of the software and hardware complexes for controlling the groupings of unmanned aerial vehicles are displayed in the matrix of relationships of the multi-table diagram of the QFD method;

- Conducting a ranking of consumer requirements of a potential operator of software and hardware systems for managing groupings of unmanned aerial vehicles. It comes down to rating weighting of the significance level of the needs and wishes of a potential operator (consumer) of the software and hardware systems for managing the groupings of unmanned aerial vehicles identified at the first stage. Due to the fact that the wishes (requirements) of the potential operator of the software and hardware systems for controlling the groupings of unmanned aerial vehicles have objective inconsistency and it is impossible to satisfy all of them at the same time, at this stage the main consumer requirements that are priority for implementation and secondary ones that can be to some extent neglected;

- Formation of a list of technical solutions, characteristics, engineering properties and functions of the developed hardware and software platform and application software for software and hardware systems for controlling the groupings of unmanned aerial vehicles. This stage is implemented by the entire SCRUM team under the guidance of a scrum master. The specified technical parameters of the software components for the PC should be described clearly,
definitely and briefly identified. The hardware platform and the composition of system-wide software are described at the level of a specific specification;

- Establishment of the logical dependencies of the consumer requirements of the potential operator and technical solutions, characteristics, functions of the generated software and hardware platform and the developed application software of the software and hardware complexes for controlling the groupings of unmanned aerial vehicles. Essentially, at this stage, the completeness of the functions intended for implementation is analyzed to satisfy the entire pool of identified consumer requirements of the potential operator of the software and hardware complexes for controlling the groupings of unmanned aerial vehicles. It also establishes those functionalities that are not requested by a potential consumer, but whose implementation is necessary for the full functioning of hardware and software systems (for example, the presence of a dedicated modeling server, or providing specialized interaction of the system ontology with the database management system, etc.). Recent functionality is also subject to implementation during development;

- Establishment of the fact of the multidirectionality (inconsistency) of the technical solutions, characteristics, engineering properties and functions of the formed software and hardware platform and the developed application software for the software and hardware complexes for controlling the groupings of unmanned aerial vehicles adopted at the previous stages that are planned for implementation. The fact of the mutual direct and inverse relationship of the indicated technical solutions is established, which is displayed accordingly in the triangular correlation matrix of the base multi-table diagram of the QFD method. This is necessary to take into account when optimizing software and hardware systems for controlling the groupings of unmanned aerial vehicles, as a software system;

- Weighing technical solutions, characteristics, engineering properties and functions of the generated software and hardware platform and the developed application software, depending on the relevant consumer requirements of the potential operator of the software and hardware systems for controlling the groupings of unmanned aerial vehicles. The result of this stage is achieved by sequentially multiplying the ranks of consumer requirements of the potential operator of the software and hardware complexes for controlling the groupings of unmanned aerial vehicles by the numerical value of the communication intensity with the corresponding technical solution and further summing the results of multiplication along the entire column of the specified technical solution. The technical solution, characteristics or function of the software and hardware systems with the highest value obtained by the above weight method requires the highest priority in the formation of the software and hardware platform and in the implementation of application software by the development team within the SCRUM technological system;

- Conducting accounting of functional and software-technological limitations. This stage has been brought to life by the fact that not all the desired technical solutions, characteristics, engineering properties and functions of the generated software and hardware platform and the developed application software are achievable. Because of this, in a special line of the base multi-table diagram of the QFD method indicate data from experts on the technical completeness of the feasibility of certain technical solutions;

- Accounting for data on competitive solutions presented both in the market of computer hardware and software, and in projects of alternative developers. This stage, in general, is more economic and political than technical, which is why this study is not considered in detail.

3. Results and conclusion

As a result of the implementation of these eight stages, it becomes possible to obtain primary data for the design (technical specifications or technical conditions) of each of the components of the specified complex, developed, systematized and coordinated with the needs of a potential operator of software
and hardware complexes for controlling groupings of unmanned aerial vehicles. Also, the consistent construction of multi-table diagrams of the QFD method at all stages of development and the life cycle of software and hardware systems for managing groupings of unmanned aerial vehicles allows us, effectively, in conjunction with the wishes of potential operators, to make decisions on improving the quality of the software and hardware platform and application software of these complexes. This, ultimately, avoids the costly and difficult to predict by other methods adjustments in the already implemented software and hardware solutions for creating software and hardware systems for managing groupings of unmanned aerial vehicles. This means that this allows you to reduce unreasonable costs for the development of appropriate application software.

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