Assessment of the Functional Operator's Condition in the Environment of a Vehicle Cabin During Construction Works

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Abstract. The study contributes to main conditions for ensuring the quality of construction production processes and products. The object of study is a maximum possible level of compliance of a human operator and the mobile environment of a technical vehicle cabin. The functional operator's condition is evaluated in accordance with his personal adaptive physiological and psychological norm. The mobile environment of the technical vehicle cabin is evaluated by the parameters specified in the Directive official regulations. The task of the study was to develop a method of the real functional operator's condition assessing in the course of his work in the mobile environment of the cabin of a vehicle. The method used in the study was a composite infographic parameter modeling of the "man-technics-environment" system. Infographic modeling as a promising tool for research and comprehensive assessment of the mobile environment influence on the functional operator's condition. The conclusions of the study have shown that the "star" multilayer infographic model gives good results in the complex evaluation of the functional state of the operator. As a tool for the development and application of such models, it is advisable to use the language R. The study has shown that the interaction of a human and the vehicle cabin mobile environment during construction works is ought to be considered not only as a socio-technical, but also as a cyber-physical system.

1. Introduction

The task to assess the functional operator's condition in the environment of a vehicle cabin during construction works is understood by researchers in various ways. Therefore, the proposals to solve it are also different [1-5]. The interaction of a functioning operator and the vehicle cabin mobile environment is the object of present study using the method of infographic modeling in the system "human-technics-environment" (HTE) [6-8]. Infography, as a scientific and practical activity, considers local and compositional infographic models. A compositional infographic (CI) model is a visual and figurative model formed by a combination of components with a given border between them. These components cannot be decomposed into smaller independent parts of elementary modules [9].

The CI model has synergetic properties, which are absent in any of the individual components of such a model. CI model suggests the possibility and necessity of:
● formal description of the transition procedures from one component of the CI model to another;
● adjustments of its specification, significance and connectivity at the stage of the CI model components connection;
● "a pass" by the composition of connecting components, with the aim of their mutual adjustment, either in the forward direction (from left to right for linear models and clockwise for circular models) and in the reverse direction [10].

The distinction in the CI model of the positions of the "object" and "subject" allows to distinguish the types of their interaction (Figure 1) [11].

![Figure 1](image_url)

**Figure 1.** The processes of interaction in the dyad "Man-Technics" with the allocation of positions "subject" and "object" [11]

2. Methods
The investigated object is characterized by the parameters and restrictions indicated in directive documents (regulations, standards, norms, codes of rules, etc.).

For the subject of activity, the individual adaptive norm (the result of adaptation to changes under environment influences) is determined by instrument based diagnostics during communication (here and now) [12-14]. In case of each HTE system components (specialists, equipment, environment) are considered either as an object or as a subject of investigation [15, 16], there are six local positions can be distinguished (Figure 1):

- a human - an object (Ho);
- a human - a subject (Hs);
- technics - an object (To);
- technics - a subject (Ts);
- environment - an object (Eo);
- environment - a subject (Es);

The processes of influence and interaction of these positions during activity process (pair component combinations of the dyad "object - subject", as shown in Figure 1) have corresponded to certain approaches:

- "object - subject" approach, Ho ↔ Ts; this is the influence (response or request) of a person (being in the position of the controlled object) on a technical vehicle (being in the position of the object which makes control);
- "object - object" approach, Ho ↔ To; this is the influence sum of a person on a technical vehicle and the technical vehicle response (feedback or afferentation); such a composition is considered an interaction; a person and technical vehicle are constantly and cyclically moving from the position of the object which makes control to the position of the controlled object (system with feedback);
- "subject - object" approach, Hs ↔ To; this is a classic version of management, when a person is always in the position of the subject who manage, and the technical vehicle is always in the position of the managed object;
"object - subject" approach, To ↔ Hs; this is the influence (response or request) of a technical vehicle (being in the position of the controlled object) on a person (being in the position of the subject who provides control), it happens within the classical version of management, when a person is always in the position of the control subject and a technical vehicle is always in the position of the controlled object;

"subject - subject" approach, Hs ↔ Ts; this is a set of human influences on a technical vehicle and a technical vehicle reactions (feedback or afferentation) in a situation where both actors are in the position of the object which makes control; such a composition of influences is considered a "discussion" interaction;

"subject - object" approach, Ts ↔ Ho; it is a control action ("loading") of a technical vehicle, (being in the position of the object makes control), aimed at a person (being in the position of the controlled object).

The problem of reorganization in the dyad "human-technics" ("operator - technics" in mechatronics "worker - technics" in machine engineering; "inhabitant - building" in the construction or facility management, etc.) is indicated by the layered CI model (Figure 2), known in infographic as a "bookcase" model.

![Figure 2. The multilayer CI model forming a hierarchical structure of reorganization in construction [11]](image)

3. Results
The model allows for the restructuring of objects or processes:
• synthesis, consolidation, integration of concepts, levels and results ("assembly", see at long vertical arrow upward on the right side of Figure 2);
• analysis, disaggregation, disintegration of concepts, levels and results ("disassembly", see at long vertical arrow downward in the left part of the Figure 2).

In the process of "assembly" on each plane of "bookcase " (for example, as shown in Figure 2) one of the two components of the dyad (here, it is the right component of the RC PT - the reorganization of construction subsystem "operator - technics" of the system HTE) is taken as a given one. It comes in the "assembly" process from the lower plane in relation to the considered plane. The left component of the considered lower plane (in Figure 2) is included from outside. In the resulting dyad (RC PT and external EL component) there are two opposite influences (two interacting components). This interaction is the meaning of activity on this "bookcase" plane. Further in the process of "assembly" there is a need to move up to the next plane. The dyad of the lower plane (its content activity) is to be transferred upwards as the right component (RC HTE on the second plane from below, Figure 2). On the left, on the second plane from below there is the second component of the new dyad to be inserted from outside and again there are two new opposite influences of the components (their interaction) to be revealed.

Infography, as a science and practice of creation, investigation, research and systematization of visual mapping of information, operates with "star" infographic models (called "convolutions" in mathematics ).

There are some recommendation for the process of "convolution" modeling:
• parameters of the investigated object are to be combined into two groups according to the positive trend of the numerical value of the estimated parameter (positive increase or decrease in the numerical value of the parameter);
• finally, local numerical estimates for each of the two models lead to an integral evaluation using analytical formulas.

Let's consider the possibility of combining all the parameters in one model and introduce the concept of the parameter importance, other words take into account their comparative priority. These models are designed for homogeneous sets of parameters of the investigated object (in our case it is HTE system shown in Figures 2 and 3).

![Figure 3. The model for parameters brought in homogeneous array [11]](image)

4. Discussion
The rules of complex assessment models creating according with a set of studied object parameters presume a number of consistently performed stages.
1. The set of parameters of the studied object is put in correspondence with a flat polygon, the number of its vertices is equal to the number of axes (Figure 3), and the parameter values define the square area of this polygon. If the homogeneous set contains more than two parameters, the number of axes of the model is equal to the n-number of parameters.

2. All axes have a common reference point; the angle between adjacent axes is $360^\circ / n$.

3. The sequence of the parameters on the axes is selected before the model is built. It remains unchanged to ensure the comparability of the estimated results. One of the axes of the model should be combined with the vertical and directed upwards, and the rest axes should be arranged and sequentially numbered clockwise.

4. There are figures of reference, design and actual polygons which distinguished in the model of integrated assessment and comparison of systems (Figure 3).

5. The parameters of the object under study can have zero, equal or different dimensions of their values. Therefore, to ensure the uniformity of the models it is necessary:

- to set the reference value of the parameter and put it on the corresponding numerical axis of the model;
- to determine and put the actual value of the parameter on this axis;
- to determine the maximum deviation of the actual value of the parameter from the reference one for all axes of the model.

Parameters can have a certain tendency of positive change of the current values (a positive one can be the trend to increase the numerical value of the parameter, or to reduce it, or to tend to a specific fixed numerical value of the norm).

5. Conclusions
1. There was a method which is developed on the basis of the "star" CI modeling which gives good results in the complex evaluation of the functional operator's condition. The method is compatible with computer information programs.

2. It is advisable to use R-language as a tool for the development and further application of such models.

3. The study showed that the interaction of an operator and the vehicle cabin mobile environment during construction works ought to be considered not only as a socio-technical, but also as a cyber-physical system.

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