

AD 06

Characteristic Feature of the Goal and Method Used for Helicopter Design as an Object of System analysis.

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In the report the question is the modern designing of helicopters, as well as designing of systems on the whole, has suited to that limit in the development, when the necessity is the revolutionary transformation of the general methodological approach to choosing of design solution. Proceeding from the historical analysis of helicopter design development, the author of the report supposes so-called system designing, about which today is many written in literature, can not to accept the completed form, until the laws of existence and dedevelopment of process of designing are known. To search of these laws the research is devoted conducted In The Institute of Cybernetics of NAS of Ukraine. In the report some initial principles, on which ithe research is based, are described. In the author opinion, that its base should make the multidiaspects system analysis of designing process. The report gives the description of particular purposes of the analysis. The goal and method of designing, as well as external and internal factors, under influence of which they are formed are considered as the individual systems.

Each object is analysing in its historical development. All of them together make, in opinion authors of report, uniform system. The fragments of some qualitative working models of studying objects are represented.

1. OBJECTIVES

By the beginning of the 80-th years in helicopter construction the indications of the next crisis were explicitly designated which per 90 years has burst in total volume. The defined braking of the aircraft development is characteristics of it, the lack, in essence, of new engineering solutions and presence of a lot of practically unsoluble problems. The periods of designing of new machines are stretched up to twenty and more years, cost of development unreasonably grows. The following, fourth, helicopters generation, which emerging was expected per the eightieth years, before this time so, on - essence, has not appeared. The modern helicopters designing maintains ideas, seggested as far as 60-th - 70-th years, and, practically, is reduced to innovation modifying of existing machines.

The historical-scientific analysis of the helicopter construction development from sources up to the middle of the 80-th years XX centuries and, in particular, analysis of the helicopter design methods carried out in due time in the Institute of Natural Sciences and Technology of SA of USSR and in the Aviation Institute in Moscow by the author of the given report [1], gives foundations to state, that this crisis has general methodological nature.

Strictly speaking, any crisis in development of technical systems in that or other sense is connected to methods for its designing: or with particular special methods of solving those or other problems, or - with the general methodological approach to a choice of a design solution. It to the full concerns and to the

helicopter. - Just about the helicopter we can it state with all determinancy.

In development of the helicopter, apart from the present, three crises took a place [1,2]. On Fig.1 the termination time of each of them is designated. Two crises - 1-st and 3-rd - were stipulated by a lack of special-scientific methods. The 1-st was arisen because of a full lack of the helicopter theory and, accordingly, methods of account of its basic parameters [1,3]. In spite of the fact that small-dimensions models successfully flied approaches to construct a life-size aircraft came to an end by failure, - the helicopter development was braked. And only after in 1903 y. Ch Renard by a research experiment established the dependence between its basic parameters - carrying capacity, engin power and the rotor diameter - the helicopter has come off ground. On Fig.1 it is designated as the leap in its development.

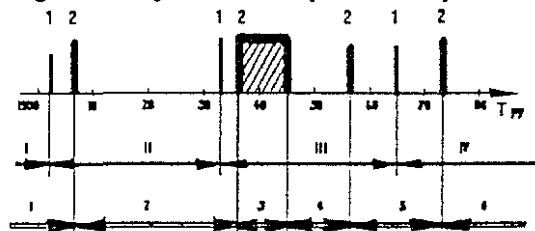


Fig.1 Situations of helicopter design development and helicopter development leaps

- 1 - Helicopter design development leaps
- 2 - Helicopter development leaps
- design development periods
- helicopter development periods

The 3-rd crisis generated per 50 years, was caused by that there were no methods of a choice of parameters in view of the requirement of profitability of the helicopter. To overcome it emerging the theory of effectiveness, the theories of optimization and rather of powerful computers has allowed. - In development of the helicopter there was the leap - has occurred of their third generation. The acuteness of the crisis was some reduced per 60 years as an outcome of emerging of more economic engines. It has reduced in the small leap - emerging of the second generation of helicopters, but these helicopters very fast have ceased to satisfy the requirements of practical application..

But the second crisis, as well as present fourth, was caused viciousness of the general methodological approach to a choice of a design solution, i.e. the design in whole was under construction on incorrect principles. The designers working in 10-th - the 20-th years, tried to solve the problem of creation of a helicopter during immediate construction a life-size aircraft, i.e. worked as a primitive trial and error method.. Between that, the objective scientific and technical premises of a solution of this problem to 30-th years already have developed. The mode of power-off landing by rotor autorotation was found. This phenomenon, discovered still in 1905 -1909 yy. by D.Rjabushinsky in the Kuchino Institute near Moscow, to 30-b to years was already applied and is completed on autojiros. The swashplate was also received wide reputation, with thr help of which a problem both controls and stabilities were solved. There were already theories for the estimation both vertical and horizontal flights of the helicopter.

However, the simplified methodological approach delayed a solution of the problem, - the helicopters rose on a height no more than 4 m, some aircrafts could make flight in limits 1 km and all helicopters were unstable and bad controlable, - their development is farther it did not move.

To cope, at last, with problem of creation of the helicopter, suitable for real flights, at which some centuries were beaten the scientists and inventors, was possible only per 30 years of our century, after basic methodological transformation of the process of the designe with which was completed it becoming as method, suitable for solving of the so complicated retrieval problem. In 30 years in the helicopter construction the designers of planes, most known in the world, have come: G.Focke, L.Breguet, I.Sikorsky. In USSR from an extremity of the 20-th years such experienced air theorists and designers, as B.N.Juriev and A.M.Cheriomuchin have begun to solve this problem. All of them have brought the experience and principles of work in the design of plane, which was in that time already quite efficient and widely used aircraft. Instead of practical designing, trial and error method, in helicopter designing the multifold research experiment - in wind-tunnel and also model and bed tests - and careful preliminary theoretical study of the project has come. The division of labour has come also, that is the designers - singletons were replaced with designer collectives. The process of designing in the basis has found to all of us now familiar aspect. It was followed with the leap in the helicopter development, - the helicopter has departed [1,4]. First in generation of efficient helicopters was a German rotor aircraft by G.Focke - FW-61. Then within 8 years have appeared fit to work helicopters of

the different schemes constructed in the different countries.

In whole it is possible to tell, that to each crisis in development of an technical system will precede crisis in development of designing methods, solving of which entails fast, taking leap form perfecting of the technical system. On Fig.1 is showed situation of the leaps in development of methods of designing and in helicopter development.

Logically the reason of each crisis of the methods consists in becoming aggravated of the inconsistency between the goal and method of designing, or between complexity of the problem and method of its solving. Such inconsistency exists always in any process of knowledge, research or design. In the methodology of a science it carries a title of an inconsistency between "a subject and method " [5]. At a defined stage of development of a system it sharply becomes aggravated, owing to what the indicated development is broken, - occurs crisis. The origin of similar crises has scientific explanation.

The complexity of inventive, technical and any search problem, including designing (on G.Polya' s classification - "problem on finding" [6]) is defined by number of the approaches - iterations, - reqeud for its solving. The theory of inventive problems solving (TIPS) in an association from necessary number of the approaches defines five levels of complexity of the problems [7]. If the first level problems are solved in some approaches, fourth - in some tens thousands. For solving problems of fifth level complexity some millions iterations can be required already.

Accordingly, the solving method should allow to realize required number of the approaches in acceptable time. However in accordance with historical development of an technical system - in our case of the helicopter - the complexity of the design problem raises because existing requirements become hard and new requirements to it emerge. The amount of necessary iterations grows. This process considerably anticipates perfecting methods. In an outcome on defined time the new design problem appears insoluble, - the crisis in development of the helicopter occurs. Such situation periodically repeats, and each consequent crisis gains a more and more deep and long character.

Today we observe in helicopter construction just these processes. As the modern crisis condition, as was already spoken above, have general methodological nature, to deduce from it helicopters design, i.e. to remove a peaking of an inconsistency, it is possible, under our judgement, only how it was made per 30 years, - by a radical modification of methodological principles of pdesigning.

What it is concrete means?

2. PRINCIPLES OF ANALYSIS OF THE GOAL AND METOD FOR HELICOPTER DESIGN

The problem on passage to a new principle of designing rises in the literature for a long time, and in general methodological [f.ex. 8, 9, 10, 11, 12] and in special [f.ex.13, 14, 15, 16]. It speaks about so-called system designing. The steps in this direction are made, in particularly, choosing of paramrters on the basic of system analysis of designing object enters the practice [17,18, ets.], an aircraft is examinated as the part of "a large system" - is an air-operation complex.

However, this is not radical, not revolutionary modification of the methodological approach yet. The present systems analysis of designing object is a little more high level of analysis, which carried out, in effect, always. Already introduction of complex economic criterions of effectiveness was essential progress in this respect, and today's analysis - it natural development, innkvation perfection of the method.

The revolutionary modification of the approach, which it would be possible to name as system designing as is thought, should consist in reviewing object, or goal, and process of designing as uniform system.

If, as it was spoken above the complexity of the design problem, or goal of designing, is defined in to an amount of iterations - approaches, - which are required for its solving, and the method is estimated by an amount of iteration, , which it allows to realize in acceptable time, it is necessary, at first to establish, at the expense of that is concrete the number of iterations is increased, and, secondly to find such structure of a method, which will allow to realize their. To solve both these problems it is possible only jointly.

However, to have a possibility consciously to operate forming of a structure of the process in the correspondence with a modification of the goal, it is necessary to know the laws, to which the design existence as uniform teleological system submits, and to know lows of this system development.

It is necessary also to know, on what objectivity laws the goal of designing develops. It will allow to foresee direction and periods of its probable modification and accordingly to correct the method.

Nowadays process of designing represents spontaneously, without conscious methodological participation of a designer formed process, - a gang of operations and procedures, the connections between which can have casual nature. As today it is a little effective, means, any its elements do not suffice, and any, most likely, superfluous.

To solving all set forth above problems for helicopters designing we put by the task of the research, some which preliminary outcomes are represented in the given report.

For to solve our research task it is necessary to analyze a system " the required helicopter - method ", to find it intrasystem connections and logic of their development. In the correspondence with a principle of decomposition of a system we conduct separately systems analysis of the goal and analysis of the method.

The goal represents a system of interconnected and interdepended requirements to designing object. It is, on - essence, model of the future helicopter constructed from the requirements, made to it, or exposition of a finding solution with the help of requirements. On the other hand, the design goal is a system of the requirements varying in time under influence of some factors, i.e. it is developing [19].

It is necessary to specify, that the goal is meant as a not concrete requirement specification on the designing (design assignment), but objectivity generated gang of the requirements to the helicopter as to a flying means of the given type reflecting public need for it.

The process of designing, or method of designing, is a system of interconnected and interdependent of operations directed on an embodiment

of a system of the requirements in a real engineering system, at first on ideological, then at a material level.

At the same time, this system, as well as goal of designing, varies in time, i.e. the method too can be considered as a developing system.

There is and *third system*, which is necessary for analyzing for deriving the planned outcome, are the factors, under which influence are formed and develop the goal and method of designing. They too are interconnected and interdependent elements, joined in a system of a special-purpose designation.

During the analysis the series of models of researched plants as static and as dynamic systems was constructed. Fragments of some of these models are represented on the Figures. At the construction of the models of the design the standard block diagram of aircraft design was used. [f.ex., 14, page 17].

At Fig.2 is shown the static model of the modern goal of helicopter design constructed as a tree of the requirements. To the present time, to be exact, - to a middle of the 80-th years in basic its becoming as systems of the requirements to the given type of a flying means was completed it. It means, that since that time it takes into account all basic connections of the helicopter with social and biological life of a society. Accordingly, it is possible to singl out three basic groups of the requirements - functional - engineering, economic and oecological in it.

On sublevels we conduct breaking up into smaller units, detaling, the requirements, which can be finished down to the requirements to the separate elements of the helicopter. By other words, we do that in system analysis is named as decomposition of a system. The grain size is determined by conditions of the soluble research problem. The similar model allows to receive a structure of the goal, to show, on what sublevels the intersection those or other requirements begins and from what sublevel the model turns to the continuous interconnected web. This model allows to receive graphic exposition of the goal of design with a necessary grain size.

However, on such model the interior connections of a system are represented only, but for our research the exterior connections are also extremely important. They show, under what influence of the factors the goal of design, or the requirements to helicopters, is formed, and how the helicopter influences the exterior world. The exterior connections can be specified and on this model, but it is possible and on a model reflecting historical development of the helicopter design goal.

To construct such model, it is necessary to arrange a so-called periodization of the helicopter industry development, in particularly, methods of designing, which reflects characteristic of this development logic stages, Tab.1.

For each of stages the static model of the designing goal similarly constructed by us for present stage is created. Then these models are definitely united in a uniform sequential circuit so that to reflect historical emerging and transformation of each of the requirements. On Fig.3 the fragments of the integrated variant of an indicated model are represented. If it to unroll, we shall receive an interior structure of each requirement with the indication of the factors, forming it and also sequence of transformation in time of each requirement.

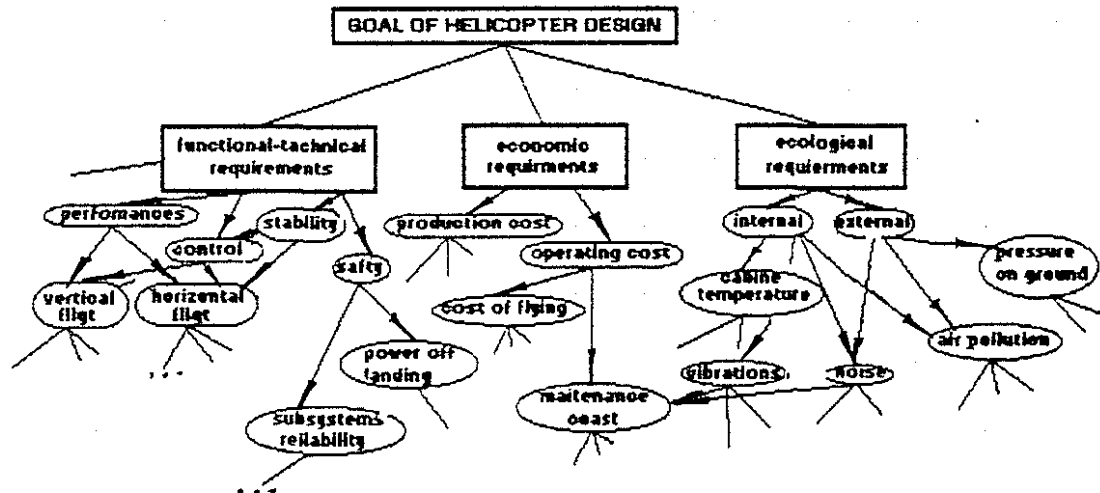


Fig.2. Modern helicopter design goal (a Fgagm.)

Division into periods of helicopter designing methods

Tab.1

Stage of the development	Chronological limited of the period	Characteristics of the period	
		Design goal	Design method
Formation	I Middle of XIX-th - Middle of XX-th centuries	Lifting	Heuristics, practical building (trial-and-error method), engineering analysis elements
	II Beginning of XX cent. - middle of 30-th yy.	Lifting, securing stability, control, power off landing	Heuristics, practical buildings, used of plane statistics, engineering analysis elements
Perfection	III Middle of 30-th - middle of 60-th yy.	(middle of 40-th - middle of 50-th yy.) performances improvement	Combination of analitical and ststistical methods (as accumulational of helicopter statistics was)
	IV Middle of 60-th - Middle of 80-th yy.	1. (middle of 50-th - viddle of 60-th yy.) performances improvement, operating economy 2. (till the end of 70-th yy.) performances improvement, operating economy, ecological suitability	Optimizang, system analysis elements, used of computers

The analysis immediately of process of designing, i.e. methods of designeng, and construction its models was carried out because of studies of the theory and practice of modern system design and purely of helicopters, experience of practical application of the given aircraft and historical-scientific research of the aircraft development.

In design we are interested some with moment:

At first, it is what concrete operations and in what sequence are made by the designer. For what concrete purpose each given operation is made, what reasons have stipulated a choice just of this operation, instead of any another, how many time is made an operation, i.e. in how many of approaches the outcome is achieved, the reasons just of such amount of the approaches and degree of reaching of an outcome are objective or subjective.

Secondly, to what type of activity the made operation concerns.

As it is known, in design three types are selected such as activity [20]: inventing - engineering analysis - decision making. For establishing the type such as activity it is enough conveniently to be guided by the given classification. By establishing the type of activity, we can ascertain relation between "creative" and "routine", or heuristic and algorithmic, parts of the process of designing. Then the majority is necessary on "routine", therefore, the method is more perfect, more effective. The majority of a load at the choice of the design solution is on heuristics, the less method is adequate to the goal, and the above level of intellectual abilities of the designers, level of their intuition is required. It can much higer then the average level. The history of the helicopter industry and, in particular, methods of helicopter design, illustrates it very good. - When the question was initial origin of idea, its authors were ingenious (L.da Vinci, M.V.Lomonosov), and then produced scientists - naturalists, physics and mechanics, (A.Paucton, Lœnoi, Bienvenju, J.Kaly, J.Babinet), then known engineers

(G.Ponton-d' Amecour, G.de la Landell, D.Chernov, etc.). Such descending sequence is explained by the level of science, appropriate everyone time, first of all - mechanics and aeromechanics, as the helicopter - system which is not having natural analogs, it the idea was born inside science and engineering.

When the idea has received wide popularity, many designers of the usual average level of intellectual abilities worked on above attempts to construct on its basis a real aircraft, though the complexity of the problem remained same, - the problem has appeared insoluble. And only improvement of the method at the expense of magnification of an algorithmic part and reduction heuristic, that has become possible due to the made scientific discoveries, has allowed to advance in its solving.

That had a place and in consequent historical phases. In whole it is possible to tell, that excessive volume of heuristics in a method of designing speaks about necessity of passage to wide scientific researches and organized, if it is possible so to be expressed, - algorithmic heuristics. There is some optimum relation of heuristic and "routine" components of the design process, which should be established.

Thirdly, in the design we interests, what groups of operations are directed on realizing that or other initial requirement and what outcome with. The principle of estimating quality of the outcome in the little bit simplified form very visually is seen on an example of early stages of the helicopter development. For this purpose it is possible to use, for example, V.Gasparsky's formula [11, p.26]:

$$\sigma = W/C,$$

where σ - Quality of an outcome; W - Outcome, i.e. positively estimated, achieved Effect, C - Goal.

The goal of designing is defined as a sum of the problems, component it, outcome - as a sum of the solved problems.

Proceeding from this, the following picture turns out:

I period C = 1; W = 0; $\sigma = 0$

II period C = 4; W = 1; $\sigma = 1/4$;

III period (up to a middle of the 40-th years) C = 5;

W = 5; $\sigma = 1$.

In - fourth, all set forth above to us needs to be analyzed in historical development.

To achieve the purpose, under our judgement, it is possible, by determining an informative structure of designing at each historical stage with a designation all internal and external connections of the system.

Internal connections is an interdependence and interfluence between operations, made during designing, as by the elements of the system. It is necessary to establish, whether their coexisting in the uniform system is natural, what inconsistencies between them, and as these inconsistencies develop. It is necessary also to establish, whether is the presence of an operation during designing naturally stipulated or its accidentally, temporarily, some kind of palliative, used the designer because he can not find a right path yet. The operation

can be and simply error generated by the objective or subjective reasons.

By other words, we should understand, whether there are in this system casual, in effect, elements, not necessary to it, and what the elements lack for it logic completion.

The external connections, the same as in a case with the goal of designing, show interaction of the process of designing with appearances of an exterior environment. The analysis of exterior connections should show, what factors render influence to forming of the method of designing, to what elements and how they are connected, what factors stimulate development of the method and what with it hinder, how they do it and at what historical tages. In this it is also necessary to separate casual connections from natural.

In Fig.4-7 the fragments of some of the constructed models of projection are represented.

As to the third researched system, i.e. system of the exterior factors, its analysis is necessary on the following reasons.

At first, supposition that the exterior factors influencing to forming of the goal and a method of designing, not separate and not independent from each other, but represent the uniform teleological system, requires the check and the corroboration. For this purpose it is necessary to reveal it interior connections and to establish the mode of their realization, and also to find the concrete purpose, on which this system is directed at each historical stage, and then the generalized purposes.

Secondly, this system does not only influences each of first two systems, but it also installs additional connection between them. As it happens too it is necessary to reveal. In Fig. the basic structure of the circumscribed system is shown. The structuring as required can be continued.

In generally, detailing of all models is probable only because of extensive practical information. At present we have constructed their preliminary variants. In the further research it is supposed to carry out required structuring and improvement of the models, and also to construct additionally models containing a quantitative evaluation of each stage among necessary and made iterations in unit of time. Then the models will be analysed in interaction with each other in the necessary combinations and at a required level of detailing, but the methods of a further research go out for frameworks of the given message.

Thus, following the selected method of the multiaspect systems analysis of helicopter design, the authors hope to find regularities, to which the general organizational structure of the designing process submits and then laws of its development. The knowledge that and another is necessary for conscious methodological control by the design in accoding with changing complexity of the design problem, that in turn, reflects a modification of social need in the given engineering plant.

The solution of the posed research problem would allow to take out helicopter design from a modern crisis condition and to notify development of crises in further.

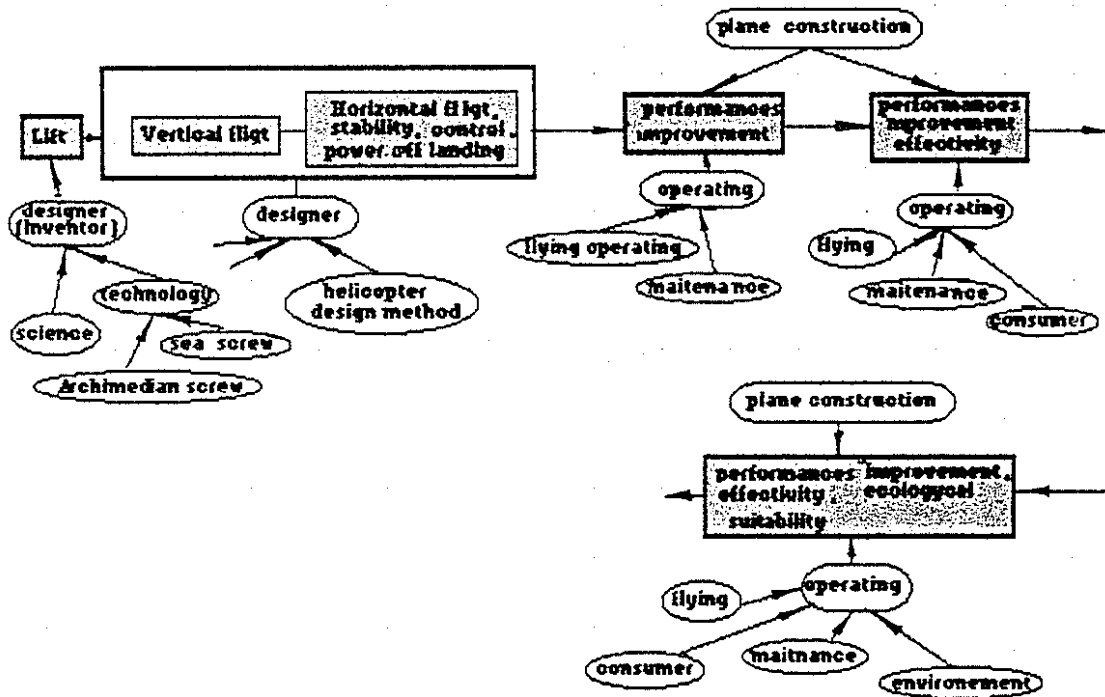


Fig. 3. Enlarged dynamical model of design goal (a Fragm.).

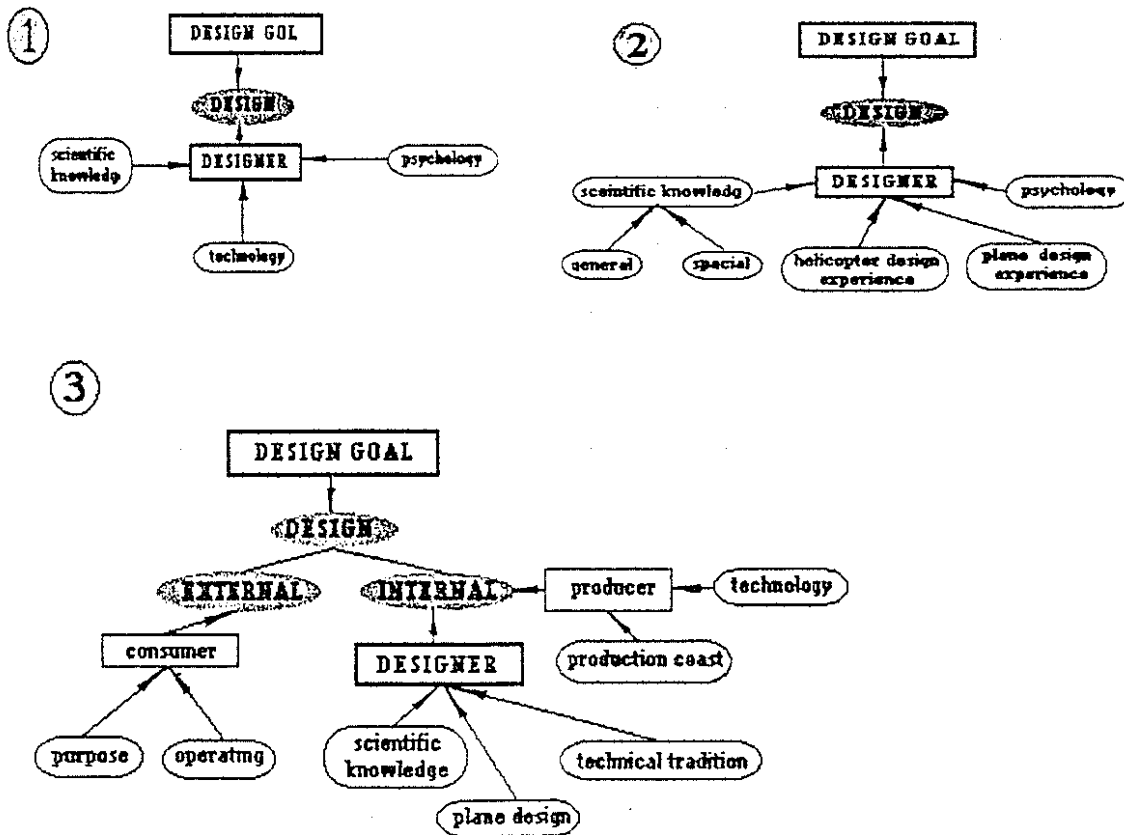


Fig. 4. Early Historical stages of helicopter design into forming factors system(a Fragm.).

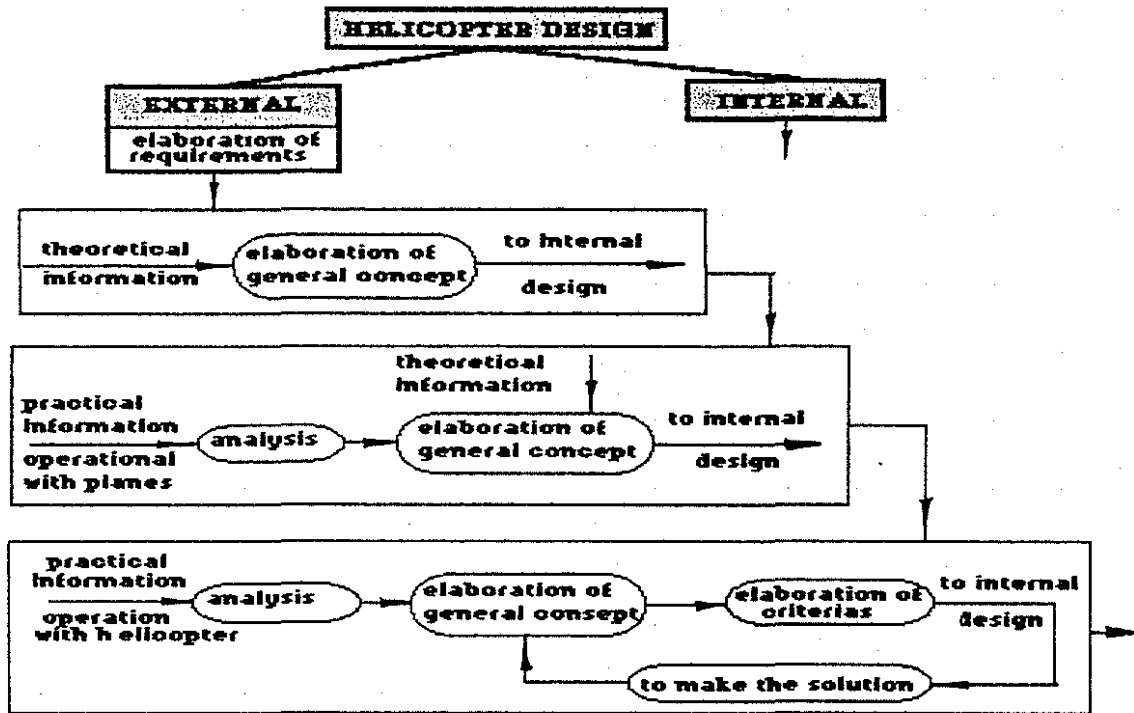


Fig.5. Enlarged dynamical Model of Helicopter design (a Fragn.).

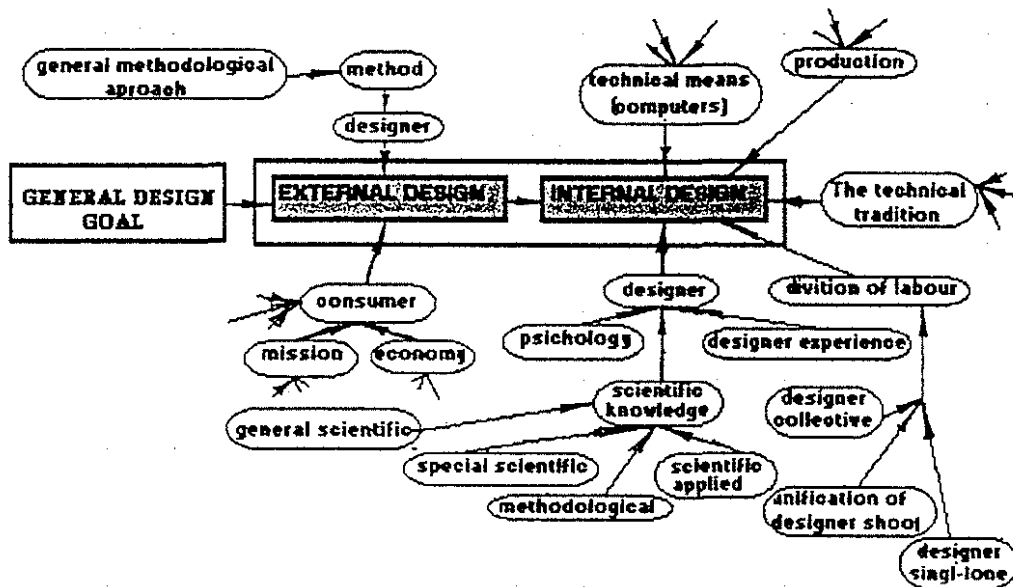


Fig.6. E[ternal forming factors about Helicopter design (a Fragn.).

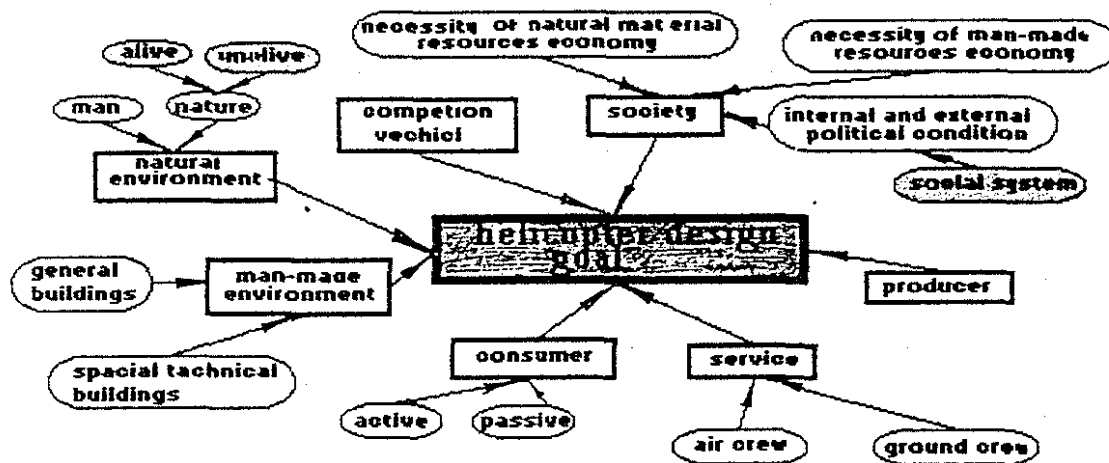


Fig.7. E[ternal forming factors about conditional helicopter design Goal (a Fragm.).

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