FINAL REPORT
AND FUTURE RESEARCH PLAN

of Olena Mul

FCT Postdoctoral fellowship SFRH/BPD/14946/2004
(Relatório detalhado dos trabalhos realizados e plano de trabalho futuro)

1. Report about fulfilled work (Relatório detalhado dos trabalhos)

My Postdoctoral fellowship in the University of Aveiro began at July, 1, 2004.

During the second year of my fellowship, I continued my investigations according to the research plan, which was approved by FCT. Thus, I studied non-stationary boundary problems with continuous-discrete parameters, which describe a wide class of controlled dynamical systems, such as aerial cable-ways and some electromechanical systems of controlled machine units for materials processing, transportation etc. I used mathematical models of such systems written in partial differential equations and applied to them asymptotical and numerical methods of investigations. I made analysis of the changes of system dynamical characteristics depending on controlled parameters and in this way found some possibilities of system control. The obtained results may be applied for design of the improved technical systems in heavy and extractive industry as well as in transport.

Below there are presented all the activities during my fellowship, which were not mentioned in the final report after the first year of the fellowship.

I published the results of my work in two papers in **International scientific journals**

1) Mul, O.V., Torres, D.F.M.: **Analysis of Vibrations in Large Flexible Hybrid Systems**, in: *Nonlinear Analysis*, Elsevier, vol. 63, 2005, pp. 350-363, http://www.elsevier.com/wps/find/journalaudience.cws_home/239/description (the off-print of this paper is enclosed, see Appendix 1);

2) Mul, O., Torres, D.: **The Numerical Method of Investigations of Vibrations in Large Flexible Systems** (in Ukrainian), in: *International Scientific Journal of Computing*, vol. 4, issue 1, Ternopil, 2005, pp. 52-59, http://www.tanet.edu.te.ua/computing/eng/index.htm (the copy of this paper is enclosed, see Appendix 2);

and also in four **preprints**, which are at the moment under reviewing for publication in the journals:

3) Tydnjuk, V. Z., Kravchenko, V. P., Mul, O. V.: **Naturally Controlled Processes and Theory of Relativity**, *Série de Investigação (Cadernos de Matemática)* CM 05/I-33, Dep. Mathematics, Univ. Aveiro, July 2005, http://www.pisharp.org/dspace/handle/2052/84 (the paper version of this preprint is enclosed, see Appendix 3);

4) Tydnjuk, V. Z., Kravchenko, V. P., Mul, O. V.: **Natural Control of Energy Material Processes and Theory of Relativity,** *Série de Investigação (Cadernos de Matemática)* CM 05/I-40, Dep. Mathematics, Univ. Aveiro, October 2005, http://www.pisharp.org/dspace/handle/2052/92 (the paper version of this preprint is enclosed, see Appendix 4);

5) Olena V. Mul, Delfim F. M. Torres and Volodymyr P. Kravchenko, **Dynamics of Controlled Hybrid Systems of Aerial Cable-Ways,** *Série de Investigação (Cadernos de Matemática)* CM 06/I-16, Dep. Mathematics, Univ. Aveiro, April 2006, http://www.pisharp.org/dspace/bitstream/2052/131/1/pam00131.pdf (the copy of this preprint is enclosed, see Appendix 5);

6) Olena V. Mul and Delfim F. M. Torres, **Some Applications of the Method of Normal Fundamental Functions to Oscillation Problems**, *Série de Investigação (Cadernos de Matemática)* CM06/I-17, Dep. Mathematics, Univ. Aveiro, May 2006, http://www.pisharp.org/dspace/handle/2052/132 (the copy of this preprint is enclosed, see Appendix 6).

The next five presentations were made (or will be made soon) at **International Scientific Conferences**:

1) "**On Asymptotical Method for Vibrations Analysis of Large Elastic Dynamical Systems**", *the Sixth International Conference* "*Symmetry In Nonlinear Mathematical Physics*", Kiev, Ukraine, June 20-26, 2005, http://www.imath.kiev.ua/~appmath/conf.html (the abstract and the copy of the done presentation are enclosed, see Appendix 7);

2) "**Dynamics of Controlled Hybrid Systems of Aerial Cable-Ways**", *the International Conference of Hybrid Systems and Applications*, Lafayette, May 22-26, 2006, http://cos.fit.edu/math/ichsa/ (the invitation letter and the copy of the presentation, which will be done, are enclosed, see Appendix 8);

3) **"Analysis of Some Nonlinear Hybrid Controlled Electromechanical Systems"**, *the INTAS Summer School "Nonlinear Analysis with Applications in Economics, Energy and Transportation"***,** Bergamo, Italy, June 5-9, 2006, http://www.unibg.it/struttura/struttura.asp?cerca=dmsia_intas (the copy of the invitation letter and the abstract are enclosed, see Appendix 9);

4) **"Some Applications of Spectral Theory for Investigations of System Dynamics and Control"**, *An Isaac Newton Institute Workshop "Spectral Theory and its Applications"*, An Isaac Newton Institute, Cambridge, UK, July 24-28, 2006, http://www.newton.cam.ac.uk/programmes/STP/stpw01.html (the abstract and the copy of the invitation letter are enclosed, see Appendix 10);

5) **"Some Applications of the Method of Normal Fundamental Functions to Oscillation Problems"**, *the 17th International Symposium on Mathematical Theory of Networks and Systems* (*MTNS 2006),* Kyoto, Japan, July 24-28, 2006, http://www-ics.acs.i.kyoto-u.ac.jp/~mtns2006/ (the abstract and the copy of the acceptance letter are enclosed, see Appendix 11).

Besides, I attended the regular seminars of the R&D unit CEOC (Centre for Research in Optimization and Control) where I presented my results in a one hour talk:

6) "**Eigenvalue Problems for Some Hybrid Aerial Cable-Way Systems**", Seminar of CEOC, University of Aveiro, Portugal, March 31, 2006, http://ceoc.mat.ua.pt/modules.php?op=modload&name=PagEd&page_id=104 (the copy of the done presentation is enclosed, see Appendix 12).

I will also present my work in the next joint meeting of the Research units CEOC-Aveiro and CIMA-Évora:

7) **"Problemas de valores próprios para alguns sistemas híbridos de controlo de teleféricos"**, *Encontro anual CEOC-UA e CIMA-UE "Optimização e Controlo Óptimo 2006"***,** Department of Mathematics, University of Aveiro, Portugal, 12-13 de Junho, 2006.

Also, I was a reviewer for **the 13th IFAC Workshop on Control Applications of Optimisation**, Paris-Cachan, France, April 26-28, 2006, http://www.ens-cachan.fr/cao06/.

2. Future research plan (plano de trabalho futuro)

In the case of the renovation of my fellowship for the period July 1, 2006 - June 30, 2007 it is planned to continue the research in the field of dynamical systems analysis where there are a lot of opened urgent problems.

At present, in industry there still exists a whole class of hybrid dynamical systems whose functioning is not enough investigated and sometimes is unsatisfactory. Therefore, a very important problem is to investigate the existing controlled elastic system dynamics, including the widespread case of vibration processes. To do this, during mathematical description of such systems we must take into account both their continuous parameters and discrete ones, that greatly complicates the investigations. Then, the study of vibrations of different types, such as longitudinal, transverse and torsional ones, is reduced to solving the partial differential equations with variable coefficients. However, we must look for the solutions, satisfying not only classical boundary conditions but also some additional system of conjugation conditions, which should be written for each problem. Such complex boundary problems describe hybrid systems with many different applications in heavy, manufacturing and extractive industry. For the investigations, we need to adapt the known numerical and approximate analytical methods to the boundary problems of the considered type.

The prospective results could be applied for design of more reliable technical systems.

I am very grateful to FCT and to the University of Aveiro and the Control Theory Group of the Centre for Research in Optimization and Control for the hospitality and the perfect working conditions.

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