Curriculum Vitae for Faculty Members

Date: May 29, 2003 Initials: MH

1. SURNAME: HUZMEZAN FIRST NAME: MIHAI
   Birth date: 27 SEPTEMBER 1968 MIDDLE NAME(S):
2. DEPARTMENT / SCHOOL: Electrical and Computer Engineering
3. FACULTY: Applied Science
4. PRESENT RANK: ASSISTANT PROFESSOR
5. PROFESSIONAL ENGINEER (P.ENG.)

POST-SECONDARY EDUCATION

University or Institution	Degree	Subject Area	Dates
UNIVERSITY OF BRITISH COLUMBIA, CANADA	P.D.F.	ADAPTIVE CONTROL	JULY 2000
UNIVERSITY OF CAMBRIDGE, U.K.	PH.D.	CONTROL SYSTEMS	JUNE 1998
UNIVERSITY "POLITECHNICA" BUCHAREST, ROMANIA	MA.Sc.	AEROSPACE, AVIONICS	JUNE 1993
UNIVERSITY "POLITECHNICA" BUCHAREST, ROMANIA	B.S.	AEROSPACE ENGINEERING	JUNE 1991

Ph.D. Thesis "Theory and Aerospace Applications of Constrained Model Based Predictive Control", Ph.D., Professor J.M. Maciejowski

MA.Sc. Thesis "Wind Tunnel Data Acquisition System with Application to Aircraft Modeling", M.Sc., Professor O.Pletter and Associate Professor C. Constantinescu

EMPLOYMENT RECORD

University, Company or Organization	Rank or Title	Dates
UNIVERSAL DYNAMICS TECHNOLOGIES INC., VANCOUVER, CANADA	Consultant	**1999 – 2000**
MIH CONSULTING GROUP, VANCOUVER, CANADA	President	**2000 – present**
DEFENCE AND EVALUATION RESEARCH AGENCY (DERA), BEDFORD, U.K.	Researcher	**1997 – 1998**
ROMANIAN AIR TRAFFIC SERVICES ADMINISTRATION (ROMATSA), BUCHAREST, ROMANIA	AIS Specialist	**1994 – 1995**
R.A. AIRPORT CLUJ-NAPOCA, ROMANIA	Technical director	**1993 – 1995**

AWARDS AND DISTINCTIONS

Outstanding Chapter Chair, IEEE Control Systems Society, **2001** ($2000 US)
Outstanding Chapter Chair, IEEE Vancouver Section, **2001**
Cambridge Overseas Trust Bursary, University of Cambridge, **1995-1998**
CT Taylor Studentship, University of Cambridge, **1995-1998**
ORS Award, University of Cambridge, **1995-1998**
Pembroke Studentship, Pembroke College, **1995-1998**
College Grant, Pembroke College, April **1996**
W.G. Collins Fund, Engineering Department, March **1997**
Rex Moir Prize, Engineering Department, May **1996**
Lundgren Studentship, University of Cambridge, **1996,1997**

TEACHING, SCHOLARLY AND PROFESSIONAL ACTIVITIES

Areas of special interest, where significant accomplishments were noted, include:
Adaptive control, closed loop identification, constrained predictive control, automatic drug delivery, process control, pulp and paper applications and aerospace related issues such as reconfigurable control in case of failures.

Courses taught while at UBC:

Session	Course Number	Scheduled Hours	Class Size	Hours Taught			
				Lectures	Tutorials	Labs	Other
1999-2000/2	EECE 361	80	40	14	4	56	6
1999-2000/2	EECE 571(L)	60	10	42	8	0	10
1999-2000/3	ELEX 7220	70	15	42	8	20	10
2000-2001/2	EECE 361	80	40	14	4	56	6
2000-2001/1	EECE 360	60	45	42	14	0	4
2000-2001/2	EECE 361	80	40	14	4	56	6
2000-2001/2	EECE 360	60	117	42	14	0	4
2000-2001/2	EECE 474	26	8	3	4	20	2
2000-2001/3	EECE 496	26	3	3	4	20	2
2001-2002/1	EECE 571(L)	60	15	42	8	0	10
2001-2002/1	EECE 361	80	40	14	4	56	6
2001-2002/1	EECE 496	26	1	3	4	20	2
2001-2001/2	EECE 360	60	130	42	14	0	14
2001-2002/2	EECE 361	80	40	14	4	56	6
2001-2002/2	EECE 496	26	4	3	4	20	2
2001-2002/2	EECE 285	26	6	2	3	10	10
2001-2002/2	EECE 496	26	2	3	4	20	2
2002-2003/1	EECE 361	80	40	14	4	56	6
2002-2003/1	EECE 571(T)	60	15	42	8	0	10

Graduate students supervised:

Student Name	Program Type	Year		Principal Supervisor	Co-supervisor(s)
		Start	Finish		
Stephane Bibian	Ph.D.	01/2001		Guy A. Dumont	Mihai Huzmezan
Tatjana Zikov	M.Sc.	01/2001	10/2002	Guy A. Dumont	Mihai Huzmezan
Terence Guihuly	Ph.D.	09/2001		Mihai Huzmezan	Guy A. Dumont
Lou Ann Mendoza	Co-op	09/2000	05/2001	Mihai Huzmezan	
Ming Chen	M.Sc.	09/2001		Mihai Huzmezan	
Guan Tien Tan	Ph.D.	12/2001		Mihai Huzmezan	Ezra Kwok
Richard Vetter	M.Sc.	09/2002		Mihai Huzmezan	Daan Maijer
Avideh Shahabi	M.Eng.	09/2002		Mihai Huzmezan	Robert Schrober
Parry Fung	M.Eng.	09/2002		Mihai Huzmezan	
Chris Mott	M.Eng.	09/2002		Mihai Huzmezan	

Research or equivalent grants

Granting Agency	Subject	$ per year	Year	Principal Investigator	Co-investigator(s)
NSERC-DISCOVERY	Nonlinearity measures for Quasi-LPV systems	23,000 23,000 23,000 23,000	2003 2004 2005 2006	M. Huzmezan	
NSERC-CHRP	On-line Monitoring Applied to Physiological Parameters in Critical Care	91,114 82,154 82,154	2003 2004 2005	M. Ansermino	M. Huzmezan
ASI	Managing Human Circadian Physiology and Optimising Alertness Using a Model-Based Predictive Control System	83,000	2003 2004	M. Huzmezan	
Centre for Anesthesia and Analgesia	Automatic Drug Delivery Advisory System for Spinal Anesthesia	10,000	2002	M. Huzmezan	
Datex	Advisory System for General Anesthesia	10,000	2002	M. Huzmezan	
TELF	The Development, and	15,000	2001	B. Macleod	M. Huzmezan

	Evaluation of a Clinical Trial Expert System				
Cognitex	Assessment of Conopeptides G1 and K10Q as Novel Neuromuscular Blockers	36,000	2001	B. MacLeod	G.A. Dumont, M. Huzmezan C. Ries
MITACS	Mathematical Modeling in Pharmaceutical Development	20,000	2001	B. MacLeod	G.A. Dumont, M. Huzmezan
Peter Wall	Automation and Robotics	15,000	2001	M. Huzmezan	G.A. Dumont
CFI	Institute for Computing Information and Cognitive Systems	8,855,000 5%	2001 2002 2003	R. Ward	et. al. including M Huzmezan
Organon	Preliminary Investigation for the Development of an Automated Drug Delivery System	20,000	2000	B. MacLeod	G.A. Dumont, M. Huzmezan
UDL and BC/ASI	Adaptive Control of Neuromuscular Block	50,000	2000	G.A. Dumont	M. Huzmezan
BC/ASI	Multivariable Adaptive Control	75,000	1998 1999	G.A. Dumont	M. Huzmezan
UDL	Development of a Multivariable Adaptive Controller	120,000	1998 1999	G.A. Dumont	M. Huzmezan

Continuing Education Activities:
IEEE Robust Multivariable Control Course taught for industrial participants from local companies such as Honeywell, Universal Dynamics Inc.etc.
IEEE Linear and Nonlinear Predictive Control course taught for industrial participants from local companies such as Honeywell, Universal Dynamics Inc.etc.
Pharmacology and Therapeutics PCTH 513 lectures
ACC 2002 Tutorial on Adaptive Control,

Visiting Lecturer:

University of Minesota, Mineapolis-Saint Paul	*05/04/2001 – 12/04/2001*
University "Politechnica", Bucharest, Romania	*20/07/2001 – 28/07/2001*
University of Cambridge, UK	*14/12/1999 – 21/12/1999*
University of California at Irvine,CA, US	*28/06/1998 – 02/07/2098*
University of Minesota, Mineapolis-Saint Paul	*19/05/2002 – 29/05/2002*

Invited Presentations:
Lecture on Modeling, Identification and Control of Affordable UAVs, Honeywell, Minneapolis, USA **2003**
Lecture on Connections between Aerospace and Automatic Drug Delivery, University of Washington, Seattle, USA, **2003**
Lecture on Automatic Drug Delivery Luncheon Peter Wall Institute, Vancouver, Canada, **2002**
Lecture on Single and Multivariate Laguerre Based Indirect and Direct Adaptive Predictive Controllers with Applications, University of Minnesota, Minneapolis, USA **2001**
Lecture on Flight Control at Canadian Aeronautics and Space Institute, Vancouver, Canada **2000**
Keynote address on Adaptive Control at IASTED Banff, Canada **1999**
Lecture on Brainwave at University of Cambridge, Cambridge, U.K. **1998**

SERVICE TO THE UNIVERSITY

Memberships in committees:

M. Sc. Thesis "Multivariable Averaging Level Control", Co-reader for Mr. Manperet Sidhu, April **2003**

Ph. D. Proposal "Automation in Clinical Anesthesia: Perspectives for Control", Co-reader for Mr. Stephane Bibian, October **2002**

M. Sc. Thesis "Monitoring the Anesthetic-Induced Unconsciousness (Hypnosis) Using Wavelet Analysis of the Electroencephalogram", Co-reader for Ms. Tatjana Zikov, October **2002**

Ph. D. Proposal "Representing Safety Critical Source Code", Co-reader for Mr. Ken Wong, July **2002**

M. Sc. Thesis "Beam Edge Detection for Radarsat ScanSAR", Co-reader for Mr. Dan Bast, May **2002**

Ph. D. Proposal "Possibility auto-regression based intelligent controller design and its application to wind energy conversion system", Head's Nominee for Mr. Hee-Sang Ko, April **2002**

Ph. D. Proposal "Structural Identification for Nonlinear Systems", Co-reader for Mr. Guan Tien Tan, August **2001**

Ph. D. Proposal "Automatic control of neuro muscular block based on a novel PK/PD modeling approach", Co-reader for Mr. Dejan Dejan Mjlanovic, July **2001**

Ph. D. Thesis "On Dual Control and Adaptive Kalman Filtering with Applications in The Pulp and Paper Industry", Examiner for Mr. Ahmed Ismail, July **2001**

M. Sc. Thesis "An Indirect Method for Non-Contact Sensing of Robot Joint Angles Using Accelerometers with Automatic In-Situ Calibration", Co-reader for Mr. Farhad Ghassemi, August **2001**

SERVICE TO THE COMMUNITY

Memberships in Societies:
Technical Chair Advanced Process Control Conference, April **2003**
Technical Chair Advanced Process Control Conference, April **2002**
Professional Engineer in British Columbia, September **2001**
Department of Pharmacology and Therapeutics, Associate Member, July **2001**
Chair of IEEE Control Systems Technical Chapter, Vancouver **1999-2001**
Member of IEEE Control Systems Society (IEEE-CSS)
Member of IEEE Communication Society (IEEE-COM)
Member of Canadian Aeronautics and Space Institute (CASI)
Member of Instrument Society of America (ISA)

Session Chair for the following conferences:
Advanced Control of Industrial Processes, Vancouver, **2002**
Advanced Control of Industrial Processes, Kumamoto, **2002**
American Control Conference, Anchorage, **2002**
Advanced Process Control Conference, Vancouver **2002**
IASTED Modeling and Control, Innsbruck, **2001**
Mediterranean Conference on Control and Automation, Patras, **2000**
American Control Conference, Philadelphia, **1998**
AIAA AERO Conference, Seoul, **1998**

Reviewer for:
IEEE Transactions on Automatic Control
IFAC Automatica
IEEE Transactions on Control Systems Technology
European Journal of Control
AIChE Journal
AIAA Journal of Guidance Navigation and Control
International Journal of Adaptive Control and Signal Processing
American Control Conference
IEEE Conference on Decision and Control
IEEE Mediterranean Conference on Control and Automation
European Control Conference

Consultant:
Pulsar Informatics Inc., **2002**
Universal Dynamics Technologies Inc., **1998-2002**
British Columbia Institute of Technology, **2000**

OTHER RELEVANT INFORMATION (please visit www.ece.ubc.ca/~huzmezan and www.mihconsulting.com)

While at UBC I have created the spin off company MIH Consulting Group Ltd., which under a contract with Universal Dynamics Technology (UDT 99038) "Development of a Multivariable Controller" took care of the programming aspects of the theoretical research performed. This company entered also the area of medical expert systems jointly with the Faculty of Medicine at University of British Columbia, with a web based project on "Clinical Trails Expert System", project amounting to 20,000 CAN $.

Publications Record

SURNAME: Huzmezan FIRST NAME: Mihai Initials: _____
MIDDLE NAME(S): Date: May 29, 2003

REFEREED PUBLICATIONS

Journal, Book and Patent Publications

1. M. Huzmezan, W.A. Gough, G.A. Dumont "Adaptive Control of Integrating Time Delay Systems: A PVC Batch Reactor" Transactions in Control Systems Technology, May **2003**

2. M. Huzmezan, W.A. Gough, G.A. Dumont and S. Kovac "Time Delay Integrating Systems - A Challenge for Process Control Industries - A Practical Solution" Control Engineering Practice, October **2002**

3. S. Bibian, T. Zikov, G.A. Dumont, C.R. Ries, E. Puil, H.C. Ahmadi, M. Huzmezan, B.A. Macleod, "Method and Apparatus for the Estimation of the Anesthetic Depth Using Wavelet Analysis of the Electoencephalogram", US Patent Pending, **2002**

4. M. Huzmezan, W.A. Gough and G.A. Dumont "Adaptive Predictive Regulatory Control with Brainwave", Techniques for Adaptive Control, ISA Control Engineering book series, edited by Dr Vance VanDoren, October **2002**

5. M. Huzmezan, W.A. Gough and S. Kovac, "A Method of Controlling a Marginally Stable Industrial Process", U.S. Patent # 5335164, **2000.**

6. M. Huzmezan and J.M. Maciejowski, "Flight Management Using Predictive Control", Robust Flight Control, **1997** Springer Verlag, Lecture Notes in Control and Information Engineering series, editors: J-F.Magni and S.Bennani.

7. J.M. Maciejowski and M. Huzmezan, "Predictive Control" (tutorial chapter) Robust Flight Control, **1997** Springer Verlag, Lecture Notes in Control and Information Engineering series, editors: J-F.Magni and S.Bennani.

8. M. Huzmezan and J. Maciejowski, "Constrained Predictive Control Methods - A State Space Formulation" Revue Roumaine de Science et Matematique Applique, November **1996.***

Conference Proceedings

1. M. Huzmezan and M. Cheng, " A Simulation Model and Hinf Loop shaping Control of a Quad Rotor Unmanned Air Vehicle", Proceedings of MS'03 Conference, Palm Springs,CA, USA, February **2003**

2. S. Bibian, C. Ries, M Huzmezan and G.A. Dumont, " Clinical Anesthesia and Control Engineering: Terminology, Concepts and Issues", European Control Conference, Cambridge, UK September 1-4, **2003**

3. G.T. Tan, M Huzmezan and K.E. Kwook, "On measuring the closed-loop nonlinearity: A Vinnicombe Metric Approach", Control and Decision Conference Maui, Hawaii, USA, December 9-12, 2003

4. M. Cheng and M. Huzmezan , "A combined MBPC/2 DOF Hinf controller for quad rotor unmanned air vehicle", AIAA Atmospheric Flight Mechanics Conference and Exhibit, Austin, Texas, USA, August 11-14, **2003**

5. D. Meade, M. Huzmezan and R. Lewis, "Adaptive model based predictive control of a Kamyr digester", Workshop on Tools for Modelling, Control and Monitoring of Continuous Pulp Digesters, Santa Barbara, CA, USA, January 23, **2003**

6. R. Vetter, D. Maijer, M. Huzmezan and D. Meade, "Control of a Simulated Die Casting 2-Dimensional Finite Element Model", APC Conference and Exhibit, Vancouver, BC, Canada, April 28-30, **2003**

7. M. Huzmezan, T. Janiewicz and D. Meade, "Industrial Automation with BrainWave Multimax" International Conference on Industrial Automation, Montreal, QU, Canada June 9-11, **2003**

8. G.T. Tan, M Huzmezan and K.E. Kwook, "Vinnicombe metric as a nonlinearity measure", European Control Conference, Cambridge, UK September 1-4, **2003**

9. M. Huzmezan "Modifying Human Circadian Rhythm Using Nonlinear Model Based Predictive Control" Proceedings of ACC'03, June **2003**, Denver, Colorado, USA. *

10. G.T. Tan, M. Huzmezan and K. E. Kwok "Vinnicombe Metric as a nonlinearity measure", Proceedings of CSCHE'02, Vancouver, BC, Canada October **2002**

11. T. Zikov, S. Bibian, G.A. Dumont, M Huzmezan and C. Ries "A Wavelet Based De-Noising Technique For Ocular Artifact Correction of the Electroencephalogram", Proceedings of EMBS-BMES Conference, Houston, TX, USA, October **2002**.*

12. M. Huzmezan and G.A. Dumont "Techniques Methods and Concepts in Adaptive Control" Proceedings of ACC'02, May **2002**, Anchorage, Alaska, USA. *

13. M. Huzmezan, G.A. Dumont, W.A.Gough, T. Janiewicz, S. Kovac and D. Meade "A Multivariable Languerre-Based Indirect Adaptive Predictive Controller Applied to A Fuel Blending Process", Proceedings of AdConIP Conference, Kumamoto, Japan, June **2002**.*

14. M. Huzmezan and G.A. Dumont "Techniques Methods and Concepts in Adaptive Control" Proceedings of ACC'02, May **2002**, Anchorage, Alaska, USA. *

15. M. Huzmezan, W.A. Gough and S. Kovac "Advanced Control of Batch Reactor Temperature" World Batch Forum, April 2002, Woodcliff Lake, USA

16. W.A. Gough, S. Kovac, M. Huzmezan and G.A. Dumont "Advanced Predictive Adaptive Control of Steam Header Pressure, Saveall, Consistency and Reel Brightness In A TMP Newsprint Mill" Control Systems, May 2002, Stockholm, Sweden

17. S. Bibian, T. Zikov, G.A. Dumont, C.R. Ries, E. Puil, H. Ahmadi, M. Huzmezan and B.A. Macleod "Estimation of the Anesthetic Depth Using Wavelet Analysis of Electroencefalogram" 23rd International Conference of the IEEE Engineering in Medicine and Biology Society, October **2001**, Istanbul, Turkey.

18. L.G. Franciosi, B.A. Macleod, M. Huzmezan, C. Ticea and A. Cosma "A Web-Based Clinical Trial Expert System (WebCTES)" 5th World Conference On Systemics, Cybernetics And Informatics July **2001,** Orlando, USA.

19. M. Huzmezan, G.A. Dumont, W.A. Gough and S. Kovac "Multivariable Laguerre-Based Indirect Adaptive Predictive Control - A Reliable Practical Solution for Process Control" IASTED Modeling and Control, February **2001,** Innsbruck, Austria*

20. M. Huzmezan, G.A. Dumont, W.A. Gough and S. Kovac "Time Delay Integrating Systems a Challenge for Process Control Industries - A Practical Solution " IFAC Workshop on Time Delay Systems, September **2000**, Ancona, Italy.

21. M. Huzmezan and G.A. Dumont, "Direct adaptive predictive control using subspace identification in Laguerre domain in the presence of constraints" IEEE Mediterranean Conference July **2000**, Patras, Greece*

22. M. Huzmezan, S. Kovac, B. Gough, L. Le and G. Roberts, "A New Generation of Adaptive Model Based Predictive Controllers Applied in Process Control" IEEE APC'99 Workshop, April **1999,** Vancouver, Canada**.**

23. M. Huzmezan and J. Maciejowski, "Reconfigurable Flight Control of a High Incidence Research Model Using Predictive Control" Proceedings of Control **1998**, Swansea, U.K. *

24. M. Huzmezan and J. Maciejowski, "Automatic Tuning for Model Based Predictive Control During Reconfiguration" Proceedings of AERO **1998**, Seoul, South Korea.*

25. M. Huzmezan and J. Maciejowski, "Reconfiguration and Scheduling in Flight Using Quasi-LPV High-Fidelity Models and MBPC Control" Proceedings of ACC **1998**, Philadelphia, USA.*

26. M. Huzmezan and J. Maciejowski, "A Novel Strategy For Fault Tolerant Control" COSY Workshop, Mulhouse, France, 3-5 April **1998.**

27. M. Huzmezan and J.M. Maciejowski, "A Development Space For Model Based Predictive Control (MBPC)" IFAC Symposium on Computer Aided Control Systems Design, Gent **1997***, Belgium

28. M. Huzmezan and J.M. Maciejowski, "Notes on Filtering, Robust Tracking and Disturbance Rejection Used in Model Based Predictive Control Schemes" IFAC SCC'97, Bucharest **1997**, Romania.

29. G. Papageorgiou, M. Huzmezan, K. Glover and J. Maciejowski, "Combined MBPC/H-inf Autopilot for a Civil Aircraft" Proceedings of ACC'97, June **1997**, Albuquerque, USA. *

SUBMITTED PEER REVIEW PUBLICATIONS

1. M. Huzmezan, G. Papageorgiou, "Autopilot Design Using Constrained Real Time Predictive and Hinf Control", Journal of Guidance Control and Navigation, submitted

2. M. Huzmezan and M. Cheng, " Nonlinear Modeling and Control of a Quad Rotor Unmanned Air Vehicle", Journal of Guidance Control and Navigation, submitted

3. T. Zikov, S. Bibian, G.A. Dumont, M Huzmezan and C. Ries "Estimation of the Hypnotic Depth During General Anesthesia Using Wavelet Analysis of the Electroencephalogram", Transactions on Biomedical Engineering, submitted

4. M. Huzmezan, T. Janiewicz and D. Meade, "Industrial Automation with BrainWave Multimax", International Journal of Process Control, in preparation

TECHNICAL REPORTS

1. M. Huzmezan, "Reconfigurable Control Methods and Related Issued - A Survey" Report prepared for the DERA Research Agreement no. ASF/3455, Department of Engineering, University of Cambridge, August **1997.**

2. M. Huzmezan and J. Maciejowski, "Reconfigurable Control Methods and Related Issued - A Survey" Technical report prepared for the DERA under the Research Agreement no. ASF/3455, Department of Engineering, University of Cambridge, August **1997.**

3. M. Huzmezan, "Constrained Predictive Control Methods - Theory and Practice" First Year Report, Department of Engineering, University of Cambridge, October **1995.**

4. M. Huzmezan and J. Maciejowski, "A Strategy For Fault Tolerant Control Using Model Based Predictive Control (MBPC)" Technical report prepared for the DERA under the Research Agreement no. ASF/3455, Department of Engineering, University of Cambridge, February **1998.**

5. M. Huzmezan and J. Maciejowski, "RCAM Design Challenge Presentation Document: The Model Based Predictive Control Approach" Technical report FM(AG08) TP-088-20 GARTEUR, 21st June **1996.**

STATEMENT OF RESEARCH INTERESTS AND GOALS

Actively engaged in control systems and biomedical research, my interests are in developing a University-based Virtual Operating Room and Intensive Care Center. Such a center is motivated by the increasing requirement to develop fundamental new knowledge on drug delivery and patient monitoring advisory systems for the intensive care unit and the operating room. In this context an innovative research program that desires to combine experiments approved by the hospital ethics committee with mathematical modeling in a systems and control framework will enable the understanding and qualifying the conditions leading to a safe environment surrounding the patient.

Combining control, in particular deterministic and intelligent control with medical applications is an exciting new field with significant impact in all streams of modern life. This fact is confirmed by the new funding opportunities, which provide an average of $100,000 US per year, open by the three of the key agencies in USA: NSF, NIH and NASA. For instance as part of NSF potential interest the enhancement of human performance by reduced workload and improved cognition is just an example. This program supports research that increases fundamental understanding of human performance through basic research in the cognitive sciences strengthens the links between applied sciences such as electrical engineering, robotics, and information technology and life sciences such as medicine. Such programs directly fit with the research program outlined in this statement. The NSF initiative is echoed by the NIH funding body through particular programs dedicated to bio-behavioral regulation and cognitive sciences. Programs like this can directly help in the case of our project via supporting clinical studies on basic mechanisms of behavioral regulation, including human research on sleep, thermoregulation, and the influence of the nervous system on related processes such as sensation, pain, hypnosis, areflexia and, at a higher level, alertness, perception, action, attention, memory, learning, knowledge, reasoning and motivation. All these processes are believed to relate to basic human regulatory functions. To enhance further this type of support NASA comes forward with two programs directly related to the outlined research. These programs are looking at habitability, the work environment and task characteristics for astronauts. Methods for objectively or quantitatively measuring habitability features are sought. These need to be corroborated with studies aimed at predicting the effects of combinations of habitability related issues such as noise, light, exercise, meals, visual environment on space flight crew performance and safety. Emphasis in such studies is placed on measuring the effects of task allocation between humans, automated systems and the overall performance.

Working closely in collaboration with other members of the Department and the University the main research aim is to develop a variety of computer-controlled drug delivery systems. Collaboration with experts from areas like anesthesia, neuro-pharmacology, systems and control will enable the development of such devices, oriented towards maintaining adequate physiological references simultaneously with the avoidance of pain, overdosing and post surgery trauma in a broad range of patients. This initiative recognizes the need for safely administrating drugs and further discharging the patients from hospital earlier to minimize health care costs without compromise. Rather than replacing the physician this research is intended to provide safer, reliable and user-friendly systems for drug delivery. Developing advanced advisory techniques, applicable to drug delivery represents a challenge due the multivariate, nonlinear, varying time delay characteristics of the patient. These systems will exist to enhance patient care while optimizing the use of skilled personnel.

For such developments expertise in adaptive and robust control, pharmaceutical agents and anesthesiology is mandatory. Enabling through feedback control the safe use of drugs with rapid onset times, short durations of action or small margins of safety will help current therapies to access such agents which are currently classified as unacceptable. This novel research approach will lead to the development of new drugs impossible to be administered using established clinical methods. The knowledge acquired will be applicable for outpatient use in the management of pain, arrhythmia or diabetes, using portable devices.

The aeronautical control systems experience possessed together with a strong willingness to make an impact on our standard of living created the need and ability to make the transition from aero to biomedical research. Carrying on such projects in an electrical engineering framework creates the ability to tap into other research streams such as robotics, communication and artificial intelligence. In this research statement few of the most relevant and innovative aspects of the envisaged projects are surveyed:

A) Patient Monitoring: The application of process monitoring in detecting changes of multiple physiological parameters, still largely unexplored, promises to make a positive impact in a health care setting. The healthcare professional's memory of a patient's physiological process is imperfect especially during long procedures when is difficult to maintain attention to the monitoring systems. Since current alarm systems do not consider trend changes, skilled clinicians must mentally combine multiple instantaneous values over time at the bedside. Automatic detection of significant changes in the physiological process, alternatively, can consistently identify subtle changes in a patient's state and provide an early alert to the health care

professional. The early alert, then, will trigger intervention and prevent adverse outcomes. Current monitor alarms are set to predefined limits unrelated to a specific patient. Thus, normal fluctuations in a patient's physiological rhythms are often mistaken for significant abnormalities. Intelligent monitoring of physiological processes can differentiate a significant change in the trend of a physiological parameter from normal fluctuations. An intelligent alarm system integrates multivariate analysis to prevent redundant, correlated alarms. It is believed that providing this tool to the anesthetist will improve port operative recovery and lead to new knowledge in applying general anesthesia and neuromuscular block, hence one of the research projects will make use of the requested equipment and concentrate on this topic.

The objectives for this research project are: I) to collect a significant sample of clinical data to facilitate evaluation of performance of automated systems that detect 'fault' conditions in physiological process monitoring; II) to develop an intelligent monitoring decision support system for clinical anesthesiologists that integrates the steady stream of physiological data produced by clinical monitoring systems; III) to apply the ability of the intelligent monitoring system to recognize patterns and identify abnormalities to a control system engineered to reduce anesthesia-related adverse events.

Any process monitoring model must fulfill two primary requirements useful in a medical environment. The first and foremost requirement is that the model must be capable of extracting signal information from noisy environments, detecting the process status despite a low signal-to-noise ratio. The second requirement is that the model must have minimum delay between the onset of a change in process and the recognition of a change. The delay is determined by the observation of the signal over a time interval, which is longer than the periods of fluctuations of the artifacts, together with the time required for processing. The design of a 'fault' detector requires a trade-off between these two qualities of extracting signals and delay. Another attribute of a robust detection system is the ability to distinguish between types of process change. An essential task in physiological signal interpretation is to determine whether the values that are measured are physiologically valid. Thus, the model that is used for process monitoring must recognize artifacts, or signals that are irrelevant to the patient's present intra-operative state, and be unaffected by them. These attributes guide the selection of process monitoring models for a computer-based intelligent monitoring system that has the capability of implementing the required pattern recognition and abnormality identification.

A three-phase study to develop a decision support system that is able to represent changes in physiological parameters over time, automatically highlighting significant changes to the overall trend of a variable has been designed. Phase I is an observational study in which the ability of the process monitoring model to identify a process change will be assessed with reference to process changes observed by the anesthesiologist in real-time and post hoc visual inspection, by a selection of clinical experts. In Phase II, the ability of the process monitoring model to identify a process change will be assessed with reference to the anesthesiologist real-time observation of process changes and post hoc expert inspection in a statistically significant sample. In Phase III, anesthesiologists will perform a true assessment of the ability of the process monitoring model to identify a process change in real-time.

C) General anesthesia advisory systems: The third representative project to be undertaken reflects the concept of an advisory system as part of the general anesthesia procedures. Advances in modern anesthesia have been built mostly through the following three aspects of the practice: I) education, which has a key role in making anesthesia as safe and reliable as possible II) sophisticated equipment, that includes standard monitoring devices such as: mass spectrometers, capnographs, pulse oxymeters, heart rate and blood pressure III) the anesthesiologists themselves, who are accessing an extensive pharmacopoeia from which a combination of drugs is selected according to the patient status (i.e. medical records, allergies, age, etc.) and the type and duration of the operation. Similarly to the development of automated flight control in the aeronautic industry, automation in anesthesia is a natural evolutionary step. Previous attempts at closed loop anesthesia throughout the past 60 years were performed on a small number of patients during maintenance. Such achievements have shown that a using a controlled infusion pump (or vaporizer) tracking a given setpoint more accurately than an anesthesiologist is possible.

After reviewing the state of the art in this field it has been assessed that the performance obtained from automated anesthesia systems can be greatly improved by using modern control techniques. Anesthesia is characterized by a strong uncertainty in patients' reactions to the administration of anesthetics and opioids. As a consequence close loop anesthesia systems can bring benefits to the current practice by providing a drug titration based on each patient individual response to the administration of drugs. By applying the proposed control systems is expected that the anesthetic state measured by hypnosis and analgesia will present less fluctuation. The controller will help compensate faster for surgical stimuli as well as detect the onset of the disturbance sooner than the anesthesiologist.

Ensuring nominal performance with respect to such uncertainties can be achieved using a robust control/advisory technique, together with an adaptation of the system gains. It is necessary to impose numerous constraints such as maximum allowed drug plasma concentrations and rates of infusion. As consequence the inclusion of a model based constrained predictive controller in cascade with the robust inner loop is recommended. It is also clear that close loop control of anesthesia should not be limited at the regulatory level which has been the main focus of the prior art. The existing synergism between opioids and anesthetics must be used as an advantage when optimizing the titration of the drugs. An appropriate solution will be to allow controller flexibility by which it can optimize drug usage with respect to criteria specified by the anesthesiologist.

Given the of the applicant achievements in patient hypnotic state monitoring using the patented WAV Index a clinical study suitable for the identification of the multivariable PD models of propofol and remifentanil can be designed. The assumption is that the PK models of propofol and remifentanil are not dependent of an operating point, remaining constant during the length of the surgery and exhibit a reduced cross coupling. This identification procedure is equivalent with the generation of a 2-D Hill equation look up table in which the steady state plasma concentration for both drugs will be linked to the observed effect. Such an approach respects the accepted pharmacological approach and produces a good estimation of the direct and coupling gains of the system. The identification can be done only in surgeries with a limited amount of stimulations (e.g. with reduced unmeasured disturbances) and of long enough duration to allow for the proper excitation of all of the system's modes. Both a pediatric and adult patient population will be considered. Note that the dynamics of the measured disturbances caused by the background inhalational agent requires also modeling, to providing a feedforward type compensation for the controller. The models acquired should provide sufficient information to carry out the design and tuning of the single input, multiple input and single output and multivariable controllers.

Based on these models, the design of a supervisory/advisory system, integrated in the user accessible auxiliary screen of the requested anesthesia monitor is possible. The models used by the supervisory system will be based at start-up on models available in the literature. As the identification procedure progresses, a complete library of models can be built. From this library an online self-tuning procedure embedded in the advisory system will select the appropriate model. The supervisory/advisory system has to be tested during another experimental study. Feedback from anesthesiologists will be critical in developing the system's user interface.

Extensive simulation will allow the estimation of the maximum uncertainty that can be allowed in the system. A tradeoff between model accuracy and robust performance is required. Based on the simulation results, the focus will be on validating the single variable control system in a clinical environment. Once satisfactory results have been reached, we will adapt the single variable control systems to work in a full multivariable setting.

C) Managing Human Circadian Physiology: This research is focused on physiological modeling, circadian state estimation, and control system design to meet the tight performance requirements imposed by the circadian cycle control application. Since we advocate a model-based solution to circadian control, therefore a major focus of the work will be the development of complete circadian physiology models. Comprehensive models of circadian physiology exist for a number of the subject inputs and outputs. However, many of the relevant models are based on a qualitative approach to the data. Key investigations will be identified by an extensive literature search and the experimental data will be re-examined from a quantitative paradigm. Making use of system identification techniques, existing models will be adapted for model-based control.

Accurate physiological measurement is necessary for feedback control. As such, the integration and development of physiological sensors will follow the initial model investigation. Signal processing, for noise removal and pattern detection, will enhance the accuracy of the recorded measurements. Upon complete instrumentation of the subject, circadian state estimation techniques will be developed using available measurements and models. Finally, a controller based on complex non-linear physiological models, and capable of managing inherent subject constraints, will be developed. By applying state-of-the-art knowledge in system identification, estimation and observer design, adaptive control, hierarchical control schemes and model-based predictive control, in a collaborative environment the above goals can be reached.

A key factor for the success of the control system development is having accurate models of human circadian physiology. Accordingly, the first stage of this project involves further expansion of the existing physiological models. The focus will be on models linking the effects of actuation stimulus with sensed physiological variables of the human body.

The strongest actuator for circadian cycle control is light. Detailed models of its effects are available. Complete subject control will be achieved by augmenting this conventional actuation with additional inputs including: sleep schedules, physical exercise timing, intake of calories, and environmental temperature. The effects of these secondary inputs to human circadian physiology have been qualitatively examined. However, only few models suitable for the purposes of control have been developed.

Utilizing data from previous experiments, which were not initially intended as modeling experiments, will pose some complexities. However, it is anticipated that a significant degree of knowledge can be acquired through the application of available system identification expertise. Laguerre system identification techniques as well as gray-box modeling techniques will be applied.

The human body presents a large number of measurable outputs. Identification of the most significant circadian physiology outputs will focus the physiological sensor development into a number of primary areas. It is anticipated that these areas will include sensors to measure the heart rate, core body temperature, physical activity, and ambient light exposure. Availability of essential physiological measurements from the subject will allow validation of currently available research models and further modeling initiatives.

Remote and non-invasive sensors are required to monitor the subject without restricting independence. Existing non-invasive commercial sensors are available for a variety of physiological variables and some sensors will modified to meet specific custom requirements. The sensors will be combined into a portable integrated sensing system.

A circadian state estimation algorithm will be developed through the application of observer design theory such as model-based Kalman filtering. As a result a composite index based on available measurements of the endogenous circadian pacemaker phase and amplitude will be developed. A precise definition of the endogenous circadian pacemaker phase and amplitude will ensure the performance of the future control system by providing robust measurements.

Current models are focused on the primary effect of the circadian cycle on core body temperature and cognitive performance. A reassessment of these models in the light of new inputs and outputs is the object of this project milestone. Data required is grouped in a number of key areas: I) the relationship between various measurable body responses and the complex circadian cycle index; II) evoked potentials in the EEG signals used to establish levels of sleep; III) evoked potentials able to detect the muscle tonus; IV) maximum limits allowable in shifting the circadian cycle peak; V) maximum intake levels of sound, light, heat, exercise, calories over a determined period of time; VI) weight, sex, age, behavior of the subjects for the circadian cycle transition etc.

Following the development of the physiological models, sensors, and circadian state estimation techniques, the framework will be set for the application of closed-loop control. The SISO, model based controller previously developed will serve as foundation. This controller will be augmented with the inclusion of new models, and new functionality to meet tight operational requirements. To achieve this, research and development of advanced constraint-based optimization, non-linear multi-variable control, and adaptive learning will be emphasized. The existing SISO controller manipulates light input to achieve control over an individual's circadian state. The inclusion of the new models will expand the controller into a non-linear MIMO system capable of manipulating light, sleep schedules, physical activity and eating schedules to achieve control over alertness and cognitive performance. One approach considered to deal with the non-linear aspects of the models is quasi-linear parameter variation.

The introduction of stimulus to an ambulatory human subject involves significant actuator constraints. Such constraints include I) maximum levels, II) rate at which inputs such as temperature or intake of food can be increased from the previous value III) the duration that actuation can be maintained, IV) scheduled activity of subject. Optimization techniques, such as constrained model-based prediction will provide an elegant solution to optimum control performance in the presence of complex constraints. An important consideration in systems interacting with human physiology is inter-subject variability. The feedback provided by the sensors and state-estimation techniques will provide a significant degree of compensation for this variability and will allow nominal subject models to be used with accuracy. This is a primary competitive advantage of closed-loop control over open-loop methods. An additional capability, which is on-line model identification and adaptation, will be developed for the controller. All control system development will be performed in Matlab, and following successful simulations, it will be ported to a "D-Space" rapid-prototyping system and to a personal-computer with sensor interface hardware capability. A graphical user interface will be developed to allow easy interaction during further refinement and testing stages. The use of the Matlab design environment

and the rapid prototyping system will allow quick iterations through the testing and tuning cycle of the control algorithm development.

An observational study for testing the developed control algorithm will be designed. In this study a limited sample of volunteer subjects will be used in the testing and tuning of the control algorithm. The invasiveness of the system is minimal and therefore no ethics committee approvals are required for this stage.

D) Neuromuscular Block (NMB): This initiative is motivated by the role that automatic control is playing in every day life and increasingly in biomedical engineering. We see that automatic drug delivery will be the standard in the operating room in the near future. As a stepping stone current research is concentrated on developing a system designed to maintain a controlled level of muscle relaxation. The challenge of this project is to achieve this objective with a minimum dose of muscle relaxant. The purpose of NMB is to produce paralysis in a patient to permit surgery. Presently, NMB drugs are administered as an intravenous bolus by the anesthetist watching the effect of an electrically evoked muscle twitch. This often results in overdosing, increased toxicity and prolonged duration of NMB. Paralysis may persist after anesthesia and surgery. This is also dangerous to patients and expensive to the health care system. Work related distractions also may sometimes result in insufficient drug doses resulting in an absence of effect with the possibility of patient motion, inadequate operating conditions, and difficulty in respiratory control. The financial cost of the agents as well as the cost of dealing with the effects of poor control of drug dosing can be reduced by the use of drug delivery control. It is expected that this strategy will reduce the recovery time resulting in reduced risks of the post-operative respiratory problem, significant savings and better utilization of scarce resources and qualified personnel available.

The NMB project was chosen for its applicability for computer control and its safety in human trials. Its short-term objective is to develop and test a computer controlled drug delivery system that is acting on measured effects of neuromuscular blocking drugs used in anesthesia and surgery. Patient models translated to hardware and software will validate the approach by further animal testing, and comparison to existing human pharmacokinetic-pharmacodynamic (PK-PD) models. The resulting device and algorithm will eventually be tested in humans. During the human trials, the information relating the infusion rate and patient characteristics to the effect will be recorded creating a database available for further pharmacokinetic modeling, yielding valuable experience in the integration of multiple drug therapies, not only in anesthesia but also in other medical fields.

The problem of controlling neuromuscular block has the peculiarity that the measurement is an active one (i.e. it requires sending a stimulus to the patient through the use of a nerve stimulator). Different stimulation patterns can be used (e.g. a single twitch, a train of four, or a tetanus stimulation). Depending upon the level of block, specific patterns are better than others. Whereas previous work has used the train of four by default, we intend to take a fresh look at the problem by analyzing the system as multivariable. In the proposed architecture the controller not only decides the new rate of infusion, but also the stimulation pattern necessary to assess the neuromuscular block level. Intelligent protocols for existing sensor hardware will be developed to allow for computer controlled excitation. The new sensor protocols will independently and actively decide the required stimulus necessary to maximize the systems sensitivity in order to detect small changes in the drug infusion rate.

To optimize the stimulation pattern, a better understanding of the neuromuscular junction is necessary. Therefore development of novel NMB agent models based on our team experience of testing neuromuscular blocking drugs with various industrial partners will be pursued. These modeling efforts are motivated by the inability of a simple sigmoid nonlinearity, currently used by other research groups and characterized by the Hill equation to capture observed hysteresis. The applicant's practical experience shows that the dynamic response directly depends on reflex stimulus used, hence the need to consider it as an independent input. The novelty of our approach lies in the combination of a linear PK/PD model with a nonlinear synapse model, where the elimination and regeneration of acetylcholine transmitter reflects the intimate processes taking place at the postsynaptic sub-unit receptor. This model will describe completely the response to nerve stimulus. The membrane model will be augmented with a muscle model to mimic responses to single twitch, train of four, tetanus or postetanic count, commonly used stimulation protocols.

Since drug responses vary greatly between individuals and for a given individual over time, a strong case can be made for the use of adaptive control. Indirect nonlinear adaptive control will be investigated in comparison with scheduled robust control. The stability and performance of this system will be studied in a systematic manner to prepare for future application of control to other drug therapies. We will use adaptive control systems knowledge on nonlinear and linear time varying systems derived from the aerospace and process control industries when generating the control algorithm. We have already shown that the dynamics of the

effects of neuromuscular blocking agent on muscular strength exhibits an output static nonlinearity. Therefore, Laguerre nonlinear modeling for such systems will be used. Theoretical and practical extensions to this approach are necessary to provide clinical control of NMB drugs.

While evaluating our controller, we will check the hypothesis that it can produce a steady state in a variety of populations during anesthesia, over a time period relevant to clinical situations. The clinical trials are to occur in the University teaching hospital facilities.

At the end of the research period we should be in possession of a proven and viable drug therapy control system for neuromuscular block. By then we will also have established the use of robust performance testing of closed loop control devices used in this type of health care delivery system. The developed certification procedures will help set a new standard for controllers employed in the medical field. The technology and methodology developed will represent a springboard for extensions to the control of other types of ambulatory drug delivery.

To facilitate the development of this independent research program, broaden the available research experience and link with other research environments engaging in a number of field trips to work and research abroad with international researchers from the Laboratoire Automatique Grenoble - France, the Automatic Control Laboratory part of Swiss Federal Institute of Technology. The industrial funding and connections that I have been able to secure up to now with leading companies such as Datex-Ohmeda or Universal Dynamics Technologies represent another asset that requires further pursuing. Additional contacts have been initiated with Cleveland Medical Devices Inc., Physiometrics Inc. and General Electric.

The research and development associated with the aforementioned topics will generate results that will be disseminated in conference and journal papers at a rate that permits their thorough reporting.

STATEMENT OF TEACHING INTERESTS AND GOALS

Since starting lecturing at University of British Columbia, I have been through a major revision of the control systems courses taught in this institution. This endeavor revealed the need for a number of core graduate courses such as Robust Multivariable Control and Linear and Nonlinear Predictive Control. As result I have introduced and taught these two new courses in the University Calendar. Introducing and teaching new material is also a challenging task. The range of tasks completed, from the setting up of the course syllabi, producing the notes, teaching and grading, has allowed me to have a complete feeling about teaching in a University environment. Despite the sometimes heavy burden of it, I have greatly enjoyed this responsibility. At the undergraduate level, I have been involved in a number of classes such as Systems and Control and project-based courses. I have managed despite the reduced funding available at UBC to set up a good laboratory-based course that involved experiments from both controls and communications.

At undergraduate level I am prepared to teach in a wide range of areas spanning from Differential Equations, and Signals and Systems to Control Systems and Communications. I also envisage the opportunity to introduce a new undergraduate course based on my current research. In exchange at graduate level I would like to focus on novel areas such as Control in Biomedical Engineering or more fundamental courses, such as the ones introduced at UBC. This means that I can teach the cross listed course on Robust Multivariable Control and Linear and Nonlinear Predictive Control. I will bring forward as an asset the WebCT electronic versions of these courses.

To give you a glimpse at my teaching philosophy here are some remarks. At the course syllabus level, concentrating on fundamental concepts at a higher level of understanding can be achieved. The course presentation should include the description and analysis of the topics. Examples serve to illustrate the fundamental concepts, analysis providing a better understanding. A new topic should be addressed by pointing out some examples. A required introduction to the subject is necessary to put things in perspective and show relationships with previous taught material. Discussing the aims and the general approach to solve the problem should follow. Finally some examples required to elucidate some of the more interesting facets of the problem are needed. Students are encouraged to interact and through in class discussions to learn more on the overlooked aspects of the course. Feedback from the class improves the teaching quality and adds to the presentation balance, which indirectly allows a wider student spectrum to benefit from the course. As for the assignments some problems are to be solved in pencil and other using computer simulations. Since solutions can be found easier when the problems are formulated correctly and clearly a great deal of attention should be focused at this level. While computer simulations are helpful for understanding the ideas, they should not substitute analytical thinking. Hence students in their exercises are expected to interpret and validate the data obtained from the computer corroborating its features at an analytical level whenever possible.

As far as the graduate students are concerned, I have already graduated a MA. Sc. student employed with one of the partner companies. Two other students, one MA.Sc. and one Ph.D., are ready to graduate before the beginning of the next academic year. I envisage that some of the students that I currently have will follow me in order to receive the right supervision,which we have agreed upon at the start of their academic program. The pool of graduate students will be expanded in the new directions mentioned in the research statement, for which I expect to secure funding from NSF, NASA and NIH as soon as the opportunity arises. Training highly qualified personnel is essential for the success of any academic research program. Engineering students producing devices are not only to interact with other engineers, anesthesiologists, surgeons and auxiliary personnel but also to have direct involvement in a various clinical aspects. In doing so the gained education in health care technology will prepare them to fulfill the new needs of the health care delivery system. Such an approach will force them to think out of the box and will allow a better understanding of the need various users have. The demand for HQP in the aforementioned area is currently increasing much beyond the economy as a whole. This phenomenon creates an acute need, which in order to satisfy, the number of educational and training programs must be increased at the same time with modification of existing programs.

REFERENCES:

Prof. J.M Maciejowski (UCAM)
University of Cambridge
Department of Engineering
Trumpington Street
Cambridge, CAMBS, CB2 1PZ, UK
Tel.+44-1223-332 732 Fax. +44-1223-332 662
jmm@eng.cam.ac.uk

Prof. B. MacLeod (UBC)
University of British Columbia
Department of Pharmacology and Therapeutics
2176 Health Sciences Mall, Block C
Vancouver, BC, V6T 1Z3
Tel. 1-604-822 2103 Fax. 1-604-822-0087
bmacleod@interchange.ubc.ca

Prof. G.A. Dumont (UBC)
University of British Columbia
Department of Electrical an Computer Engineering
2385 East Mall
Vancouver, BC, V6T 1Z4, Canada
Tel +1-604-822 8564 Fax. +1-604-8228563
guyd@ece.ubc.ca

P.Eng. W.A. Gough (UDL)
Universal Dynamics Ltd.
100-13700 International Place
Richmond, BC, V6V 2X8, Canada
bgough@udtech.com

D. Linkens, Professor,
University of Sheffield
Control Dept.
D2, Army Johnson Building, Sheffield, U.K.
d.linkens@sheffield.ac.uk

R. Bitmead, Professor
Mechanical & Aerospace Engineering
University of California - San Diego
9500 Gilman Drive
La Jolla, CA CA92093
UNITED STATES
rbitmead@ucsd.edu

M. Morari, Professor,
Automatic Control Laboratory, ETH Zentrum, ETL I 29, CH-8092, Zurich, Switzerland
morari@aut.ee.ethz.ch

Willy Wojsznis
Fisher-Rosemount Systems,
Division of Emerson Process Management
willy.wojsznis@frco.com

Other references can be obtained on request from world renowned researchers such as Karl Astrom, Frank Doyle III, Keith Glover that had opportunities to look upon my work .