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Evaluating the automated organizational decision support effectiveness

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Abstract. In the automating the management process practice, there is currently a challenges number identified by the toolkit ability to evaluate the management automation tools implementation expected effectiveness, including industrial process management. In practice, an automation assessment tools wide range are used, but none of the tools used provides an automated management system quality comprehensive evaluation as a whole and its components separately. This situation makes it difficult to develop and implement automated production management tools. The article suggests applying a methodology that uses the automatic control theory mathematical apparatus to evaluate control automation effectiveness. An example of how to evaluate a typically automated control system effectiveness is given. This example analysis shows the proposed approach' practical applicability. The proposed mathematical apparatus practical application will ensure an express assessment when comparing the various options for providing control automation, which is especially important at the pre-project research and project stages

1. Introduction

The automated decision support organization problems one for production management is the expected efficiency evaluation from this process certain components' introduction into management practice [1]. In assessing the management system effectiveness, despite the problem long history, there are many unresolved issues, ranging from the difference in management effectiveness definition interpretation to the indicators set for its evaluation. Currently, researchers abroad [2,3] and domestic [4,5,6] researchers are offered an approaches fairly wide range to assessing the management systems effectiveness that has evolved as scientific schools have developed and developed: scientific, classical, behavioural, quantitative. These most accurate are based on the managed systems use statistical estimates processing in different management options. On the statistical estimates processing basis, the system's functioning indicators are formed: performance, stability, adaptability, economy, awareness, etc. In some cases, these assessments are collected in larger functional groups. A predictive mathematical apparatus, from expert assessments to simulations, is used to obtain quantitative estimates for newly created systems when there are no statistics on their functioning yet.

These methods each has advantages and disadvantages, primarily in obtaining an assessment and the fundamental ability speed terms to evaluate the promising options for building automated decision-making support systems. These properties' absence makes it problematic to use them for the options' rapid analysis for building complexes and control automation systems during the conceptual design phase, during the project implementation to create them, including the cost-efficiency criterion, which



determines the almost any activity effectiveness, including management. In the information technology dynamic development context and management systems priori diversity, this disadvantage harms the automation introduction into management practices. Thus, at present, despite the research carried considerable amount out, the automated management evaluating the effectiveness problem has not been fully resolved and remains relevant.

2. On the automatic control theory techniques used to assess the control automation effectiveness

Experience with research suggests that methods for solving the obtaining forward-looking assessments problem are not limited to existing approaches. In the researching complex systems practice, mathematical modelling techniques are usually used to obtain efficiency quantitative parameters, especially for newly developed systems [7, 8, 9]. In the management automation assessment area, as noted earlier, they are also applied, but not effectively enough, as there is a problem evaluating results. This problem is determined by the segregating factors' difficulty that influence management performance from heterogeneous modelling results. Also, it is not always advisable to create (or refine) a complex mathematical model for each specific situation.

Taking into account these factors, to use mathematical modelling methods more effectively, the production management system is proposed to be described in the automatic control (TAU) theory terms, which mathematical apparatus is well known and tested [10-13]. This will allow the Automated Organizational Decision Support System (AODSS) model structure to be presented as a dynamic system model, implemented in a set of disparate transmission links form (figure 1), which will enable its core characteristics analysis. Of course, not for such systems full range, but for those that can be formalized to the TAU format without significantly losing the evaluation results credibility.

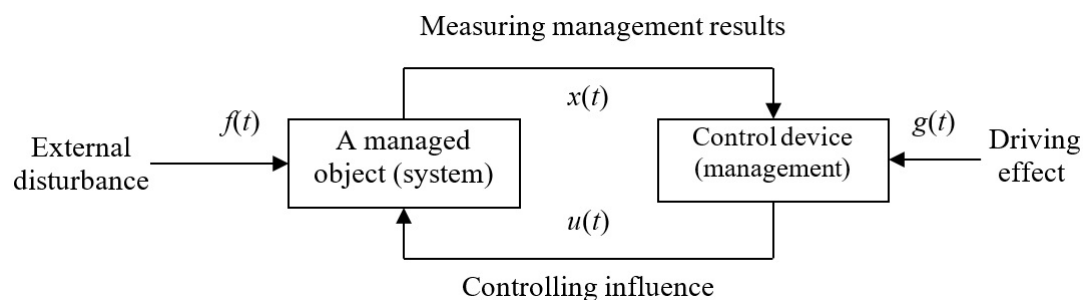


Figure 1. The management system structure formalized representation.

In figure 1 $g(t)$ is the goal (task) function; $f(t)$ - disturbing influences function, interference; $u(t)$ - control actions; $x(t)$ - feedback parameters (control result measurement).

In the TAU terms, the production control system model is a nonlinear feedback control loop typical case. To ensure its characteristics' analysis, the specified system, with an assumption to a certain degree, can be described by an integrating, differentiating and aperiodic links connected set characterized by transfer functions $W_j(p)$.

In terms of describing automated AODSSs, these links can be characterized as follows (figure 2):

- automation tools complexes and control bodies (managers) officials with the forming control actions functionality $W_{Gov}(p)$;
- assessing the current state means $W_{FB}(p)$;
- the managed object executive bodies $W_{Co}(p)$ and data automated collection mean on the managed objects state $W_{DC}(p)$.

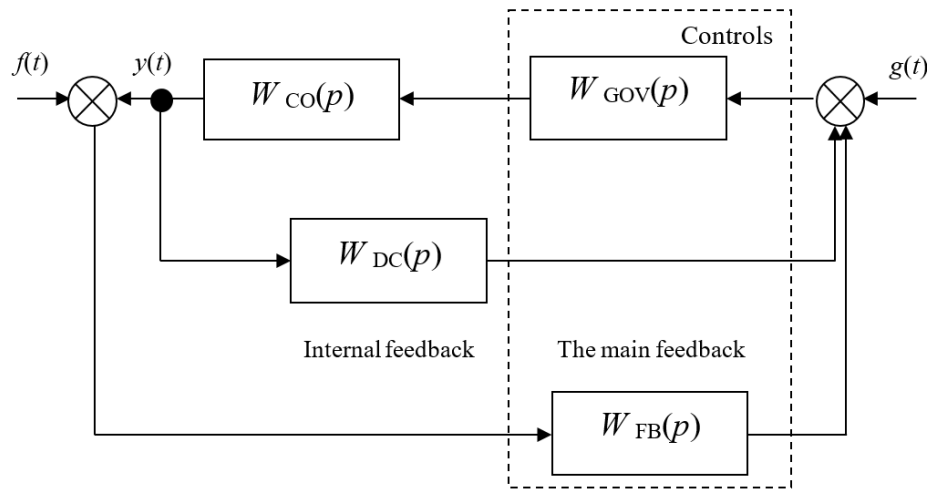


Figure 2. The control system representation in a transfer links set form.

It is known that the continuous system transfer function $W(p)$ is the output signal Laplace transform ratio $y(p)$ to the input signal Laplace transform $g(p)$ with zero initial conditions. Usually, such dependence is described by a differential equations' system or a coefficients' matrix, which makes it possible to obtain a system output signal image from its input signal known image:

$$y(t) = W(p)g(t).$$

The transfer function $W(p)$ allows one to characterize the studied system all the properties in stationary and transient modes: stability, sensitivity, astatism degree, frequency and amplitude characteristics.

At the same time, as practice shows, the system transfer function as a whole is not always convenient when analyzing its individual components functioning. From the automated controls functioning analyzing viewpoint, an open-loop system transfer function, which includes, in the proposed methodology terms, only controls and feedback components seems to be more important. It fully provides a system controllability assessment as a whole, according to the control quality main parameters.

3. On the proposed model use for the automated decision support systems' assessment

For the system under consideration, an open-loop model that includes only the control system components is shown in figure 3.

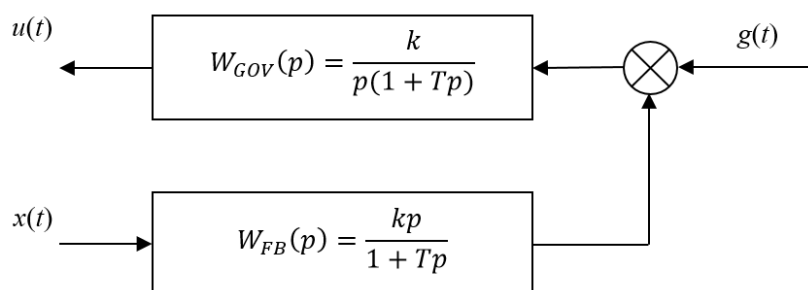


Figure 3. The open segment structure of the system controls - the external environment - the managed object.

The subsystem for the control actions formation in the model proposed version can be described as an integrating link with delay form, which transfer function looks like:

$$W(p) = \frac{k}{p(1 + T_1 p)}.$$

The subsystem for assessing the controlled system current state and the external environment, in turn, is described by a differentiating link with a delay, which transfers function:

$$W(p) = \frac{kp}{1 + T_2 p},$$

where k is the transmission coefficient;

p - differentiation operator $p = \frac{d}{dt}$;

T_1 and T_2 are time constants.

With this approach, the open-loop system total transfer function described in figure 3 looks like this:

$$W(p) = \frac{k}{p(1 + T_1 p)} + \frac{kp}{1 + T_2 p} = \frac{kp(p^2 T_1 + p + T_2)}{p(1 + T_1 p)(1 + T_2 p)} = \frac{k(p^2 T_1 + p + T_2)}{p^2 T_1 T_2 + p(T_1 + T_2) + 1}.$$

The resulting formal model allows for ways to express assessment to improve management efficiency, evaluating the modelled system. Using any of the known stability criteria, on this model it is possible to estimate the modelled system stability boundaries, through which to calculate the automation tools parameters that ensure their implementation. To obtain numerical parameters characterizing the options indicators for constructing a control system, the denominator $W(p)$ is simply equated to zero and a characteristic equation is formed. The characteristic equation coefficients matrix analysis for various options for constructing a control system will make it possible to conclude the various factors control and the influence quality on it.

The proposed approach allows for ways' generalized assessment to improve the automated control efficiency for organizing an automated system in each specific case for supporting organizational decisions. At the same time, various methods of improving the control accuracy provided in the TAU can be evaluated: increasing an open-loop system transmission coefficient, increasing the system astatism order, applying control based on error derivatives. In the proposed methodology, these methods should be interpreted concerning the parameters and the analyzed system model components.

From the such an interpretation viewpoint, in the obtained model, the transfer ratio physical meaning k is a system control quality indicator, taking into account both errors in planning actions and distortion errors during control signals transmission.

The time meaning T_1 in the model is the delay in developing a solution, that is, the total time from the command receipt at the planning beginning, to the commands' issuance to the executive bodies. Accordingly, the time T_2 is the cycle duration for collecting information about the controlled object state, that is, the feedback efficiency.

Thus, having a specific system model with given requirements, it is possible to determine the time rational ratio T_1 , T_2 , taking into account the transmission coefficient, which ensures the system's functioning stability. This, in turn, will allow you to rank the system components in order of importance and justify the requirements for them.

4. On implementing the proposed approach practice

The proposed approach application makes it possible, on the express analysis basis, to formulate measures that provide both a transfer function indicators joint improvement and optimization for one of them for newly developed or modernized automated control systems.

For example, from the organizational and technical measures viewpoint for the development of AODSS, the following can be justified:

- the circulation speed indicators in the control documents system, which reduce the time for making decisions T_1 and the time for collecting and processing data on the system state T_2 ;

- the personnel training level, which ensures both an increase in the coefficient k and a decrease in the time T_l .

An increase in the transmission coefficient k has a favourable effect in terms of reducing errors in almost all modes of using the system [14, 15, 16]. This is determined, in particular, by the fact that it is included as a divisor in all error rates [12]. Moreover, the coefficients' analysis at the transfer function formula components $W(p)$ shows that the approach to improving the control quality by increasing the coefficient k provides an increase in control efficiency much more than reducing the time T_1 and T_2 .

It should also be noted that the proposed approach, in contrast to the currently used ones, allows interpreting some indicators in an economic form, for example, the managerial and technical personnel maintaining and training the necessary number and quality cost (table 1). This, in turn, will make it possible to evaluate the options for constructing an AODSS according to the cost-effectiveness criterion [17], and not in the way it is done in some cases now - in purchasing automation tools terms costs and software development, unreasonably accepting the remaining management costs for shareware.

Table 1. The automated control system model indicators option interpretation.

Indicator		Technical and organizational interpretation	Technical and economic interpretation
Transmission coefficients k		1. Automated control functions share.	Costs for the development and implementation of applied software for decision support, personnel in its use training
		2. Solving optimization problems and predictive models accuracy from the applied software composition	
	Time T_1	Automated workstations' performance characteristics	Equipment purchase costs
	Time T_2	1. The big data processing software effectiveness. 2. Data transmission networks bandwidth	The ODMSS management and technical personnel number, its maintenance cost

And of course, the one described in figure 1 the system is nested and layered, and its model looks more complex. The nesting degree is determined by the considered control level. However, this assumption does not affect the proposed approach use for assessing the automated control quality.

5. Some conclusions

The mathematical apparatus analysis that implements the proposed approach to assessing the organizational and technical systems automated management effectiveness allows to draw some conclusions.

The method novelty lies in the fact that the proposed approach expands the currently used research toolkit, it provides another tool for analyzing the decision support automation effectiveness, combining the expert assessments' simplicity, the estimates efficiency and validity obtained on the mathematical modelling basis. A tool that allows to quickly and economically obtain both qualitative and quantitative (interpreted through the model phase-frequency characteristics) changes assessments in management efficiency under different options and, therefore, its organization costs. Accordingly, the proposed mathematical apparatus, ranking the certain factors influence on the management efficiency, provides the developer with the opportunity to form and compare the options for organizing automated decision-making support according to the efficiency-cost criterion [18, 19].

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