POSTDOC WORK PROGRAM FOR OLENA V. MUL
Scientific Coordinator: Delfim F. M. Torres

Title of the proposed investigations: **Analysis of Vibrations in Nonlinear Dynamical Systems**

Proposed start date: **01/07/04**

Duration: **12 months**

The objectives of the investigations:

Nonlinear dynamical systems with distributed and discrete parameters are widespread not only in heavy, extractive and manufacturing industry but in space-system engineering as well. Different complex dynamical processes are possible in such systems including vibrations, which always have negative influence on their functioning and sometimes even can result in system breakdown.

Therefore the objectives of the investigations are to study possible vibrations in such nonlinear dynamical systems with distributed and discrete parameters as spacecrafts of big size and controlled machine units as well as to find ways how it is possible to decrease harmful effect of vibrations on normal functioning of the systems.

The phases and the time schedule of the investigations:

1. **Development of New Mathematical Models for Spacecrafts of Big Size**, 01/07/2004 - 15/08/2004.

On the first phase it is necessary to consider the spacecrafts of big size, which contain some flexible elastic elements. Specifications for the spacecrafts (for example, in the part of form control and accuracy of space antenna orientation) provide for that intensive vibrations in such flexible constructions are not admissible. Passive damping of vibrations is often applied for vibrations elimination but strict specifications for the spacecrafts call the other methods of struggle against vibrations. For example, it is using of systems of vibrations active control.

Therefore the problem is to study effect of active control on dynamical characteristics of the elastic construction with distributed parameters. It is necessary to point out that earlier there were several attempts to solve this problem. But the used mathematical model of the system accounted only discrete parameters of the construction and so it was not accurate enough for this purpose.

If we take into account all the distributed parameters of the flexible elastic construction, we will formulate the mathematical model in the form of a nonlinear boundary value problem, which consists of a partial differential equation and nonlinear boundary conditions.

2. **Development of Numerical Methods for Investigations of Vibrations in Spacecrafts of Big Size**, 16/08/2004 - 15/11/2004.

On this phase it will be possible to develop some numerical methods for the investigations of vibrations in spacecrafts of big size on the base of their new mathematical models developed on the first phase of the investigations.

For example, the numerical method of normal fundamental systems of solutions allows to determine first of all frequencies at which excitation of vibrations is possible.

3. Development of Asymptotical Methods for Analysis of Vibrations in Spacecrafts of Big Size, 16/11/2004 - 15/02/2005.

On this phase it is necessary to develop some asymptotical methods for analysis of vibrations in spacecrafts of big size on the base of the mathematical models developed on the first phase of the investigations. Such asymptotical methods will allow to obtain under some assumptions not only frequencies of vibrations but their amplitudes as well. In this way we can determine conditions of stability of the considered construction at vibrations active control as well. After analysis of influence of different parameters of the considered systems it will be possible to make a conclusion about the optimal parameters of such systems.

4. Development of Homogenization Methods for Analysis of Vibrations in Controlled Machine Units, 16/02/2005 - 15/06/2005.

On this phase it is necessary to study possible dynamical processes in some controlled machine units with discrete parameters, which are used for materials processing, transportation etc. Such dynamical systems consist of motor, some mechanical part and system of process control. Functioning of such machine units showed that dual-frequency vibrations are possible. As there are some controlled dynamical parameters in such systems, it is necessary to study their influence onto the character and modes of possible self-vibrations.

The mathematical models of such systems are nonlinear boundary value problems with non-classical boundary conditions. Such a model is a system of ordinary differential equations of the fifth order and one of the boundary conditions is a nonlinear one. This allows applying some kinds of homogenization methods for the investigations.

Such methods make possible to determine conditions of stability of both one-frequency stationary modes and dual-frequency ones. Besides we can obtain frequencies and amplitudes of the vibrations as well as the character of transient to stationary modes. Such calculations will allow to study the dependence of stationary modes characteristics in the considered controlled machine units on the different parameters of the systems. For example, it is very important to study such a dependence of frequencies, amplitudes etc. on electromagnetic sluggishness of motor. After such investigations we will be able to propose to use some feedbacks, which allow purposefully changing electromagnetic sluggishness of motor and in this way to optimize functioning of the controlled machine units with discrete parameters.

5. Writing of the Report, 16/06/2005 - 30/06/2005.

The last phase will be devoted to the preparation of the Report about fulfilled investigations.

The prospective benefits of the investigations:

The prospective fellowship could allow to raise scientific level of the visitor and give to the visitor the possibility to study modern conceptions and methods of applied mathematics for investigations of functioning of dynamical systems with distributed and discrete parameters. This allows to choose the most promising techniques for prospective investigations and to establish mutually beneficial international scientific contacts between the home institution and the host institution. Besides skills obtained during possible fellowship could be applied for improvement of qualitative level of visitor teaching in the home institution.

The results of the investigations could be applied in space-system engineering as well as in heavy, extractive and manufacturing industry for design of new improved technical systems such as spacecrafts of big size and different controlled machine units for materials processing, transportation and so on.