Alina VODA

FUNDING APPLICATION FOR
EXPLORATORY RESEARCH PROJECTS - PN-II-ID-PCE-2011-3
Section 3

This document uses Times New Roman font, 12 point, 1.5 line spacing and 2 cm margins. Any modification of these parameters (excepting the figures and their captions), as well as exceeding the maximum number of pages set for each section can lead to the automatic disqualification of the application. The grey text contains instructions for the candidates and it may be removed and replaced with the required information. The black text must be kept, as it marks the mandatory information and sections of the application.

Number of pages required (Sectiunea3 - application form) does not contain bibliographical references. They will be placed on additional pages.

B. Project leader

B1. Scientific visibility and prestige (maximum 2 pages)

B.1.1. *Main research results.*

1) Research activity of the project leader was mainly focused on identification and control of continuous and discrete time systems. Also, the interaction between theory and practice concerning identification and control of such systems has been a field of interest. Experimental systems modeling and closed loop validation have been in attention of the project leader. During her doctoral studies, she developed a new method for self tuning PID controller ([R1], [R2], [R8],[R9], [D1], [O3], [O1], [O2], [C1], [C2], [C3], [C4], [C5], [C6], [C7], [C8], [C11],[C14], [C15], [C16], [C26]).. This method has been successfully applied in several industrial fields and the most important was semi-continuous aluminum molding. This method has been presented by the project leader to Research Centre in Pechiney, in 2001. She studies deeply the interaction between identification and control ([O1], [O4], [O6], [O14] [OE1], [OE2], [R11], [R12], [C8], [C9], [C21], [C22], [C27]). Her major contribution on this way was the exploitation of the sensibility functions as closed loop quality criteria and evaluation methods of model uncertainties have been developed by using H_2 and H_∞ norms ([R12], [R17], [O10], [C7], [C8], [C9], [C14], [C15], [C16], [C23], [C28], [C30], [C32], [C52], [C71], [E2], [E3]. Simultaneously, a closed loop identification method including relay nonlinearity has been established. This method uses exact or approximate time domain or frequency domain techniques.

2) The study of micro and nano-mechatronic systems had a special attention for the project leader in last few years. The measuring aspects of at level micro of mechatronic systems, by specific estimation and control have been solved. Specific automation methods of mini systems have been applied to control read/write head of DVDs. For the first time project leader and her research team a RST controller for mini and micro systems has been designed AFM ([R16], [O5], [C38], [C39], [C43], [C45], [C46], [C48], [C49], [C66], [RC7]..[RC13]). The controller has been implemented in siliceous circuit for an accelerometer with high measure performances versus the state of art in the world. This important realization has been possible by combining identification and robust control and has lead to a reformulation of the acceleration measuring under constraints by a confrontation between sensibility functions([R9], [R19], [R21], [D1], [O1], [O12], [C12], [C13], [C31], [C37], [C43], [C48], [C69], [C80], [C82]).

3) The project leader is initiator at the Laboratory of Automation Grenoble, France (former LAG, actually GIPSA-lab) of the researches of mini and micro systems control which are uniqu in France. The international brevet concerning conception of an atomic microscope has been the startup of the “Small Infinity” control. The Ph. D. these of Michal Hrouzek([R11], [C27], [C43],

[C48], [S12]), supervised by Alina Voda, and presented by European Synchrotron (ESRF) Radiation Facility is relevant in this domain.

B.1.2. *The visibility of the scientific contributions.*

All this work has led to: 23 articles published ([R1]…[R23]) in international journals (Automatica, Control Engineering Practice, IEEE Transactions on Control Systems Technology, JPC, IJC, IJACASP, European Journal of Control, Sensors and Actuators, Mechatronics) 14 book chapters([O1]…[O14]); 88 articles published and presentations at international conferences with proceedings and refereed journals([C1]..[C88]); 15 invited seminars([S1]..[S15]); 3 patents, from which 2 international patents ([B1], [B2], [B3]).

- Co-Scientific responsibility of an international symposium in Grenoble (Feb. 1996), with I. M'Saad Mr. Landau and the interaction between Identification and Control, 120 participants;
- Co-Scientific responsibility with Mr. Gevers of the♣ International Summer School in Grenoble (Sept. 1998) on the interaction between Identification and Control, for 95 participants: Implementation of application sessions (BE Identification in closed loop, 4 TP Identification in closed loop control and iterative);
- Co-editing a collective work: "Identification Systems", Ed I. Landau and A. Besançon-Voda, Traite IC2 - Automated Systems, Ed Hermes, Paris, 2001, 384p. ISBN: 2-7462-0220-4;
- Discussions Associate Editor European Journal of Control, between Jan 1999 and Jan 2003;
- Participation in two European projects: DYCOMANS between 1995 and 1997 (led by colleagues from the University of Strathclyde, UK) and BLAZE with Philips and other industry partners in the MEDEA more) between 2005 and 2008, 233,154 Euros for 3 years. Co-responsibility of a regional TARGET 2007 Region Rhone-Alpes: Human-like haptic interface system dynamic loop between 2007 and 2009, with the computer lab and Artistic Creation of INPG;
- 2 Invitations to foreign universities in 2000 in Lund, Sweden, for prof.KJ Aström, for participation in a thesis in 2006 and EPF Lausanne in Switzerland, by prof. R. Longchamp to report an argument and jury;
- 1 Report and jury in 2007 HDR Supélec 1 Report and jury Ph.D. in 2007 from the Univ. Pierre and Marie Curie in 2010 at the Univ. Paris 13, invited the jury doctorate in 2009 from the Univ. Orleans and in 2010 at the Univ. Claude Bernard Lyon;
- Participation in Research Group Automatic CNRS (PRC - Fluid power systems between 1997 and 1999 GT - Identification, since 1997);
- Readings of articles for journals and international conferences (Automatica, EJC, CEP, LBI, APII-JESA, CDC, IFAC ...);
- Member of the International Technical Committee IFAC System Identification, from 2005.

B2. Curriculum vitae (*max. 4 pages****)***

a) education, degrees and diplomas;

Birth date on April, 21, 1964, Place of birth: Galati, Romania

Habilitation of research supervisor Institut National Polytechnique de Grenoble (INPG);

Title: "On some aspects of the interaction between identification and control and its applications."

Date: February 3, 1999;

PhD thesis Institut National Polytechnique de Grenoble;

Title: "Contribution to the methodology for self-calibration of digital controllers. Date: September 29, 1994;

b) professional experience, former employers;

Current employment status:

Since 1995 Lecturer at Polytech 'Grenoble, Joseph Fourier University;

Since 2009 Lecturer Out Qualified Class Features to University Professor since 1999, the 61st Division.

Previous employment status:

Sept. 1994 - 1995 Teaching Assistant and Research at the ISTG (UJF) and the LAG and LIME;

Sept. 1991 - 1994 PhD researcher at LAG;

Sept. 1990-1991 DEA Automation at LAG;

1990 Assistant Professor at the Polytechnic Institute of Bucharest (Romania), Faculty of Energetics;

1987-1990 Research Engineer at the Cernavoda Nuclear Power Plant (Romania), secondment to the Institute Politehnica Bucharest.

Teaching activities:

Since 1995 Lecturer at Polytech 'Grenoble;

1994-1995: ATER

Lecturer at Polytech 'Grenoble (ISTG formerly);

1992-1994: assistant at the Ecole Nationale Sup. of Electrical Engineers of Grenoble (INPG).

Teaching activity in the field of automatic control:

At Polytech 'Grenoble: Identification, Control and Industrial Control; Industrial Control, Numerical Analysis;

A PHELMA 2009: Neural Networks;

Master's 1 EEATS (Dept. of Physics) between 2001 and 2009: Discrete systems;

ENSIEG the former (and Master 2 research EEATS): Control II; Identification.

Other activities related teaching;

1. Coaching assignments, practical work in the field of automatic control: Asservisements linear, tutorials for students of 1st year 3I; Automatic, Hands for students of 1st year 3I, in the Hall of TP Auto Polytech '; Computer controlled tutorials for students of 2nd year 3I; Discrete Event Systems and Hands for Students of 3rd year 3I, the Inter-University Workshop AIP; Identification Offices of study for students of 2nd year ENSIEG students and Research Master Automatic;
2. Introduction of courses, practical work: Automatic adjustment of PID controllers, courses and consultancies for the training of society Adaptech; Process control, Hands for students of the Electrical Licensing Inginiérie Distance, in 2002; Interaction Identification-Control, Hands-on courses and optional module of the graduate school EEATS, intended for PhD students in 2003;
3. Pedagogical framework: 1992-2006: Graduation 11 projects and 6 projects research masters / graduation projects; 1994-2007: 12 projects from 40 h (and 56 h) in 3rd year of 3I and 3 projects of 3 months in the second year of 3I on real applications delaboratoire or on projects with industrial partners.

Collaborations international university

For fifteen years I worked with foreign universities, through the Tempus, Erasmus-Socrates and Tempra. A regular annual collaboration takes place with the engineering schools of Czech universities (Brno, Ostrava, ...), Romanian (Bucharest, Iasi) and the Italian University La Sapienza of Rome (the collaboration ended in 2003, other continue).

Administrative responsibilities:

- Elected member of the Board of the University Joseph Fourier (2003-2006);
- Elected member of the Scientific Council of the University Joseph Fourier (2007-2008);
- Member of the Executive Committee of the GDR Automatic between 2001 and 2003;
- Elected member of the National University, 61st Division, from de2008;
- Head of International Summer School of Automation of Grenoble (2001-2009) and in the new laboratory GIPSA-lab involving ex-LAG-LIS-ICP:
    i) responsible for the International Summer School of Automation, Signal, Image, Word of Grenoble (see next page);
    ii) associate project manager in the multi-training plan of the current quadrennial.

Valuation summary research, industrial relations.

Responsibility and co-responsibility of 8 scientific research contracts and 2 Projects:

- In 1995 Chief Scientist of the contract with Pechiney Research Centre Voreppe, on "Improving control the process of smelting aluminum by the techniques of self-adjustment of PID controllers";
- In 1996 Chief Scientist of the contract with Pechiney Research Centre Voreppe on "Identification and control of the thickness in mill output";
- Chief Scientist in 1999-2000 Contract with INPG-Enterprise and
- Chief Scientist in 2000-2001 Contract with Gilson, Villiers-le-Bel on "Pressure control of a hydraulic pumping system, an instrument of manipulation and measurement of liquid samples";
- In 2000 Chief Scientist of the contract with ST-Microelectronics on "Regulation of optical pickup of a DVD";
- From 2000 to 2003 Co-Chief Scientist (with O. Sename) Contract with ST-Microelectronics on "Analysis and control of the head of a DVD on solutions and implementation target ST" (thesis Cifre) ;
- Between 2002 and 2006 co-chief scientist (with G. Besançon) of a multi-year contract with the LETI / CEA on "Modelling and control of resonant microstructures";
- Between 2005 and 2008 co-chief scientist (with O. Sename) in collaboration with Philips "Order for Blu-Ray Laser" in the European contract BLAZE;
- 2008 Co-Chief Scientist (with JL Florens) TARGET program of the Rhone-Alps on the "Study of Man-Machine interface system as dynamic loop" between 2007 and 2010;
- In 2010 the scientific director of research collaboration agreement with the company ALPAO, concerning "Method for servo applications in adaptive optics."

Responsibility for scientific research of 2 axes term contract with Alstom (edited by g. bornard)

- Between 1999 and 2001 scientific director of the axis "Identification in closed loop electrical parameters of induction machines", 120,000 francs;
- Between 2000 and 2001 scientific director of the axis "Identification of linear and nonlinear parameters (set) an electro-mechanical drive," 200,000 Frs.

c) list of publications and patents; See Appendix: Publications Alina Voda

- 23 papers published in international journals (Automatica, CEP, IEEE Trans. Control Syst. Technology, JPC, LBI IJACASP, EJC, Sensors and Actuators, Mechatronics): [R1] .. [R23];
- 14 book chapters: [O1] ... [O14];
- Editing a collective work by Wiley (IST): "Micro and Nanosystems Systems on Chip - Modeling, Control and Estimation", London (UK) and Hoboken (New Jersey): [OE2];
- 85 articles publiés et exposés dans des congrès internationaux avec actes et comité de lecture : [C1]..[C88] ;

- 15 invited seminars: [S1] .. [S15];
- 3 patents of which 2 international patents: [B1] .. [B3].

d) Hirsch index and the total number of citations, according to Web of Science

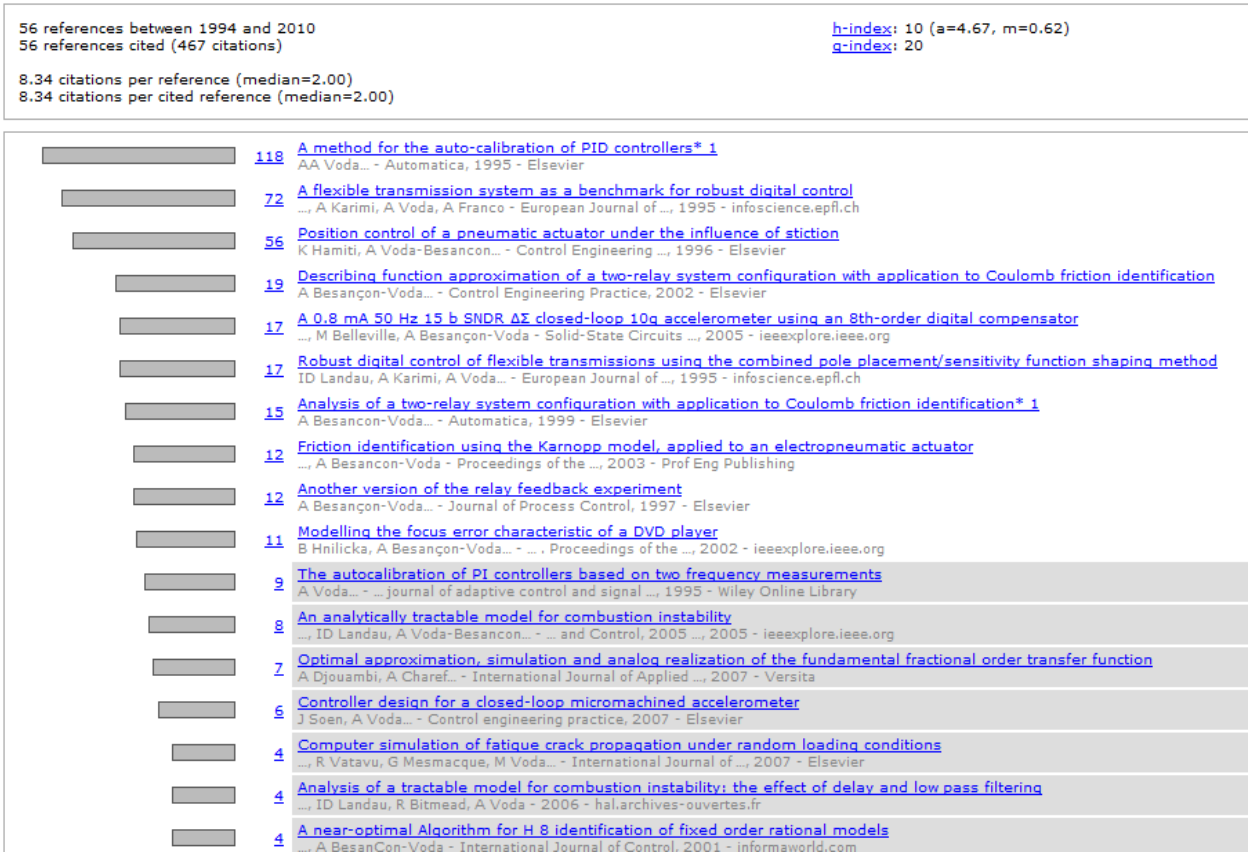

Figure 1

Evaluating the entire research project leader, one can identify thematic connections with the current proposal. Research in the general area of controlling and identification continuous and discrete systems, allow the project leader supervising component of modeling and control of such systems, which emerges from the structure and dynamics of flexible manufacturing system served by mobile robots equipped with robotic manipulators.

Her research in the field of micro and nano-mechatronic, allows a specialized approach of the mobile robot systems equipped with robotic manipulators from the point of view of automation engineer, also preoccupied with concurrent and simultaneously tasks, sharing and allocation of resources, and collaborative control systems.

Given the concerns and achievements of the research laboratories GIPSA-lab Grenoble, CRS-UDJ Galati and DCEM-UVT Targoviste, on two thematic axes of the project proposal, continuous and discrete event systems, certifies that the project leader has the skills necessary to meet objectives.

B3. Scientific contributions from the period 2001-2011(max 3pages);

13 articles published in international journals: [R11] .. [R23] (Automatica, Control Engineering Practice (CEP), IEEE Trans. Control Syst. Technology, JPC, International Journal of Control (IJC), IJACASP, European Journal of Control (JCS), Sensors and Actuators, Mechatronics);

Articles indexed in the Web of Science database

[ISI1] Besançon, **A. Voda**, G. Jouffroy: "A note on state and parameter estimation in a van der Pol oscillator", Automatica 46, pp. 1735-1738, 2010., R.I.S.= 3,16625, No. of citations: 0, **DOI:** 10.1016/j.automatica.2010.06.033

Summary: An exact observer approach for simultaneous state and parameter estimation is proposed for the well-known van der Pol oscillator. The approach is based on an appropriate state space representation–using the so-called Liénard transformation–allowing for an exact Kalman-like observer design. The stability is then formally checked relying on the natural oscillatory behaviour of the system, and the corresponding results are illustrated in simulation.

[ISI2] Jairo-Martinez, O. Sename, A. Voda: "Modeling and robust control of Blu-ray disc servo-mechanisms", Mecatronics Vol. 19, Number 5, pp. 715-725, 2009; R.I.S.= 1,46273, No. of citations: 0, **DOI:** 10.1016/j.mechatronics.2009.02.006

Summary: This paper deals with the modeling and the robust control of the next generation of optical disc drives servo-mechanisms. While in many industrial servo-control implementations, the radial and focus loops are considered as decoupled, e.g. DVD drives, this is no longer true for HD-DVD and Blu-ray disc (BD) formats which are more sensitive to opto-mechanical interactions at high frequencies. The impact of such phenomena on the robustness of the servo is evaluated by using experimental data, and an $\mathcal{H}_\infty$ controller is designed to reduce the coupling effect, by using a suitable disturbance model into the problem formulation. Simulations using experimental data illustrate the performance improvement of the compensated system despite the parametric uncertainties in mass-production optical disc drives.

[ISI3] Kharrat, E. Colinet, L. Duraffourg, S. Hentz, Ph. Andreucci, A. Voda: "Modal Control of Mechanically Coupled NEMS Arrays for Tunable RF Filters", Transactions on Ultrasonics, Ferroelectrics, and Frequency Control vol. 57, no.6, pp. 1285-1295, 2010; R.I.S.= 1,61640; No. of citations: 0, DOI: 10.1109/TUFFC.2010.1549

Summary: A novel tuning strategy of nanoelectromechanical systems (NEMS)-based filters is proposed based on the modal control of mechanically coupled NEMS arrays. This is done by adjusting separately addressed distributed actuation and detection configurations proportionally to desired modal vectors. This control scheme enhances the global output

signal, raising the power handling of the filter on all channels. Although the modal control of 1-D arrays exhibits narrow-band responses with adjustable resonance frequency, its application to 2-D arrays produces filters with both adjustable bandwidth and central frequency. One possible realization scheme is suggested by using electrostatically driven coupled NEMS arrays whose transduction gains are adjusted by changing the electrodes¿ bias voltages. Dispersion effects on both 1-D array and 2-D array frequency response are analytically expressed using eigenvalues perturbation theory. Based on these results, we show how to reduce their impact by appropriately choosing the coupling stiffness and the number of resonators.

[ISI4] J. Soen, A. Besançon-Voda, C. Condemine: "Controller design for a closed-loop micromachined accelerometer" Control Engineering Practice, Vol. 15, Issue 1, pp. 57-68, 2007; R.I.S.= 1,28784, No. of citations: 5, **DOI:** 10.1016/j.conengprac.2006.03.001

Summary: This paper presents control strategies for the design of a digital closed-loop micromachined accelerometer. The microsystem is composed of a mechanical part sensitive to the external acceleration, and a fully integrated electronic part devoted to the readout and control. A feedback control approach was used from the beginning of the sensor design in order to reach a good trade-off between circuit complexity and control requirements (inputs/outputs required for identification, sampling frequency, controller order, …). The measurement performance is linked to the closed-loop sensitivity functions and a controller design based on a pole placement method with sensitivity functions shaping is proposed. Simulation results forecast excellent performance and this identification/controller design procedure was successfully applied to an early microsensor prototype.

[ISI5] I.D. Landau, F. Bouziani, R.R. Bitmead, A. Voda-Besançon: "Analysis of control relevant coupled nonlinear oscillatory systmes", European Journal of Control, Vol. 14, Number 4, pp. 263-282, 2008; R.I.S.= 1,08478; No. of citations: 0

[ISI6] Hnilicka B, Voda A, Schroder HJ, "Modelling the characteristics of a photodetector in a DVD player", SENSORS AND ACTUATORS A-PHYSICAL Volume: 120 Issue: 2, Pages: 494-506 , published 2005, No. of citations: 4, **DOI:** 10.1016/j.sna.2005.02.008

Summary: This paper presents a new method for modelling the non-linear characteristics of a photodetector (so-called the S-curve) in a DVD player. The photodetector is used in the DVD player to generate the focus and tracking error signals, which in turn have to be controlled at the minimum levels. For focus error signal generation, an analytical and a numerical photodetector model are developed here, based on the astigmatic method and on opto-geometrical analysis. The influence of model parameters on the focus error signal is

discussed. To estimate the unknown model parameters, a curve fitting method is applied, using measured data from an industrial DVD-video player developed in STMicroelectronics laboratories. Model quality is illustrated by a comparison with the real focus error signal.

[ISI7] Besançon-Voda, P. Blaha: "Describing function approximation of a two-relay feedback configuration with application to Coulomb friction identification", Control Engineering Practice, vol. 10, pp. 655-668, (2002); R.I.S.= 1,28784, No. of citations: 0

Monographs.

- 2 edited book: [OE1] [OE2] ((Ed Hermes, Paris, Ed ISTE Wiley, London (UK) and Hoboken (New Jersey);

[Bk1] Landau et A. Besançon-Voda : Identification des systèmes, Traité IC2 -Section Systèmes Automatisés, Ed. Hermès, Paris, 384 p, ISBN 2-7462-0220-4, 2001 ;

[Bk2] A. Voda : Micro, Nanosystems and Systems on Chip - Modeling, Control and Estimation, Ed. Wiley ISTE, London (UK) and Hoboken (New Jersey), 304 p, ISBN 978-1-84821-190-2, december 2009.

- 14 book chapters: [O4] .. [O14] (Ed Hermes, Paris, Masson Ed, Kluwer Academic Publishers; Edition Springer-Verlag)

Intellectual property titles.

3 patents of which 2 international patents (Patent N_ 60945, 1995; N_ Patent 60945, 06/04674, 2006, B8790, Patent FR N_08 / 5) ([B1] .. [B3]):

[P1] A. Voda, I. Landau: "Méthode et appareil pour l'identification d'un point de la caractéristique fréquentielle d'un procédé par le test du relais, avec retard ajustable", **N_ patent 60945, 1995.**

[P2] M. Hrouzek, A. Voda, J. Chevrier, G. Besançon, F. Comin: "Microscope à Force Atomique Asservi", ESRF-UJF-INPG-CNRS, Brevet N_ 60945, 06/04674, 2006. European Patent, International Patent spent in 2008.

[P3] A. Voda, G. Besançon, S. Blanvillain: "Dispositif de positionnement d'un objet mobile submicronique", UJF-INPG-CNRS, N. Ref : B8790, **Brevet FR N_08/52007** du 28 mars 2008.

Work in recent years of the project leader in the field of hap tic systems, gives her as principal investigator (PI) general skills and expertise in modeling and control of robotic systems interfaced with human action.

This represents a potential new research on the theme proposed by the analysis and modeling of reversible manufacturing systems, assembly and disassembly, using mobile robots equipped with robotic manipulators or alternatively, manual control.

Annex Publications Alina VODA

JOURNAL ARTICLES TO REVIEWERS

[R1] Voda, I.Landau: "A method for the auto-calibration of PID controllers", Automatica, vol.31, N_1, pp. 41-53, (1995).

[R2] A. Voda, I.Landau: "The Auto-calibration of PI controllers based on two frequency measurements", International Journal of Adaptive Control and Adaptive Signal Processing, vol.9, no.5, pp.395-421, (1995). FRI= 1,34491

[R3] I.Landau, A.Karimi, D.Rey, A. Voda, A.Franco: "A flexible transmission system as a benchmark for Robust Digital Control", European Journal of Control, vol.1, no.2, pp.77-96, (1995).

[R4] I.Landau, A.Karimi, A. Voda, D.Rey:" Robust Digital Control of Flexible transmissions using combined Pole Placement/Sensitivity Function shaping method", European Journal of Control, vol.1, no.2, pp. 122-133, (1995).

[R5] K. Hamiti, A. Besançon-Voda, H. Roux-Buisson "Position control of a pneumatic actuator under the influence of stiction", Control Engineering Practice, vol.4, no.8, pp.1079-1088, (1996).

[R6] A. Besançon-Voda, H. Roux-Buisson: "Another version for the feedback relay experiment", Journal of Process Control, vol.2, no.7, pp 240-246, (1997).

[R7] Besançon-Voda, Ch. Delclos: "Control of semi-continuous aluminium casting process", IEEE Control Systems Technology, vol.6 no.2, pp.233-245, (1998).

[R8] A. Besançon-Voda: "Iterative auto-calibration of digital controllers. Methodology and applications", Control Engineering Practice, vol.6, pp 345-358, (1998).

[R9] A. Besançon-Voda, I.Landau, A. Karimi, J. Langer : "La robustesse à travers l'identification en boucle ferméé ", Journal Européen des Systèmes Automatisés (JESA), vol. 32, no. 5-6, pp. , 1998.

[R10] A. Besançon-Voda, G. Besançon: "Analysis of a class of two-relay systems with application to Coulomb friction identification", Automatica, vol. 35, no. 8, pp. 1391- 1399, (1999).

[R11] M. Namvar, A. Besançon-Voda: "A near-optimal algorithm for Hinf identification of fixed-order rational models", International Journal of Control, vol. 74, no. 13, pp. 1370-1381, (2001).

[R12] A. Besançon-Voda, P. Blaha: "Describing function approximation of a two-relay feedback configuration with application to Coulomb friction identification", Control Engineering Practice, vol. 10, pp. 655-668, (2002).

[R13] A. Besançon-Voda: "A periodic modes analysis in a two-relay feedback system", Control Engineering and Applied Informatics, ISSN 1454-8658, vol. 4, No. 3, pp. 6123-138, 2003.

[R14] L. Ravanbod-Shirazi, A. Besançon-Voda: "Friction identification using Karnopp model, applied to an electropneumatical actuator", Proc. Instn. Mechanical Engrs., Part I: Journal of Systems and Control Engineering, vol. 217, pp. 123-138, 2003.

[R15] A. Besançon-Voda, L. Ravanbod-Shirazi: "High performance position tracking with friction compensation for an electropneumatical actuator" Control Engineering and Applied Informatics, ISSN 1454-8658, Vol. 6, No. 2, pp. 4715-33, 2004.

[R16] B. Hnilicka, A.Besançon-Voda , H.J. Schröder: "Modelling the characteristics of a photodetector in a DVD player", Sensors and Actuators A 120, pp 494-506, 2005.

[R17] J. Soen, A. Besançon-Voda, C. Condemine: " Controller design for a closed-loop micromachined accelerometer" Control Engineering Practice, Vol. 15, Issue 1, pp. 57-68, 2007.

[R18] A. Djouambi, A. Charef, A. Besançon-Voda: "Optimal Approximation, Simulation and Analog Realization of the Fundamental Fractional Order Transfer Function", International Journal of Applied Mathematics and Computer Science, Vol. 17, Number 4, pp 455-462, 2007.

[R19] A. Djouambi, A. Charef, A. Voda-Besançon: "Fractional Order robust control based on Bode's ideal transfer function", Journal Européen des Systèmes Automatisés, No. special "Fractional order systems", Vol. 42, pp. 999-1014, 2008.

[R20] I.D. Landau, F. Bouziani, R.R. Bitmead, A. Voda-Besançon: "Analysis of control relevant coupled nonlinear oscillatory systmes", European Journal of Control, Vol. 14, Number 4, pp. 263-282, 2008.

[R21] Jairo-Martinez, O. Sename, A. Voda: "Modeling and robust control of Blu-ray disc servo-mechanisms", Mecatronics Vol. 19, Number 5, pp. 715-725, 2009.

[R22] Kharrat, E. Colinet, L. Duraffourg, S. Hentz, Ph. Andreucci, A. Voda: "Modal Control of Mechanically Coupled NEMS Arrays for Tunable RF Filters", Transactions on Ultrasonics, Ferroelectrics, and Frequency Control vol. 57, no.6, pp. 1285-1295, 2010.

[R23] Besançon, A. Voda, G. Jouffroy: "A note on state and parameter estimation in a van der Pol oscillator", Automatica 46, pp. 1735-1738, 2010.

DISCUSSION-EUROPEAN JOURNAL OF CONTROL

[D1] A. Besançon-Voda: "Discussion on : Robust tuning of low-order controllers via uncertainty model identification by M. Canale, G. Fiorio, S. Malan and M. Taragna, European Journal of Control, no. 5, pp. 329-332, (1999).

BOOK PUBLISHED

[OE1] Identification des systèmes, Traité IC2 -Section Systèmes Automatisés, sous la direction de I.D. Landau et A. Besançon-Voda, Ed. Hermès, Paris, 384 p, ISBN 2-7462-0220-4, 2001.

[OE2] Micro, Nanosystems and Systems on Chip - Modeling, Control and Estimation, edited by A. Voda, Ed. Wiley ISTE, London (UK) and Hoboken (New Jersey), 304 p, ISBN 978-1-84821-190-2, december 2009.

BOOK CHAPTERS

[O1] I.D.Landau, F.Rolland, C.Cyrot, A. Voda: chapitre 6 de l'ouvrage collectif "La robustesse: Analyse et synthèse de commande robuste", édition Hermès, 1994.

[O2] A. Voda: "Auto-calibrage des régulateurs PI(D)", chapitre dans "Systèmes de Régulation", pp. 84-108, édition Masson, 1996.

[O3] A. Besançon-Voda, S. Gentil: "Régulateurs PID analogiques et numériques", "Techniques pour Ingénieurs", Systèmes de Mesures, R7 416, 1999.

[O4] A. Besançon-Voda, M. Namvar : " Interaction entre l'identification et la commande ", Chapitre 6 de l'ouvrage collectif: "Identification des systèmes ", Traité IC2 -Section Systèmes Automatisés, sous la direction de I.D. Landau et A. Besançon- Voda, Ed. Hermès, Paris, 384 p, ISBN 2-7462-0220-4, 2001.

[O5] B. Hnilicka, A. Besançon-Voda, G. Filardi: "Control of DVD players: focus and tracking loop" , Chapitre (pp. 101-128) dans " Advances in Automatic Control ", (sous la direction de M. Voicu), Edition Kluwer Academic Publishers, 2004, 444pages, ISBN 1-4020-7607-X.

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[S14] "Identification itérative et commande", séminaire à l'Université Technique de Brno, Rép. Tchèque, avril 2004.

[S15] "Pole placement design and sensitivity calibration for DVD players", séminaire à l'EPFL, Lausanne, Suisse, avril 2006.

C. Project description

C1. *Scientific context and motivation*.

The main idea of the project, launched for the first time, is the advanced control of manufacturing reversible systems of assembling and disassembling using wheeled mobile robots equipped with robotic manipulators. It proposes a new approach to manufacturing flow optimization problem: aggregation problems at levels of continuous and discrete event in a hybrid system.

The system is the type Discrete Event Systems (**DES**) and the control that is done conventionally through supervision. The objective of supervisor control, introduced by Ramadge and Wonham [IC33], based on control events, is to reduce the set sequences of events allowed and lead system available to **states and / or authorized**, by eliminating **blockings**.

The current proposal focuses on two categories of specific control problems of manufacturing systems: *blocking system*, generated by faults that may occur at the workstation and *workstation overload* that have not been well sized/optimized properly with resources (production or transportation) depending on the ranges of manufacturing. The overload, at least one station, will lead to queue and the manufacturing tasks will be lead to unacceptable delays. The malfunctioning in production flow fluidity, caused by the occurrence of breakdowns (up) - uncontrollable events, transforms the manufacturing in probability Markov flow phenomena.

To solve the two categories of problems, we propose a hybrid structure: **reversible manufacturing system served by mobile robots equipped with robotic manipulators (RMSMRRM).** The robot will be used in the shared system handling/transport. Transport engineering resource sharing, is to control stationary regime of queues waiting for load balancing workstation. A *balanced* line will have a production flow without any delay or loss. In a balanced production line productivity increases, working time is better used, variations in demand are balanced, and the cost of production decreases. In this sense, *the line balance can be considered as an ordering technique used in production supervision.*

Using **systems mobile robots equipped with manipulators**, with specified time tasks, transform the control into hybrid one, structured on two levels: a) a robust nonlinear control the continuous-time system consisting of the system of mobile robots, b) level of control by supervising modular discrete event system. Such a system has a control structure on two levels: **a) the continuous system** (mobile robotic system equipped with robotic manipulator) which is proposed to be realized with advanced control techniques: sliding-mode, virtual pheromone and artificial, neuro-fuzzy, to increase system robustness for variable tasks, external disturbances and model uncertainties and parametric; **b) the DES**, for which we propose solving the problem of control through a modular supervision. The working structure RMSMRRM leading to reduction or elimination of blocking dynamic states. Service lines only flexible mobile robot is to be conducted when reach undesirable

states (malfunctions, blockings, application oversized). This is the major difference compared to conventional control by supervision (Ramadge and Wonham formalism), leading system accessible only by state and / or authorized, without solving the dynamic states of the system undesirable.

In the **continuous system** for the control of advanced mobile robots equipped with manipulators, the following method will be used: ● sliding-mode control the mobile robot with two wheels and four engines using algorithms proposed in [R1], [R2], [R3], [R4], [R5], [R6], [R7], [R8], [R10], [R12], [R9], [R20], [R21], [R22], [R23], [R25], [R26], [IC7], [IC9], [IC15], [IC17], [IC18], [IC20], [IC21];● advanced control using mobile robots, virtual pheromones and neuro-fuzzy techniques, however proposed to [R9], [R11], [R13], [R14], [R15], [R16], [R17], [R18], [R24], [R27], [IC8], [IC11], [IC19]. In the **DES systems**, to address control issues of manufacturing systems served by mobile robots the following methods will be used: ● supervised control of hybrid systems and the hybrid hierarchy, which will be used formalisms [IC22], [IC23], [IC32];● techniques for modeling and analysis using Hybrid Petri Networks **(HPN)**, Petri Nets with constant speed and T-timed temporized Petri Nets (**TPN**), proposed in [R28], [R29], [R30];● advanced scheduling techniques presented in the papers, proposed in [IC24], [IC25], [IC28], [IC29];● synthesis of hybrid systems supervisor, presented in the papers [IC27]; ● control the hybrid system (manufacturing system served by mobile robots) by modular supervision proposed to [IC1], [IC2], [IC3], [IC4], [IC5], [IC6], [IC10], [IC12], [IC13], [IC14], [IC31]. The **DES control** is dedicated to: a) control system to guarantee the capability to reach targets required under the appearance of uncontrollable events (malfunctions, blockings); b) the line balance and failure impairment tasks if the manufacturing time, caused by delays in queues; c) impairment of reactive tasks in case a workstation or one of the robots in the system is no longer able to perform tasks.

The aggregation approach of the two categories of control issues, proposed in this project: robust nonlinear control of continuous systems, with the control by supervision of DES for manufacturing systems served by mobile robots, have not been implemented ever and thus establishes a new direction for treatment of theoretical and applied problems of these systems.

C2. *Objectives*.

The scientific objectives covered in the project, will be treated in the topics below:

Theme 1: Control system for balancing the two conventional manufacturing systems (FESTO MPS504FMS and MPS502FMS) that share a resource (a workstation). Using mobile robots equipped with robotic manipulators to make completely *reversible an assembly line / disassembly, that means a* manufacturing line capable of doing both assembly and disassembly (Mechatronics Training Systems HERA);

Theme 2: Hybrid system designated to balance the two manufacturing systems for small (payload from 50 to 250 grams) and medium weight (payload from 250 grams to 1kg) tasks, served by

mobile robots with two driving wheels (DW) and one or two steering wheels (SW): 2DW/1SW, (Pioneer 3-DX, PeopleBot, for small weight) and 2DW/2SW (PatrolBot, for medium weight), equipped with robotic manipulators with 5 degrees of freedom (Pioneer 5-DOF Arm, 5-DOF Premium and Affordable P-Series Robot Arm);

Theme 3: Hybrid system designated to balance the two manufacturing systems for heavy weight (payload from 1kg to 5 kg) tasks, mobile robots served: with two driving wheels and two steering wheels 2DW/2SW (PowerBot) and four-driving and steering wheels, 4DW/SW, (Seekur Robot) and equipped with robotic manipulators with 5 degrees of freedom (5-DOF Adept Robot Arm).

OB1) Obtaining kinematics and dynamic models of mobile robots 2DW/1SW, 2DW/2SW and 4DW/SW, which are equipped with robotic manipulators and allow the transport of loads, small, medium and large (**Themes: 1, 2, 3**);

OB2) a) Design of a tool, HPN, dedicated to hybrid systems modeling having RMSMRRM structure in order to model temporal components (Temporized Petri Nets-TPN) and the continuously variable (PN with constant speed), by extracting features of dynamic model of RMSMRRM; (**Themes 1, 2, 3**); **b)** Design HPN hybrid model, according to the ordering system RMSMRRM (**Themes: 1, 2, 3**);

OB3) a) Design supervisor system of RMSMRRM taking into account restrictions on the operation of mobile robots 2DW/1SW, 4DW/SW 2DW/2SW and treated as discrete event dynamic systems; **b)** Design Supervisor RMSMRRM system restrictions on the operation of mobile robot systems 2DW/1SW, 4DW/SW 2DW/2SW and treated as discrete event systems and related restrictions generated by applying the techniques of balancing manufacturing lines (**Themes 2, 3**);

OB4) a) Design Supervisor for driving an assembly line served by mobile robots equipped with robotic manipulators (RMSMRRM) to execute and disassembly (reversible line) (**Themes 1, 2, 3**); **b)** sliding-mode control of mobile robots 2DW/1SW, 2DW/2SW, 4DW/SW required for tracking a given trajectory while avoiding obstacles and robustness to variable loads, external disturbances and parametric uncertainty model. Virtual pheromones and neuro-fuzzy control of mobile robots 2DW/1SW, 2DW/2SW, 4DW/SW will also be used (**Themes 1, 2, 3**);

OB5) a) Advanced control using virtual pheromones, neuro-fuzzy and sliding-mode techniques of hybrid RMSMRRM structure, the types of parts for manufacturing, small and medium weights, served by systems of mobile robots: 2DW/1SW (Pioneer 3–DX, PeopleBot) and 2DW/2SW (PatrolBot) equipped with robotic manipulators with five degrees of freedom (Pioneer 5-DOF Arm, 5-DOF Premium and Affordable P-Series Robot Arm) (**Themes 2, 3**); **b)** Advanced control using virtual pheromones, neuro-fuzzy and sliding-mode techniques of hybrid RMSMRRM structure, the types of parts for heavy manufacturing, systems served by mobile robots: the 2DW/2SW

(PowerBot) and 4DW/SW (Seekur Robot) equipped with robotic manipulators with five degrees of freedom (5-DOF Adept Robot Arm), in order to balance the production flow (**Themes 2, 3**).

C3. *Method and approach*.

The concordance between the research methodology and the project objectives is made by the manners of goal achieving and the research methods associated to the project objectives of this exploratory project. For each scientific objective of the project, the research used method will be:

OB2; OB 3*:* **a)** Dedicated modeling tools: HPNs for obtaining the control system RMSMRRM; **b)** The research method is testing the obtained models in simulation mode. The stocks breakings and workstations failures will be experimented, for steady state evaluate of waiting queues;

OB1; OB3; OB4*:* **a)** For robotic systems modeling, nonlinear systems, considering Antsaklis formalism and using simulation, the state space between discrete states and initial conditions are defined. For robust control of robotic systems: the methods that for analyzes and design are based on virtual pheromones, neuro-fuzzy and sliding- mode; **b)** For advanced control of assembling lines served by mobile robots equipped with robotic manipulators, for reversible manufacturing lines (assembling line HERA) the method that will be used are: sliding mode, virtual pheromones and neuro-fuzzy control; **c)** the hybrid model of RMSMRRM control system will be defined using HPN. Alla formalism will be used in order to transpose the model made with D – elementary hybrid PNs into a hybrid automata; **d)** The model is tested in simulation. The research will establish the restrictions in functioning of hybrid system RMSMRRM, as well as the restrictions of robotic systems control to be fulfilled for safeness (failures, synchronizations, conflicts);

OB 4; OB 5: These objectives will make the RMSMRRM system with minimal configuration: two manufacturing lines (FESTO MPS504FMS, MPS502FMS). Each one has three working station and share a system with mobile robots equipped with manipulators. The research method is based on: a) Successive choosing of mobile robots composed by: ● Two mobile robots: 2DW/1SW, (Pioneer 3-DX, PeopleBot) and 2DW/2SW (PatrolBot) equipped with robotic manipulators with 5 degree of freedom Pioneer 5-DOF Arm, for transportation of small and medium parts; ● Two mobile robots: 2DW/SW, (PowerBot) and 4DW/SW, (Seekur Robot Base) equipped with manipulators with 5 degree of freedom (5-DOF Adept Robot Arm), for transportation of heavy parts; b) Choosing the manufacturing assembling sets, lanced simultaneously, with different working tasks generating malfunctions. Choice the serving strategy of workstations from maximum lengths of queues point of view; c) Defining the communication protocol, for the trajectory tracking of mobile robots. odometric system and/ or ultrasounds, the infrared system and video camera for localization, visualization and obstacles avoiding will be used. Real-time controlling of RMSMRRM by RMSMRRM supervisor design which synthesizes the autonomous control of two controlled systems and the controlling of manufacturing cells.

The research team has the following nominated structure:

Assoc Prof. Ph. D. Eng. Alina VODA-project leader, principal investigator, Ph.D. in Control Systems, Ph.D. supervisor in Control Systems;

Prof., Ph.D., Eng. Adrian FILIPESCU - senior researcher, University "Dunarea de Jos" of Galati, Ph.D. in Control Systems (Contributions to the synthesis of systems with variable structure and adaptive), Ph.D. supervisor in Control Systems;

Assoc Prof., Ph. D. Eng. Eugenia MINCA -senior researcher, University "Valahia" of Targoviste, Ph.D. in Control Systems (Contribution to the supervision of production systems using fuzzy Petri nets: application to the e-maintenance), second Ph. D in Industrial Engineering;

Assistant, Ph.D., Eng. Otilia DRAGOMIR -Postdoctoral researcher, University "Valahia" of Targoviste, Ph.D. in Control Systems (Contribution to prognosis failures of production, by neuro-fuzzy network: control of the prediction error);

Eng. Bogdan DUMITRASCU, - Ph.D. student in Control Systems (contributions to control, navigation and obstacle avoidance of mobile robots and autonomous vehicles), University "Dunarea de Jos" of Galati, Adrian Filipescu is his Ph.D supervisor;

Lecturer eng. Adriana SERBENCU, Ph.D. student in Control Systems (contributions to intelligent control of collaborative mobile robots), University "Dunarea de Jos" of Galati, Adrian Filipescu is her Ph.D. supervisor;

Eng. Adrian RADASCHIN, Ph.D. student in Control Systems (contributions to the intelligent control of mobile robots integrated in flexible manufacturing lines), University "Dunarea de Jos" of Galati, Adrian Filipescu is his Ph.D supervisor, Alina Voda is his Ph.D co-supervisor;

Eng. Adrian Mihai ENACHE, Ph.D. student in Control Systems (contributions to advanced control of mobile robots equipped with robotic manipulators using a LINUX platform), University "Dunarea de Jos" of Galati, Adrian Filipescu his Ph.D supervisor, Alina Voda his Ph.D co-supervisor;

Eng. Cristian VASILACHE, Ph.D. student in Control Systems (contributions to the control of mobile robots equipped with robotic manipulators by biometric techniques), University "Dunarea de Jos" of Galati, Adrian Filipescu is his Ph.D supervisor, Alina Voda is his Ph.D co-supervisor.

The work plan with objectives and associated activities, estimation of the time commitment from each of the team members in units of man-months and dissemination are presented in figure 2

Year	**Objectives, the time commitment from each of the team members in units of man-months.**		**Associated activities, dissemination**
2011	**1**	**OB1)** Obtaining kinematics and dynamic models of mobile robots 2DW/1SW, 2DW/2SW and 4DW/SW, which are equipped with robotic manipulators and	1.1. Modeling robot manipulators. It will synthesize MIMO models for robotic manipulators with n-DOF, with rigid links and rigid or flexible joints;
			1.2. Model parameter identification, numerical simulation test models;

		allow the transport of loads, small, medium and large; (months 1-3); Alina VODA, Adrian FILIPESCU, Bogdan DUMITRASCU and Cristian VASILACHE-100% entire norm, 3 months;	1.3. Obtaining kinematics and dynamic models of mobile robots: 2DW/1SW (Pioneer 3-DX, PeopleBot) 2DW/2SW (PatrolBot, PowerBot) and 4DW/SW (SEEKUR robot); 1.4. Models testing by numerical simulation; 1.5. Dissemination of research results: Paper publishing in IEEE Trans. on Vehicular Technology;
	2	**OB2) a)** Design of a tool, HPN, dedicated to hybrid systems modeling having RMSMRRM structure in order to model temporal components and the continuously variable (PN with constant speed), by extracting features of dynamic model of RMSMRRM; (months 1-3) Eugenia MINCA, Otilia DRAGOMIR, Mihai ENACHE, Adrian RADASCHIN and Adriana SERBENCU-100% entire norm, 3 months;	2.1 RMSMRRM identification of system features continuously variable time; RMSMRRM modeling as discrete event dynamic system using PN with constant speed; 2.2. Identifying discrete system traits and states associated with temporal aspects or events to RMSMRRM. RMSMRRM modeling as DES using temporal PN; 2.3 Develop a tool-Hybrid Petri Nets, dedicated hybrid modeling of RMSMRRM; 2.4. Dissemination of research results IFAC WC2011, ASCC2011, WCICA2011, MED2011, ICST2011;Paper publishing in IEEE Trans. on Vehicular Technology;
2012	**1**	**OB2) b)** Designing HPN hybrid model, according to the ordering system RMSMRRM; (months 4-15) Eugenia MINCA-50% entire norm, 12 months; Otilia DRAGOMIR, Mihai ENACHE, Adrian RADASCHIN and Adriana SERBENCU- 100% entire norm 12 months	1.1. Control input analysis order to identify characteristics of continuous time variable system time and temporal aspects (time windows) associated with operations and blockages. 1.2. Development of control system models as hybrid type, using the HPN; 1.3. PNH simulation model based on the application of sequences of events resulting from the ordering of controllable and uncontrollable tasks: faults, overload of work stations 1.4. Hybrid model analysis of RMSMRRM by specific criteria of PN: margins, liveliness, conflicts; 1.5. Dissemination of research results: Paper publishing in the IEEE Transactions on Control Systems Technology.
	2	**OB3) a)** Design supervisor system of RMSMRRM taking into account restrictions on the operation of mobile robots 2DW/1SW, 4DW/SW, 2DW/2SW and treated as DES; (months 4-15) Alina VODA, Adrian FILIPESCU, Bogdan DUMITRASCU and Cristian VASILACHE, 100% entire norm,12 months Eugenia MINCA- 50% entire norm, 12 months	2.1. Analysis of operational restrictions of mobile robot systems 2DW/1SW, 2DW/2SW, 4DW/SW treated as DES; 2.2. Analysis of operational restrictions RMSMRRM served by mobile robots, the DES approach, meeting the allowable duration of operations, and the maximum length of waiting queues; 2.3. Supervisor of RMSMRRM system design based on operational restrictions of mobile robot systems 2DW/1SW, 4DW/SW 2DW/2SW and treated as discrete event dynamic systems; 2.4. Dissemination of research results: IROS 2012; ICINCO 2012;CDC 2012;
2013	**1**	**OB3) b)** Design Supervisor RMSMRRM system restrictions on the operation of mobile robot systems 2DW/1SW, 4DW/SW 2DW/2SW and treated as discrete event systems and related restrictions generated by applying the techniques of balancing manufacturing lines; (months 16-27) Alina VODA, Eugenia MINCA, Otilia DRAGOMIR, Mihai ENACHE, Adrian RADASCHIN and Adriana SERBENCU-50% entire norm, 12 months	1.1. Analysis of blocking states of RMSMRRM system by evaluating the controllable events (poor ordering of Tasks) and the uncontrollable (faults, overload of the stations); 1.2. Analysis of RMSMRRM operating restrictions, by applying techniques of balancing the flow of production; 1.3. Supervisor RMSMRRM system design based on systems operating restrictions collaborative 2DW/1SW mobile robots, and 4DW/SW 2DW/2SW, treatment as a discrete event dynamic systems, coupled with restrictions arising from the application of techniques to balance manufacturing lines; 1.4. Dissemination of research results Paper publishing in IEEE Trans. in Automatic control
	2	**OB4) a)** Design Supervisor for driving an assembly line served by mobile robots equipped with robotic manipulators (RMSMRRM) to execute and disassembly (reversible line) (months 16-27) Adrian FILIPESCU, Eugenia MINCA, Otilia DRAGOMIR, Mihai ENACHE, Adrian RADASCHIN and	2.1. Defining the target trajectory and performance tracking; 2.2. Switching hyper surfaces choice and design in order to ensure the operation of sliding mode; 2.3. Defining and editing environment map stored in a pheromone server; 2.4. Design and implementation of neuro-fuzzy control for mobile robots leadership, oriented and positioned with concentrations of pheromones 2.5. Bubble rebound algorithm design and implementation in order to avoid obstacles;

		Adriana SERBENCU-50% entire norm, 12 months	2.6.Conducerea in real time based on sliding-mode techniques, virtual pheromones and neuro - fuzzy
			2.7. Dissemination of research results: Publishing paper in IEEE Trans on Robotics.
	3	**OB5) a)** Advanced control using virtual pheromones, neuro-fuzzy and sliding-mode techniques of hybrid RMSMRRM structure, the types of parts for manufacturing, small and medium weights, served by systems of mobile robots: 2DW/1SW (Pioneer 3 – DX, PeopleBot) and 2DW/2SW (PatrolBot) equipped with robotic manipulators with five degrees of freedom (Pioneer 5-DOF Arm, 5-DOF Premium and Affordable P-Series Robot Arm) (months 16-27) Alina VODA and Adrian FILIPESCU-50% entire norm, 12 months Bogdan DUMITRASCU and Cristian VASILACHE-100% entire norm,12 months	3.1. Analysis of operational restrictions RMSMRRM in approach DES, custom fabrication parts RMSMRRM for small and medium weight is serviced by mobile robots with 2DW/1SW (Pioneer 3-DX, PeopleBot) equipped with robotic manipulators with five degrees of freedom (Pioneer 5-DOF Arm).
			3.2. Analysis of blocking states RMSMRRM system by evaluating the controllable events (ordering wrongly) and the uncontrollable (faults, overload of work stations).
			3.3. Supervisor RMSMRRM system design based on systems operating restrictions collaborative mobile robots 2DW/1SW, 2DW/2SW treated as EDI systems, coupled with restrictions arising from the application of techniques to balance manufacturing lines.
			3.4. Control system design of mobile robots 2DW/1SW (Pioneer 3-DX, PeopleBot) equipped with robotic manipulators (Pioneer 5-DOF arm), sliding-mode controllers based on adaptive virtual pheromones and neuro-fuzzy techniques.
			3.5. Design supervisor for advanced management of mobile robots served RMSMRRM 2DW/1SW (Pioneer 3-DX, PeopleBot) equipped with robotic manipulators with five degrees of freedom (Pioneer 5-DOF arm), the modular structure of supervision. The modular design of control systems: finite state automaton with discrete levels, and neuro-fuzzy controllers, sliding-mode and adaptive management techniques based on virtual pheromones, continuous level.
			3.6. Dissemination of research results: IEEE ICRA2013;IEEE ICCA 2013;CDC 2013; Paper publishing in Automatica
2014	**1**	**OB4) b)** sliding-mode control of mobile robots 2DW/1SW, 2DW/2SW, 4DW/SW required for tracking a given trajectory while avoiding obstacles and robustness to variable loads, external disturbances and parametric uncertainty model. Virtual pheromones and neuro-fuzzy control of mobile robots 2DW/1SW, 2DW/2SW, 4DW/SW will also be used (months 28-36) Alina VODA, Mihai ENACHE, Adrian RADASCHIN and Adriana SERBENCU-100% entire norm, 9 months Adrian FILIPESCU-50% entire norm, 9months;	1.1. Analysis of operating restrictions in RMSMRRM, DES approach to compliance times of operations allowable assembly / disassembly;
			1.2. Analysis of blocking states RMSMRRM system by evaluating the controllable events (poor ordering of assembly operations) and the uncontrollable (defects, scrap the appearance of products);
			1.3. The design of two control sub assembly / disassembly, proper flow of operations in RMSMRRM. RMSMRRM control system design, the DES approach able to tilt controls assembly / disassembly in blocking situations;
			1.4. Control system design for mobile robots, controllers based on sliding-mode adaptive controllers, virtual pheromones and neuro-fuzzy techniques;
			1.5. Design of modular components of the hybrid drive: the finite state automaton with discrete and neuro-fuzzy controllers, sliding-mode adaptive detergents, technical and management based on virtual pheromones, continuous level. Design supervisor for driving an assembly line served by the collaborative mobile robots equipped with robotic manipulators RMSMRRM the modular structure of supervision, the flow control assembly and the blocking position command switch assemblies scrap disassembly;
			1.6. Dissemination of research results: MCPL 2014, ICCA 2014, ECC 2014, ASCC 2014, WCICA 2014; Paper publishing in IEEE Trans in Automatic Control.
	2	**OB5) b)** Advanced control using virtual pheromones, neuro-fuzzy and sliding-mode techniques of hybrid RMSMRRM structure, the types of parts for heavy manufacturing, systems served by mobile robots: the 2DW/2SW (PowerBot) and 4DW/SW (Seekur Robot) equipped with robotic manipulators with five degrees of freedom (5-DOF Adept Robot Arm), in order to balance the production flow (months 28-36) Adrian FILIPESCU-50% entire norm, 9 months	2.1. Analysis of operational restrictions RMSMRRM in DES approach, custom systems for manufacturing parts RMSMRRM is heavy weight served by mobile robots with 2DW/2SW (PowerBot) 4DW/SW (Seekur Robot Base) equipped with robotic manipulators with five degrees of freedom (5-DOF Adept Robot Arm);
			2.2. Analysis of blocking states RMSMRRM system by evaluating the controllable events (ordering wrongly) and the uncontrollable (faults, overload of work stations);
			2.3. Supervisor RMSMRRM system design restrictions on mobile robots operating systems 4DW/SW, treated as DES systems, coupled with restrictions arising from the application of techniques to balance manufacturing lines;

		Eugenia MINCA, Otilia DRAGOMIR, Bogdan DUMITRASCU and Cristian VASILACHE-100% entire norm, 9 months	2.4. Control system design of mobile robots 2DW/2SW (PowerBot)and 4DW/SW (Seekur Robot Base) equipped with robotic manipulators with five degrees of freedom (5-DOF Adept Robot Arm) controllers based on sliding-mode adaptive controllers, and virtual pheromones and neuro-fuzzy techniques operation in collaborative arrangements;
			2.5. The design of modular components of the hybrid drive: the finite state automaton with discrete and neuro-fuzzy controllers, sliding-mode adaptive detergents, technical and management based on virtual pheromones, continuous level.Advanced management supervisor for the design of mobile robots served RMSMRRM collaborative 4DW/SW (Seekur Robot Base) equipped with robotic manipulators with five degrees of freedom (PowerBot Arm1), the modular structure of supervision;
			2.6. Dissemination of research results: The proposal for the patentability of the control model: Leadership modular manufacturing systems served by mobile robots equipped with robotic manipulators, the hybrid approach: ICRA2014, ICCA 2014, CDC 2014, CCC2014, IROS 2014: Paper publishing in Control Engineering Practice.

Figure 2

C4. *Impact, relevance, applications*.

The major impact of the project is provided by the high potential of new and original results in systems engineering and informatics. The results which will be obtained give a very high potential for dissemination.

This research contributes to the development of laboratory and industrial applications. Up to now, there are no control applications, in real-time, of manufacturing systems served by mobile robots, treated as hybrid systems and working in industrial conditions. There are only a few applications at laboratory level **(Themes 1, 2, 3)**. Modeling, balancing and control of reversible manufacturing lines, serviced by robotic manipulators mounted on wheeled mobile robots, are addressed for the first time and is an absolute novelty part of the proposal. Making reversible and controlling an assembling line, in order to perform disassembling, served by wheeled mobile robots equipped with robotic manipulators, is also a premiere (**Theme 1**). Hybrid control structure, with a continuous control level and a logical level (occurrence), gives to the control structures high robustness to disturbance and uncertainty: uncontrollable events, variable load, wear components, magnetic fields, heavy environmental conditions (wind, humidity, dust, high temperatures) **(Themes 2, 3).**

However hybrid control system with the RMSMRRM supervisor can be deployed in enterprises, such as ARCELOR MITTAL Galati, SHIPYARD DAMEN Galati, SC ROMETAL Targoviste assembly to optimize flow valves in compressible gas transmission lines and liquefied etc. The mobile robot system will be dedicated to transport by both the low and medium loads (Pioneer 3DX, PeopleBot and PatrolBot) and equipped with robotic manipulators such as Pioneer 5-DOF Arm, and the large weight (PowerBot and Seekur Robot Base) **(Themes 2, 3).**

The aims of the project will consist of defining conceptual RMSMRRM control techniques that should provide the following performances: **1)** balance tasks oriented flexible control structures; **2)** Control structures with reactive damage capabilities of tasks; **3)** controllable response rate within

imposed limits; **4)** precise positioning and trajectory tracking the imposed by reduced errors; **5)** high robustness to external perturbations, and parametric model uncertainty.

C5. *Resources and budget*.

The infrastructure needed to achieve the objectives, is available mainly in Control of Robotic Systems Laboratory (CRS)-UDJ Galati and secondary in Energy-Environment Research Department DCEM-UVT Targoviste. Infrastructure available at the host institution (CRS-UDJ Galati) includes the following equipments:

Figure 3

Figure 4

Figure 5

Figure 6

Figure 7

Mobile robots: 2DW/1SW Pioneer 3-DX with robotic manipulator Pioneer 5-DOF Arm (Fig.3); 2DW/1SW PeopleBot (Fig. 4); 2DW/2SW PatrolBot (Fig.5); 2DW/2SW PowerBot (Fig.6)**;** 4DW/SW SEEKUR Robot Base (Fig. 7); Navigation and obstacle avoidance systems (ultrasonics, video cameras, laser system, on board PCs and specific software)**;** Mecatronic assembly/disassembly system Mecatronic HERA (Fig.8 and 9)**;**

Figure 8

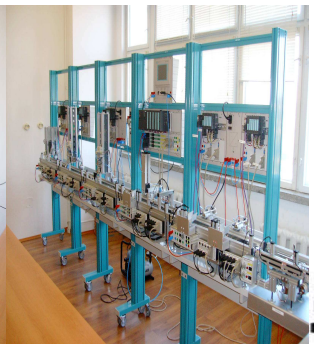

Figure 9

Figure 10

Figure11

In order to achieve the objectives of themes 1, 2 and 3 is needed to acquire the followings robotic manipulators and flexible manufacturing systems:

-5-DOF Adept Robot Arm (fig. 10), to be mounted on PowerBot and Seekur, with payload from 1kg to 5kg, price less than 10000 EURO;

-5-DOF Premium and Affordable P-Series Robot Arm (Cyton Premium) is available for Pioneer, -PatrolBot, as well as PeopleBot, payload up to 1.0 kilograms, price less than 7000 EURO;

-5-DOF Affordable P-Series Robot Arm (Cyton II-Fig.11), mounted on a Pioneer, PeopleBot PatrolBot , payload up to 250 grams, price less than 5000 EURO;

-two identical production lines, equipment components of modular teaching FESTO MPS 500-FMS Flexible production. Each production line consists of three workstations: Workcell Distribution, Workcell Testing, Sorting Workcell and a conveyor type transport system. The cost of each line is less than 15,000 €. The two manufacturing systems (teaching equipment), served by robots equipped with robotic manipulators for the transport of small, medium and heavy weight parts, are purchased to test balancing production lines (2014: Objective OB5) b)).

*The available infrastructure at the research partners***.** Through collaborative relationships with: GIPSA-lab (Grenoble laboratory of image, speech, systems and automation), National Polytechnic Institute of Grenoble, France (GIPSA-lab), Institute for Systems and Robots, University of Coimbra, Portugal (ISR-UC), the project will benefit from the available infrastructure in these laboratories: Manipulators with 5-degrees of freedom (with rigid or flexible links and joints): Robot ACMA and Robot Framatoem TAM/ GIPSA-lab, France; SCOUT and LABMATE 2DW/1SW mobile robots /ISR-UC.

Budget Breakdown (lei)

Budget chapter (expenses)	2011 (lei)	2012 (lei)	2013 (lei)	2014 (lei)	Total (lei)
Salaries	69000	320000	320000	210250	919250
Inventory	10000	110000	110000	28750	258750
Mobility	30000	90000	90000	90000	300000
Overhead	16000	80000	80000	46000	222000
Total	125000	600000	600000	375000	1700000

Figure 12

Budget Breakdown (euro)

Budget chapter (expenses)	Total (euro)	Justifications
Salaries	**213779.07**	TOTAL expenditures with salaries (919,250lei) are 54.07% of TOTAL budget. The amount includes the cost of employed and employer and ensure each team member working a fee corresponding to a rule (100%) or fraction (50%) of full-time, so that each team member at work expense is salaries ≤ 16,600 lei.
Inventory	**60174.41**	TOTAL Inventory costs (258,750 lei) Total budget is 15.21% and is distributed acquisition costs of equipment (above presented and which shall be purchased in 2012 and 2013), consumables and dissemination (2011, 2012, 2013 and 2014).
Mobility	**69767.44**	TOTAL project expenditures with mobility (300,000) represent 17.64% of the total budget. The amount is distributed as follows: - 2012, 2013, 2014: four stages of research per year (a period = 3 months) x 15,000 Euro / Training = 60,000 lei per year. The four stages per year will be conducted at the National Polytechnic Institute of Grenoble, France (GIPSA, INPG) and Institute for Systems and Robots, University of Coimbra, Portugal (ISR-UC); - 2011, 2012, 2013, 2014: one costs 30,000 lei/year participation to international conferences
Overhead	**51627.90**	TOTAL Expenditure of Overhead is 13.05% of the total budget and represents 14.81% of direct costs (salaries + Inventory + Mobility = 1,498,000 lei). The amount of overhead is in agreement with the Senate's decision of UGAL (4. Other documents: Lower Danube University of Galati-Percentage of overhead, Regie_IDEI_2011.pdf)
Total	**395348.82**	

Figure 13

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The information in this application is hereby certified to be correct.

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