METROLOGY, STANDARDIZATION

AND CERTIFICATION

МЕТРОЛОГІЯ, СТАНДАРТИЗАЦІЯ І СЕРТИФІКАЦІЯ

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METROLOGICAL SUPPORT OF DESIGN PROCESSES

USING THE "BIG BANG" INFORMATION MODEL

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Ключові слова: моделі об'єктів та процесів проектування, оптимізація підпроектів, «Великий вибух», медичне обслуговування

H. Oborskyi, I. Stanovska, I. Prokopovych, V. Tonkonogyi, O. Stanovskyi, P. Shvets. **Metrological support of design processes using the "Big Bang" information model.** Even the simplest design work is performed, as a rule, by a design institution, which involves several designers of different qualifications. Therefore, practically, each design is divided into several design works (subprojects), which are performed sequentially and in parallel with the constant coordination of the impact of individual subprojects. Some elements are not designed in the general sense. Their results are transferred to the list of "purchased" elements and components (fasteners, standard components, etc.). Hence the problem of optimizing such elements with the designed parts and providing the opportunity to directly "buy" them. During the design of the designer there are various surprises or risks that can also significantly change the course and outcome of the design. Therefore, the design must take into account not only the constraints imposed by "internal" circumstances, which are usually unchanged, but also the variable "external" circumstances, which include: constraints arising from the changing operating conditions of the future design object; technological limitations related to the specific capabilities of the organization that will implement the project; financial constraints; time restrictions; etc. Depending on the degree of parallelization of individual design subprocesses, the overall process can be considered as sequential, partially parallel or parallel. Overlapping, these constraints create a unique and whimsical background, creating the preconditions for deepening optimization. Against this background, new models and design objects can be built, such as the cosmogonic model of the Big Bang. The model of the project space description is offered and the possibilities of the latter transformation during the

optimization of the design process according to the information model of the "Big Bang" are estimated. The concept of "protomodel" as the first "edition" of multidimensional morphological information model of design process is created and analyzed. The Center for Reconstructive and Reconstructive Medicine conducted tests of the anti-crisis system of designing the optimal process of making design decisions in medical practice. Tests have shown that its use has achieved significant results in terms of quality of care.

Keywords: models of objects and design processes, optimization of subprojects, "Big Bang", medical care

1. Introduction

Even the simplest design works are usually performed by a design institution, which involves several designers of various qualifications in these works. Therefore, in practice, each design is divided into several project works (subprojects), which are performed sequentially-parallel with constant coordination of the impact of individual subprojects. At the same time, some elements are not projected in the general sense. Their results are transferred to the list of "purchasable" elements and nodes (fasteners, standard nodes, etc.).

Hence the problem of optimizing such elements with designed parts and providing the possibility to "buy" them directly.

As you know, optimization is a search for the value x^* of some independent variable x (parameter, which optimizing), which delivers some extreme value y^* to another dependent variable y (optimizing parameter) [1]. Naturally, there should be a known functional dependence $y = y(x)$ between these two variables and the value of the optimizing variable can be changed within known limits. There are many methods of calculating such values, but in any case, the best method of optimization is mathematical, that is, there must be mathematical models of all the above-mentioned objects and subjects of optimization.

It is also known that during design, the designer must constantly calculate and reproduce independent parameters in such a way that the dependent design parameter (design goal) is within the specified limits.

During the design process, the designer encounters various surprises or risks, which can also significantly change the course and result of the design. Therefore, during design, it is necessary to take into account not only the limitations imposed by "internal" circumstances, which are usually unchanging, but also by variable "external" circumstances, which in particular include:

– restrictions arising from the changing operating conditions of the future design object;

– technological limitations related to the specific capabilities of the organization that will implement the project;

– financial restrictions;

– time limits; etc.

2. Literature review and formulation of the problem

Depending on the accepted degree of information of the future project, restrictions may be determined by the "level of application of purchased elements and nodes". Depending on the degree of parallelization of individual design subprocesses, the overall process can be considered sequential, partially parallel, or parallel.

Stacked on top of each other, these constraints create a unique and whimsical background, setting the stage for a deeper optimization. On this background, new models and design objects can be built, for example, the cosmogonic model of the "Big Bang".

The design process, like any other type of human activity, begins with the planning of all types of project work. The plan is a complex of predictive models of the project, and therefore the main indicators of the design processes, which are included in the groups of their efficiency and quality, depend on the accuracy and adequacy of all the used models of the complex [2, 3].

After all, it is known from world practice that almost no design "does not fit into its planned time" [4]. Therefore, the actual upward curve of design costs is usually higher than the planned one (see the solid curve in Fig. 1). It is clear that from the sets of vectors in the space of the design process [5] in Fig. 1, only one is used, namely costs during design. In real design, we have a set of vectors based on the number of parameters of the design process in general.

It is obvious that such a set consists of separate sets – separate "bundles" of vectors that are part of separate design sub-processes.
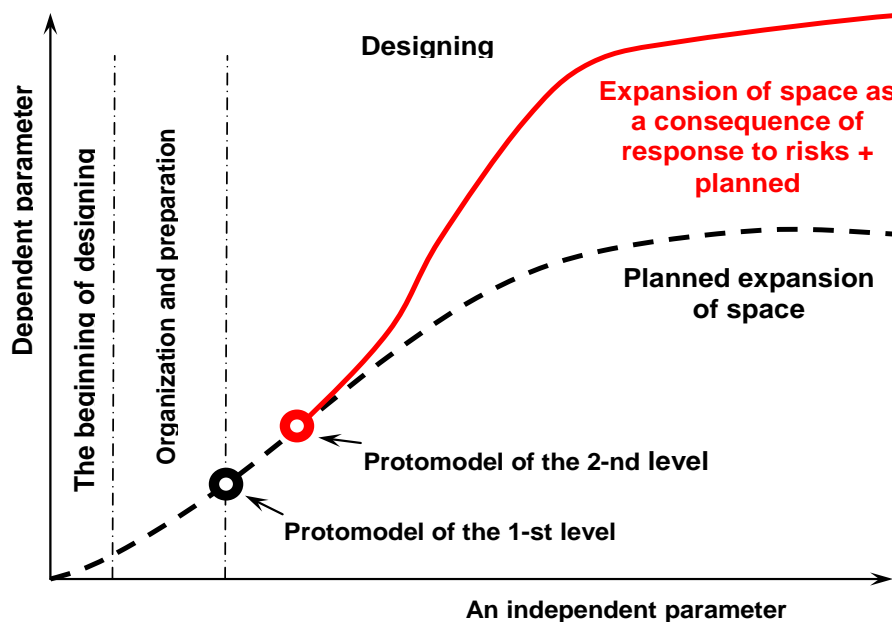
Fig. 1. Growth of an independent parameter of the design process: planned and anti-risk

Creation of a set of initial design models is a mandatory part of design in general [6]. Note that from the first moment of project implementation, the "Big Bang" of the model takes place (by analogy with the well-known theory of the origin of the universe [7]) with its subsequent expansion in the space of project management parameters.

Accordingly, the primary field of parameters created by the Protomodel is subsequently subjected to deformation – expansion within the framework of innovative sub-projects [8]. If we consider these parameters as discrete, then the expansion of the Protomodel will take place in some morphological (structured, discrete) space.

This means that in the future the Protomodel will continuously change structurally [9].

Measuring such changes and being able to take them into account based on forecasting is the key to improving the efficiency and quality of complex projects.

Thus, as a result of design planning, before the beginning of the latter, its Protomodel appears - the first "edition" of the multidimensional informational morphological model [10].

3. The purpose of the work and research tasks

It follows from what has been said that the goal of the work is to find such object models and optimization methods that allow, moving from sequential to parallel design structures, to ensure global decision-making.

To achieve this goal, the following tasks were set and solved in the work:

– to propose a model of the description of the project space and evaluate the possibilities of its transformation during the optimization of the design process according to the "Big Bang" information model;

– to analyze the concept of "protomodel" as the first "edition" of the multidimensional morphological information model of the design process;

– to analyze the model of the development of the design process according to the "Big Bang" scheme and to identify the advantages of this approach in terms of design speed and the quality of the latter's results;

– to test the proposed approach in the process of real design of objects in the relevant (technical, organizational, medical, etc.) field and evaluate the research results.

4. The main content of the work

4.1 Project space and its transformation during optimization of the design process

From a mathematical point of view, the design space can be represented as a combination of dependent parameters of the object and the design process. A change in these parameters (not necessarily

in time; other parameters can act as independent variables: funds, sizes, etc.) is their transformation, and the cumulative change is a transformation of the project space as a whole.

The transformation of the design space during design occurs mainly for two reasons:

– planned expansion of the design space;

– total expansion caused, firstly, by responding to project risks, plus, secondly, planned ones.

Let's look at the typical curve $y = y(x)$ of the planned project life cycle (Fig. 1) [6]. On this curve (solid line) is marked the point at which the planning of the design process is practically completed and the execution of the latter begins (Protomodel of the 1-st level). This is followed by the fastest growth of costs (time, money, etc.), the curve turns into a horizontal section, which ends with a decline.

Let's pay attention to the ascending section. The expansion of the planned design space (see Fig. 1) occurs at the expense of attracting new ideas, processes, people, resources, methods, etc. to it. Most often, in real life, there are more factors of project expansion and, first of all, they are various crises that accompany the project and increase the costs of the latter.

4.2 Protomodel – as the first "edition" of the multidimensional morphological information model of the design process

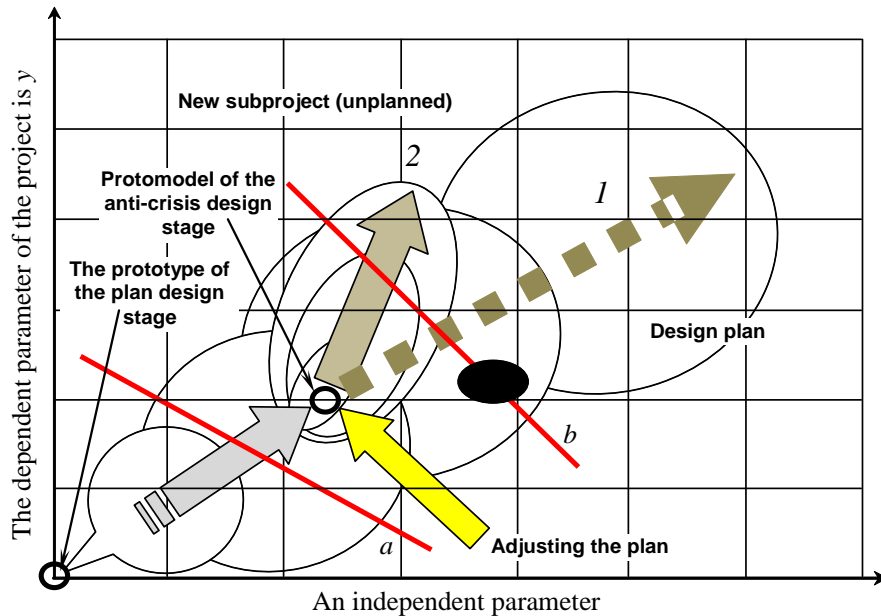In Fig. 2, only two measurements are used to simplify the display.

Fig. 2. Scheme of the development of one parameter (bundle of parameters)
of the project after the "Big Bang"

Protomodels are conditional design parameters E (a dependent parameter, for example, time or funds) and an independent parameter Y (the designed object).

With the beginning of designing, there is a "Big Bang" of the Protomodel, which in the future leads to the iterative expansion of the latter according to, for example, sequential technology.

As a result, at the end of each design iteration, we have a new "edition" of a consistent morphological model, and the process of its dynamic expansion can be described by a time discrete function.

The directions of expansion of the models are determined by the content of the corresponding projects [8] and are described by vector 1, Fig. 2. Simultaneously with the development of the main stage of designing according to a sequential technology, there may be a need for an additional substage, which has its own Protomodel and develops further after its "Big Bang", for example, according to one of the known technologies [11, 12, 13].

Any $(n - k)$ – dimensional section of an n-dimensional design model, where k is the dimension of the "plane" that makes the section, $(k < n)$ (red lines in Fig. 2) will reflect its status at the current moment of time [2, 14].

It is possible to perform several such measurements on a time-discrete model, and their set will be a discrete model of the life cycle of the design process [15].

As can be seen from the example shown in Fig. 2, in addition to the parameters of the main sequential technology, parallel technologies, as well as "black spots" that simulate the dying of past fragments on the way to the end of the design, can fall into such a section.

A complete morphological model of the design process consists of elementary models of individual measurements on all nodes of the discretization of the design object.

Note that the expansion of the model during the "Big Bang" differs significantly from the "normal" explosion in that each element of the model begins to move at each "design" iteration from the point at the beginning of this iteration as a new center (Fig. 3).

As a result, at the end of each design iteration, we have a new "edition", for example, of a sequential morphological model, and the total movement for t iterations will be equal to vector $\mathbf{R}_{1-6}$ (Fig. 3), which is the vector sum of all intermediate vectors: $\mathbf{R}_{1-6} = \mathbf{a}_i + ... + \mathbf{a}_{ijklmn}$.

This figure shows how the original sequential design process in the course of project activity can generate additional (unplanned, for example, anti-crisis) sub-projects, and also leaves behind some "black holes" that indicate the resources of the design process, unused and abandoned for various reasons , that is, direct losses of time, money, materials, equipment, specialists, etc.
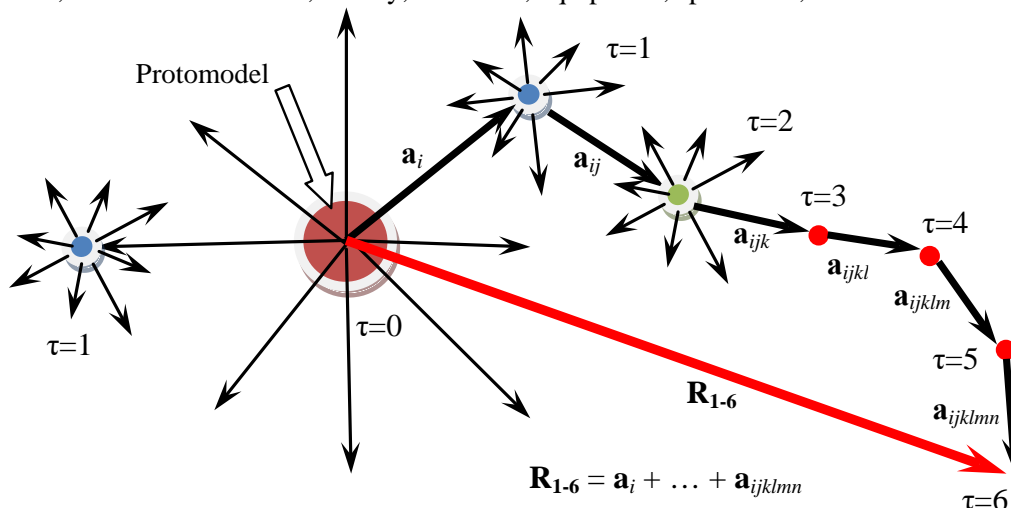

Fig. 3. Scheme of measurement of one parameter (set of parameters) of an object or design subject after a series of "Big Bangs"

4.3 The model of the development of the design process according to the "Big Bang" scheme and the measurement of the parameters of this approach from the point of view of design quality

To take into account the circumstances listed above, design management models based on the cosmogonic theory of the Big Bang were proposed (Fig. 4). The main time unit in this model is the time interval between the start of the subproject τ_0 and the time of any event τ_1 that stopped this design subprocess.

Counting time τ_1 not only starts a new design sub-process (instead of a stopped one), but also initiates measurement and evaluation of some design properties for this period.

4.4 Practical implementation of research results

In the Center of Reconstructive and Restorative Medicine (University Clinic) of Odesa National Medical University, tests of the anti-crisis system for measuring the parameters of the optimal project decision-making process in medical practice were conducted.
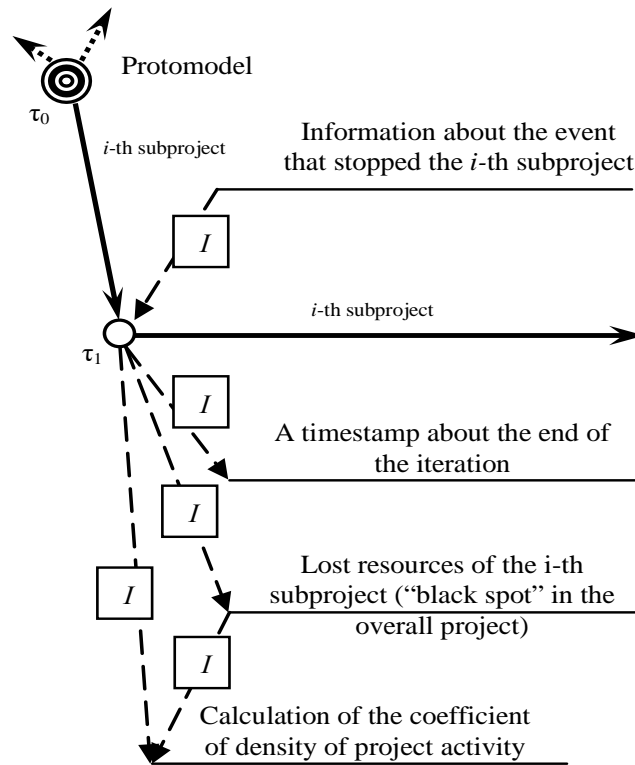
Fig. 4. Scheme of sub-processes that take place
at the end of iterations of the design process

The system was used in the design of treatment tactics for patients with disseminated tumors of the abdominal cavity IV stage using cytoreductive surgical interventions, systemic polychemotherapy and the technique of intra-abdominal high-temperature chemoperfusion.

Tests showed that its use allowed to achieve the following results:

– the resectability of the primary tumor increased to 65% (2.3 times compared to the control group);

– according to survey data, the quality of life in the postoperative period improved by 43%;

– the number of patients whose life expectancy exceeded 1 year after the diagnosis and the start of special treatment increased by 23%.

5. Conclusions

1. A model for measuring the design space is proposed and the possibilities of transformation of the latter during the optimization of the design process according to the "Big Bang" information model are evaluated.

2. The concept of "protomodel" as the first and subsequent "editions" of the multidimensional morphological information model of the design process was created and analyzed.

3. A model of the development of the design process according to the "Big Bang" scheme was created and analyzed, and the advantages of this approach in terms of design speed and the quality of the latter's results were revealed.

4. In the Center of Reconstructive and Restorative Medicine (University Clinic) of Odesa National Medical University, tests of the anti-crisis system for designing the optimal process of making project decisions in medical practice were conducted. Tests showed that its use allowed to achieve the following results regarding the quality of medical care:

– the resectability of the primary tumor increased to 65% (2.3 times compared to the control group);

– according to survey data, the quality of life in the postoperative period improved by 43%;

– the number of patients whose life expectancy exceeded 1 year after the diagnosis and the start of special treatment increased by 23%.

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