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SUBMISSION TO ONTARIO COUNCIL ON GRADUATE STUDIES

PROPOSAL FOR A

MULTI-DISCIPLINARY PH.D. PROGRAM

IN

INDUSTRIAL AND MANUFACTURING SYSTEMS ENGINEERING

VOLUME I

THE PROGRAM

DEPARTMENT OF INDUSTRIAL & MANUFACTURING SYSTEMS ENGINEERING (IMSE)

UNIVERSITY OF WINDSOR

June 2004

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1. INTRODUCTION

1.1 Executive Summary

Modern Manufacturing Systems consist of advanced machinery and material handling systems, computers and people. The design, operation and control of such systems greatly affect their productivity, efficiency, reliability and quality of their products. Successful manufacturing enterprises in the 21st century must be lean, agile, responsive and adaptive to changes in products as well as markets. Emphasis is placed on competitiveness and optimising the global supply chain and production cost. The role people play in such systems is becoming increasingly important both on the shop floor as well as in the whole enterprise.

The University of Windsor is located in the industrial heart land of Ontario and Canada. The current Strategic Plan of the University identifies the Automotive area as one in which to invest and grow: "The University has also established three pinnacle areas for special development (automotive, the environment, and social justice) and achieved considerable success in each. Each is supported by a number of Canada Research Chairs, core faculty has won a number of research awards, the University is the host institution for the highly successful AUTO 21, the Network of Centers of Excellence for the Automobile of the 21st Century…". The Automotive and Manufacturing Industries are important engines for jobs and wealth generation in Ontario and Canada. The proposed multi-disciplinary Ph.D. program reaches across the departmental boundaries and responds to this vision.

In order for Canadian Manufacturers to survive they must be globally competitive. They must produce brilliantly designed products, with highest quality at competitive prices and with ever shrinking product development/manufacture life cycle. They must develop sophisticated manufacturing systems that are flexible and well integrated. This requires advanced knowledge regarding: 1) physical components of the system (machines, robots, inspection devices, material handling equipment, etc.), 2) effective information systems for controlling, monitoring, scheduling and operating in a dynamically changing environment, 3) human related issues such as ergonomics, interaction among people and between people and machines as well as human modelling, 4) management of technology and operational issues throughout the manufacturing enterprise, and 5) integration of all elements to ensure achieving the desired competitiveness.

This challenge clearly calls for a multi-disciplinary approach to problem solving, research and development and the training of HQP (Highly Qualified Personnel) in the systems approach for dealing with this multi-facetted domain in a structured and systematic way.

The proposed new Ph.D. program in ***Industrial and Manufacturing Systems Engineering*** affords us the opportunity to achieve these goals. The participating faculty are drawn from several disciplines and departments within the University, namely, Department of Industrial and Manufacturing Systems Engineering, the Faculty of Human Kinetics (Department of Kinesiology), the Odette School of Business, the Faculty of Science (Operational

Researchers), Mechanical, Automotive and Materials Engineering Department, Electrical and Computer Engineering Department and the School of Computer Science.

The proposed program will provide new opportunities for students providing a multi-disciplinary Ph.D. Program that is focused on the field of "Industrial and Manufacturing Systems Engineering". Industrial and Manufacturing Systems Engineering is an integrated discipline that includes the study, management and control of integrated systems of people, machines, and technologies utilized to improve the quality and productivity of the entire system.

A Canada Research Chair in "Manufacturing Systems Engineering" has been awarded in late 2002, along with infrastructure grants from CFI (The Canada Foundation for Innovation) and OIT (Ontario Innovation Trust), to the Intelligent Manufacturing Systems (IMS) Centre. Dr. Hoda ElMaraghy was named to this Chair starting in the Year 2002 for 7 years (renewable). These developments added strength, created critical mass and enhanced the scope to the existing research thrusts in Manufacturing Systems. In addition, several of the participating faculty are recent appointees thus adding vitality, vigour and a wider scope to the proposed graduate and research program.

Strong linkages with industry, through collaborative research and contracts, help offer the graduate students desirable exposure to practical manufacturing systems problems that can provide focus and relevance to their fundamental program of studies. Current industrial collaborators include leading automotive industries in the region and many of their suppliers, tool and die makers, and manufacturing and automotive assembly manufacturers.

Some of the applicants are participants in the provincial Centre of Excellence in Manufacturing (MMO), the Auto21 NCE (National Network of Centres of Excellence), and the International Program in Intelligent Manufacturing Systems (IMS). Some collaborate with University colleagues in Canada and internationally. This national and international networking is extremely beneficial to both the educational and research programs in Industrial and Manufacturing Systems.

The proposed new multi-disciplinary Ph.D. program will be unique in Ontario and Canada and it is our objective and vision to make it one of the best in this field. The commitment of the core faculty is substantive and this proposal further strengthens existing research collaborations among members of the group. The core faculty members would be able to co-supervise or supervise Ph.D. students in the proposed Ph.D. program.

The following submission is prepared according to the format specified in the ***PROCEDURES FOR NEW PROGRAMME APPRAISALS*** and provides relevant data and information for the past 7 years.

1.2 Program Objectives

The proposed multi-disciplinary Ph.D. program is designed to meet the clear and growing need for highly qualified personnel trained to have a deep appreciation for the important system's issues in manufacturing, to prepare candidates for an academic career in teaching and research or leadership roles in industrial research and development, industry and academia. The objective of this program is to impart the required multi-disciplinary education and skills in an environment that fosters excellence in research and awareness of the many challenges of modern Industrial and modern Manufacturing Systems. The program leverages the combined expertise and resources of active researchers in four Faculties/Schools including the IMSE laboratories and IMS Centre facilities.

The program will provide students with an opportunity to acquire, through courses, seminars and networking, advanced academic and professional knowledge in the multi-faceted area of industrial and manufacturing systems and related subjects as well as develop basic and applied research skills to become independent research investigators capable of disseminating knowledge and research results through scholarly publications. The Ph.D. thesis projects emphasize original research that provides significant contributions to knowledge. The applicants consist of 14 investigators that have their own independent research programs and many of them form groups (e.g. the IMS Centre and the Operational Research (OR) group) that collaborate in research and graduate education. They often act as co-investigators, co-authors, co-supervisors, and members of joint committees and/or participants in research groups and collaborate with each other on interdisciplinary projects. These linkages provide Ph.D. students and postdoctoral fellows with valuable interactions and exposure to more than one discipline.

The proposed multi-disciplinary Ph.D. programme in ***Industrial and Manufacturing Systems Engineering*** will be based in, and coordinated by, the Department of Industrial and Manufacturing Systems Engineering (IMSE). It aims at creating and maintaining excellence in specific areas of this vast field that are at the forefront of research and innovation which helps attract well-qualified students from related disciplines as well as research funds. We strive to provide the necessary research tools and facilities and a scholarly and dynamic environment in which the students find scope for intellectual development. The program areas of research on which we concentrate are sufficiently broad to provide challenges to excel, and yet focused enough to direct our resources effectively in pursuit of these objectives.

1.3 Historical Background

The Industrial Engineering program at the University of Windsor started in 1966 as an option within the Department of Mechanical Engineering, and the first candidates for the Master's degree were accepted in early 1967, followed later during the same year by the Doctoral program. The Department of Industrial Engineering was formally established in 1972 and has since provided programs leading to the B.A.Sc., M.A.Sc., and Ph.D. degrees. The department was named Industrial and Manufacturing Systems Engineering (IMSE) in 1995. The Ph.D. program in Manufacturing Systems was offered between 1995 and 2002. At present 30 full- and part-time students are enrolled in the Master's degree program and 9 students are completing the

Ph.D. requirements under the discontinued program.

The Department of Industrial and Manufacturing Systems Engineering has, for many years, a close cooperation with the Department of Mathematics and Statistics in the area of operational research. This has resulted in offering an interdisciplinary program leading to a Bachelor of Operational Research, managed by the Operational Research Group through the Department of Mathematics and Statistics. The IMSE department participates in the offering of this bachelor program. Dr. Richard J. Caron, Professor of Mathematics and Statistics and Dean of Science, is also the Director of the Operational Research Program.

Three new faculty members have been recently appointed in the IMSE department including a Department Head with extensive industrial experience, and an additional faculty position is being filled. These additions offered an opportunity for renewal. The IMSE undergraduate program has been streamlined, in response to the University priorities and market demands. Three streams have been designed in Automotive Manufacturing Systems, Supply Chain Management and Industrial Engineering with Business minor option. This new program has been approved by the University Senate and is scheduled to begin in September 2004. The proposed Ph.D. program in Industrial and Manufacturing Systems is in line with this new thrust.

Recently OCGS has approved the renewal of the M.A.Sc. Program in Industrial Engineering, which was judged to be of "Good Quality" (the highest OCGS rating). A new M.Eng. Program in Industrial Engineering has also been approved. These are outlined in Appendix 4.

The proposed multi-disciplinary Ph.D. program opens new venues for Ph.D. supervision to many active researchers who do not have such a program in their home units. *Therefore, the benefits of the proposed program are demonstrably manifold*.

1.4 Method Used For Self-Study

This proposal is designed to respond to the vision of the University of Windsor to be a key player in the automotive and manufacturing fields and to the needs of Canadian Industry.

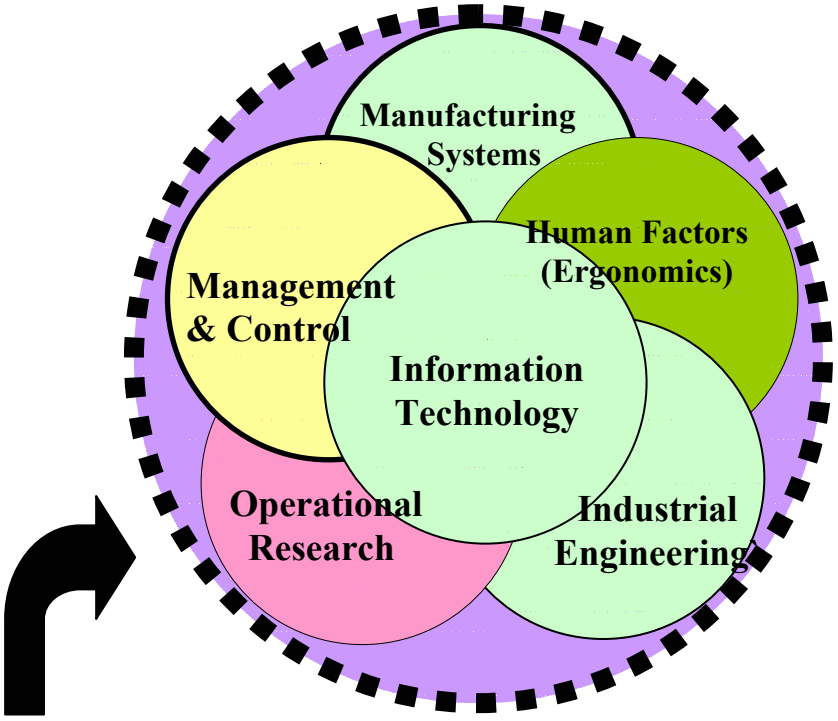
A Committee for examining the program and preparing this document was formed, and met six times to develop the proposal and review the various issues, drafts and input from the faculty. All participating faculty contributed to the development of this proposal and were provided with an opportunity to review several draft copies of the write-up and critique their contents. The group as a whole also met two times to approve the final draft submission. Input from current graduate students was also solicited regarding the various features of the proposed Ph.D. program.

The procedure followed for preparing this proposal was open, transparent, collaborative and inclusive and participants are enthusiastic about its potential and benefits.

1.5 Fields In The Program(s)

We are proposing a multi-disciplinary Ph.D. in the single field of "Industrial and Manufacturing Systems Engineering". Industrial and Manufacturing Systems Engineering is an integrated discipline that includes the study, management and control of integrated systems of people, machines, and technologies, in order to improve the quality and productivity of the entire system. IMSE includes not only the manufacturing systems themselves, but also the operational research, and human factors (ergonomics: both physical and cognitive). Operational research is involved with developing models, algorithms and optimization; e.g. inventory control & production planning. Information technology is an integration tool.

There are identifiable areas of research interest such as the Supply Chain Management, Operational Research, Operations Management, Product Design and Manufacture, human factors and Manufacturing Systems Design, Operation and Control human. Individual faculty expertise is clustered around focus groups such as those belonging to the Center for Intelligent Manufacturing Systems (IMS), Environmentally Conscious Design and Manufacturing, Ergonomics and Human-Centered Manufacturing, the Manufacturing Systems Modeling and Operational Research.



The field of Industrial and Manufacturing Systems Engineering.
Information technology is an integration tool. Note that Information Technology is an integrator.

1.6 Areas Of Research Interest

Examples of the above research areas include: systems design / modelling, integration,

control and scheduling, cellular manufacturing and group technology, flexible and re-configurable manufacturing, supply chain management, operational research, optimization, enterprise management, sustainable manufacture, facility planning, process planning, ergonomics, human simulation, human factors, safety, virtual reality, material handling systems, robotics, automotive engineering, manufacturing assembly, fastening, industrial management, applications of artificial intelligence and expert systems in manufacturing systems, product innovation, CAD/CAM/CIM, concurrent engineering, intelligent and integrated product design and manufacture, rapid manufacture and prototyping, manufacturing-driven product design, re-configurable control, advanced machining, inspection, and quality control**.** A list of faculty and their corresponding areas of research interests is given in Tables 2.1 and 2.2. While students may choose to focus on a variety of specialization flavors, the core courses offer an *integrated, multi-facetted perspective on the design, development and production of products and deployment of services in modern and complex manufacturing systems.*

1.7 Special Features And Linkages

- A Canada Research Chair in "Manufacturing Systems Engineering" has been awarded in late 2002, along with infrastructure grants from CFI (The Canada Foundation for Innovation) and OIT (Ontario Innovation Trust), to the Intelligent Manufacturing Systems (IMS) Centre. Dr. Hoda ElMaraghy was named to this Chair starting in late 2002 for 7 years (renewable). These developments added strength, created critical mass, and enhanced the scope to the existing research thrusts in Manufacturing Systems and capacity to support graduate researchers.
- The proposed program replaces the now discontinued Ph.D. in Manufacturing Systems and offers an opportunity for several active researchers to access graduate education and supervision at the Ph.D. level that is not available in their home units. It also provides unique synergetic collaboration amongst the participating faculty and Departments.
- The proposed Ph.D. program in Industrial and Manufacturing Systems Engineering would be unique in Ontario and Canada particularly given its multi-disciplinary nature. Our graduate programs attract more than 500 enquiries and applications every year from all over the world. Approximately 13 admissions are offered annually, and our attrition rate is about 10% of the intake as shown in Tables 5.1.1.1 and 5.1.2.1.
- The core faculty of 14 members include both senior accomplished researchers and promising and capable younger professors. This combination provides an excellent opportunity for faculty with different research strengths to interact and excel. Senior professors will provide their established research strength and leadership and join the younger faculty in addressing new research endeavours and challenging advances.
- Members of the applicants group have been actively involved in research collaboration with industry in areas related to Industrial and Manufacturing Systems Engineering. A number of industry-sponsored projects are underway; these provide funding to support a few more graduate students and postdoctoral fellows. Such linkages attract a significant number of graduate students from industry, most of whom

work on industrial projects for their theses and dissertations.

- Several faculty members are engaged in multi-disciplinary research projects related to the Canadian Network of Centers of Excellence in "the Automobile of the 21st Century" which is housed and managed by and at the University of Windsor (e.g. Dr. J. Potvin, Dr. H. ElMaraghy, and Dr. W. ElMaraghy).
- The IMSE Department and the Faculty of Engineering have an established Co-Operative Undergraduate Education scheme. This provides the opportunity for faculty members to interact and establish contacts with industry that in turn enriches their graduate teaching and attracts more funds for supporting graduate students. Furthermore, students who enroll in our graduate programs, after completing their co-op education in Engineering, have substantial industrial skills, and do bring a more mature approach to their applied research and graduate work.

1.8 Review of Previous Concerns and Action Taken

The concerns expressed about the earlier Ph.D. program by the OCGS Appraisal Committee have been addressed as follows:

a. Lack of sufficient Intellectual Focus

The research focus in industrial and manufacturing systems is clearly summarized in the executive summary and detailed under program objectives. The proposed Ph.D. program is focused on manufacturing systems and their design, operation, control, logistical and people issues.

b. Environment in the Program

Fifty percent of the faculty in IMSE are changed. One of the previous members passed away, another departed to industry and a third moved back to Manitoba. Three new faculty members have been hired including a new Head. An additional position is currently being filled. A collegial and collaborative relationship exists among faculty. They collaborated effectively on developing this proposal and renewing and restructuring the undergraduate program into 3 new attractive options.

The core faculty participating in this proposal extends beyond IMSE. They feel very positively about it and contributed actively to its development. There are new synergies and linkages developing.

The requirements and procedures for the comprehensive examination in the proposed program are clearly outlined and uniformly applied.

We feel confident that there is a healthy dynamic and interaction among the participants group and believe that this multidisciplinary Ph.D. program will attract even more faculty in the future as well as qualified students.

2.0 THE FACULTY

2.1 Core faculty

This program is multi-disciplinary by design to meet the challenges of modern Industrial and Manufacturing Systems**.** There are a total of 14 core faculty members from 3 Engineering Departments and 4 Faculties/Schools. ***This represents an increase of 7 faculty members (i.e. 100% increase) since the last appraisal.*** This adds much strength and scope to the research program and enhanced ability to supervise Ph.D. students.

The 14 core faculty can supervise or co-supervise Ph.D. students in the new program. They include both senior accomplished researchers and promising and capable new professors. New appointments were made recently including Drs. W. Abdul-Kader, G. Zhang and L. Oriet (IMSE Head) who has extensive industrial experience in Automotive assembly and manufacturing. There is a vacant position in IMSE to be filled shortly, in Manufacturing Systems. All participating faculty members work on various aspects of Industrial and Manufacturing Systems and related areas, and supervise graduate students. The following is a brief summary of their profiles and expertise listed by category in alphabetical order.

Table 2.1 Core faculty Members

Core faculty Members And Their Areas Of Specialization					
Faculty Name	**M / F**	**Retirement Date**	**Home Unit**	**Grad. Faculty**	**Areas of Specialization**
Category 1					
Dr. W. Abdul-Kader, Ph.D., Associate Professor	M	2018	IMSE	Yes	Virtual Factory Design, Simulation Performance Optimization Manufacturing Systems Modelling Of Manufacturing Systems Statistical Quality Control
Dr. H. ElMaraghy, Ph.D., P.Eng., FSME, FCSME, Professor & Canada Research Chair (CRC), Manufacturing Systems Engineering	F	2011	IMSE	Yes	Manufacturing Systems Products Design For Manufacture Process Planning & Scheduling Flexible Automation & Robotics Assembly, Tolerancing Reverse Engineering Rapid Product Manufacture Inspection & Quality
Dr. W. ElMaraghy, Ph.D., P.Eng., FASME, FCSME Professor	M	2010	IMSE	Yes	Design Theory & Methodology Product Development Rapid Manufacturing Complexity Modelling Robotics & Intelligent Systems Assembly Tolerancing & Inspection Cognitive Ergonomics

Core faculty Members And Their Areas Of Specialization					
Faculty Name	**M / F**	**Retirement Date**	**Home Unit**	**Grad. Faculty**	**Areas of Specialization**
Dr. R. Lashkari, Ph.D., P.Eng. Professor	M	2007	IMSE	Yes	Supply Chain Management Modelling Of Mfg. Systems Flexible Manufacturing Flexible Assembly Systems
Dr. L. Oriet, Ph.D., P.Eng., CCPE Associate Professor and Department Head	M	2028	IMSE	Yes	Manufacturing Engineering Tool Engineering Ie & Facility Engineering Fastener Engineering Product Design Lean Manufacturing Ergonomics Engineering
Dr. M. Wang, Ph.D., P.Eng. Professor	M	2028	IMSE	Yes	Concurrent Engineering Sustainable Manufacturing Product Innovation
Dr. G. Zhang, Ph.D., Assistant Professor	M	2029	IMSE	Yes	Optimization Decision Support Systems Supply Chain Management Modelling Of Manufacturing Operational Research Operations Management
Dr. X (New Faculty position being advertised)			IMSE	Yes	Manufacturing Systems Robotics & Control Computer Aided Design Computer Aided Manufacturing Integrated Manufacturing

Core faculty Members And Their Areas Of Specialization					
Faculty Name	**M / F**	**Retirement Date**	**Home Unit**	**Grad. Faculty**	**Areas of Specialization**
Category 3					
Dr. D. Andrews, Ph.D. Associate Professor	M	2033	H.K.	Yes	Human Tissue Mechanics Ergonomics & Occupational Biomechanics
Dr. F. Baki, Ph.D., Assistant Professor	M	2030	Business & Cross Appt. IMSE	Yes	Operations Scheduling Production Lot Sizing Vehicle Scheduling Operations Management
Dr. R. Caron, Ph.D., Professor and Dean, Faculty of Science	M	2019	Math & Statistics Faculty of Science	Yes	Operational Research Probabilistic Analysis Mathematical & Non-Linear Programming
Dr. X. Chen, Ph.D., Associate Professor	M	2022	MAME & ECE (jointly)	Yes	Control Engineering Design Of Multi-Objective Control Sys. Network-Based Quality Control Sensor-Based Pattern Recognition Robust Control Design Smart Vision

Core faculty Members And Their Areas Of Specialization					
Faculty Name	**M / F**	**Retirement Date**	**Home Unit**	**Grad. Faculty**	**Areas of Specialization**
Dr. J. Potvin, Ph.D., Associate Professor	M	2028	H.K. Cross Appt. IMSE	Yes	Human Factors And Safety Human Simulation And Virtual Reality To Design Manufacturing Processes Ergonomics And Occupational Biomechanics
Dr. X. Yuan, Ph.D., P.Eng. Associate Professor	M	2028	CS	Yes	Assembly Planning Virtual Assembly Intelligent Systems Software Engineering Virtual Reality Applications In Manufacturing Intelligent Interface Technology

Commitment of faculty members from other graduate programs:

The commitment of the core faculty is substantive. The core faculty members would be able to co-supervise or supervise Ph.D. students in the proposed Ph.D. program. The commitment of faculty members is classified as follows:

A) Core faculty:

1. All nine IMSE Faculty, including Prof. Potvin and Prof. Baki who are cross appointed to IMSE.

2. Prof. Potvin (H.K.), and Prof. Baki also do not currently have a Ph.D. Program in their home Departments, although they have research funding, including NSERC Discovery and other research funding.

3. Professor R. Caron (Operational Research Group) is also committed to this Program since the Operational Research Group does not have a Ph.D. Program.

The number of Ph.D. students projected in Table 5.4, increases gradually to include an average of two (2) Ph.D. students for each of these faculty members in any given year. This is a conservative estimate that provides for adequate research assistance support for students.

4. Those who are participants in another Ph.D. program in their Departments: Prof. X. Yuan and Prof. X. Chen

The number of Ph.D. students projected in Table 5.4, includes one (1) Ph.D. student for each of these faculty members in any given year. Currently Prof. Chen supervises 3 Ph.D. students and Prof. Yuan is not currently supervising Ph.D. students.

B) Collaborating Non-Core faculty:

The nature of collaboration is explained in the write-up and is in the form of serving on supervisory and examination committees, offering a course and collaborating in joint research. It is expected that in due time, some of the Collaborating faculty will become core faculty, particularly those that do not have a Ph.D. Program in their units.

2.2 Collaborating Non-Core Faculty

There are a total of 7 collaborating non-core faculty members from the Department of Mechanical and Material and Automotive Engineering, the School of Computer Sciences and the Odette School of Business. The collaborating Faculty include senior as well as promising and capable new professors in complementary areas of research interest and specialization.

Collaborating faculty participate in the graduate program, through the offering of graduate course, and participation in joint research and membership in supervisory and examination committees.

Table 2.2 Collaborating Non-Core Faculty Members

Collaborating Non-Core Faculty Members And Their Areas Of Specialization				
Faculty Name	**M / F**	**Home Unit**	**Graduate Faculty**	**Areas of Specialization**
Category 6				
Dr. A. Y. Alfakih Assistant Professor	M	Math & Statistics	Yes	Mathematical Programming Combinatorial optimization Semidefinite programming Linear Programming
Dr. R. Bowers, Ph.D., Assistant Professor	M	MAME	Yes	Materials and Manufacturing Resistance Spot Welding Microstrucural Evolution Welding Design Heat Treatment
Dr. R. Gaspar, Ph.D., P.Eng. Associate Professor and Department Head	M	MAME	Yes	Dynamics & Vibrations Solid Mechanics Sound Measurements Design for Acoustics Design for Manufacturing
Dr. M. Hlynka, Ph.D., Associate Professor	M	Math & Statistics	Yes	Probability & Statistics Multivariate Statistics Queueing Theory Stochastic Models
Dr. F. B. P. Moro, Ph.D., Dr.Eng. Assistant Professor	M	Business	Yes	Industrial Engineering/Human Factors Macroergonomics Workplace Ergonomics Occupational Safety Statistics and Research Methods

Collaborating Non-Core Faculty Members And Their Areas Of Specialization				
Faculty Name	**M / F**	**Home Unit**	**Graduate Faculty**	**Areas of Specialization**
Dr. A. Tawfik, Ph.D., Associate Professor	M	CS	Yes	Temporal Reasoning Knowledge Representation and Reasoning Multi-Agent Systems Artificial Intelligence Model-based Diagnosis
Dr. N. Zamani, Ph.D., P.Eng. Professor	M	MAME	Yes	Finite Element Analysis Computer Aided Engineering Applications In Engineering Design
New Faculty (to be hired)		H.K.		Ergonomics

2.3 Collaborations and Interactions

2.3.1 Examples of Core Faculty Interactions

Collaborations among members of the group already exist and are expected to increase. Examples include:

- Dr. Caron has co-supervised a doctoral student in IMSE and has served on numerous MSc.and PhD committees in the Department. Dr. Caron has also co-taught (with Dr. Lashkari (ISME), Dr. Gencay (Economics) and Dr. Ahmadi (Electrical Engineering)) an interdisciplinary IMSE graduate course in optimization in 2000.
- Dr. R. Lashkari has been collaborating with Dr. R. Caron & Dr. M. Hlynka for several years within the OR group.
- Drs. F. Baki and G. Zhang are active members of the Ph.D. supervisory committee of Mr. R. Majety, supervised by Dr. H. ElMaraghy, on Supply Chain Management.
- Dr. F. Baki has taught courses in IMSE and participated in several graduate supervisory and examination committees as well.
- Dr. J. Potvin has taught courses in IMSE and participated in joint research and graduate supervision. There is great potential for collaboration between Dr. Potvin and Dr. Leo Oriet and others in the area of ergonomics, occupational biomechanics and autoworkers safety in the workplace.
- Dr. Potvin collaborated with the late Dr. Dutta to host the "Brouha Ergonomics Conference" in September 1999.
- Dr. X. Yuan participated in graduate supervisory committees of students supervised by Dr. Waguih ElMaraghy. His areas of research in assembly planning, virtual assembly, intelligent systems, and virtual reality applications in manufacturing match the research interests in manufacturing systems of several applicants and provide excellent potential for future cooperation.

- Dr. X. Chen's interest in control engineering, design of multi-objective and robust control systems, on-line quality control, sensor-based pattern recognition and smart vision are an excellent fit with the reconfigurable control research activities in the IMS Centre.
- Dr. G. Zhang participated supervisory committee of a graduate student supervised by Dr. X. Chen.
- Dr. M. Wang, Dr. W. ElMaraghy and Dr. H. ElMaraghy serve on supervisory and examination committees of other core group members' students.
- Drs. H. ElMaraghy, W. Abdul-Kader and L. Oriet collaborate with the International Truck and Engine Corporation (ITEC) of Chatam / Wallaceburg, Ont. in manufacturing Systems design and modeling.

2.3.2 Participant's Collaboration Within the University

In addition to the collaboration among the core faculty in this application, networking and close interaction with other researchers exist within the University. Some examples of these collaborative activities include:

- Collaborative activities exist among the participants and colleagues in several departments at the University of Windsor. Joint supervision, participation in supervisory and examination committees and joint research publications are indicators of such efforts. Examples include: i) Mechanical, Automotive and Materials Engineering (Dr. R. Gaspar co-supervises 4 Ph.D. students in MAME with Drs. H. and W. ElMaraghy from IMSE and Dr. N. Zamani is a research collaborator and a member of several graduate supervisory committees and comprehensive examination committees), ii) School of Business (graduate supervisory committees memberships, Dr. F. Baki, Dr. F. Reiger), iii) Computer Science (Dr. R. Kent, Dr. X. Yuan and Dr. A. Tawfik members of graduate supervisory committees and comprehensive examination committees), and iv) Mathematics and Statistics Etc….
- Dr. J. Potvin collaborated with Dr. Bill Altenhof (Mechanical Engineering) on child safety and simulation during motor vehicle accidents (2 years) and Dr. Anne Snowdon (Nursing) on child safety and interventions to reduce MVA fatalities (4 years).
- Discussions with Dr. F. Moro regarding collaboration with Dr. L. Oriet and other applicants in the area of Human Factors, workplace ergonomics and occupational safety are ongoing.
- Dr. F. Moro taught courses in IMSE.
- Dr. X. Chen has been collaborating with Dr. H. Hu in Materials Engineering to conduct research on control and monitoring of die-casting processes
- Dr. M. F. Baki collaborates on the tool management problem: with Professor B. Chaouch and the grouping problem: with Professor Y.P. Aneja, both of the school of

Business at the University of Windsor.

- Dr. R. Lashkari has collaborated with Dr. M. Ahmadi, Electrical and Computer Engineering, for a number of years in the area of the applications of genetic algorithms and integer programming to the design of digital filters.

2.3.3 Networking And Research Collaborations

Some applicants have various types of collaborative activities with researchers from other institutions. The following are examples of such networking:

- Dr. Abdul-Kader has collaborated with Dr. Ali Gharbi, École de technologie supérieure de Montréal, on Capacity Estimation of a Multi-Product Unreliable Production Line.
- Dr. Caron has collaborated with colleagues in major academic institutions in the United Sates, Israel, The Netherlands, and across Canada. He has served as President of the Canadian Operational Research Society and is currently on the Board of Directors of the Canadian Mathematical Society.
- Drs. Hoda and Waguih ElMaraghy collaborated with Dr. Tarek Lahdhiri, Manager, Global Systems, General Motors, Michigan, Reconfigurable Control Process (NSERC Strategic Research) (2 years). Dr. Lahdhiri was also a Sessional and adjunct professor with IMSE.
- Drs. Hoda and Waguih ElMaraghy collaborated with Professor Luc Laperriere (UQTR) and Alain Desrochers (Laval U.), joint Auto-21 research projects in rapid product development (4 Years).
- Dr. Hoda ElMaraghy co-supervises a Ph.D. student at , Mr. A. Barari , at U. Western Ontario with Professor G. Knopf (2 years)
- Dr. Waguih ElMaraghy collaborates with Professor Alain Bernard, Ecole Central de Nantes, France, inspection and quality (1 Year). Dr. W. ElMaraghy will also be an external Ph.D. Examiner of Mr. S. Remy (A. Bernard's Student).
- Dr. Hoda ElMaraghy and Dr. Waguih ElMaraghy are elected Members of the prestigious the international academy of production engineering research (CIRP) based in Paris, France. They engage in major collaborative and international research initiatives that lead to important keynote papers or collaborative research. Visiting researchers and exchange graduate students from various countries are attracted to their manufacturing research program and spend time in the IMS Center (e.g. Mr. Rudolf Henning from Technical University of Munich, Germany in 2003 (process planning), Mr. Sebastien Denis from LURPA-ENS de Cachan, France, 2004 (inspection)).
- Dr. R. Lashkari was a Summer Intern Professor in the Advanced Manufacturing Engineering of Daimler Chrysler World Headquarters, Auburn Hills, Michigan, in Summer 1999, and Summer 2000, to study the paint warranty cost minimization and the paint operation capacity optimization.

- Dr. J. Potvin collaborated with Dr. Jack Callaghan (Waterloo): cumulative tissue loading in automotive manufacturing (3 years), Dr. Jan Polgar (Western): Child safety in MVAs (3 years), Dr. Jim Dickey (Guelph): Spine stability and loading (5 years) and Dr. Jaap van Dieen (Vrie Universitie, Amsterdam): Spine stability and loading (2 years).
- Dr. F. Baki will be a summer Professor intern from May to August, 2004 in the Advance Manufacturing Engineering in Daimler Chrysler World Headquarters in Auburn Hills, Michigan, USA, to study flexible resourcing and the integrated problem of scheduling, batching, tooling and grouping.
- Dr. F. Baki collaborates on the scheduling and batching problem: with Professor R.G. Vickson, University of Waterloo, Production lot sizing: with Professor P. Iyogun, Wilfrid Laurier University and vehicle scheduling: with Professor S.N. Kabadi, University of New Brunswick.
- Dr. D. Andrews has collaborated with Dr. Jack Callaghan (Waterloo): cumulative tissue loading in the automotive industry (3 years), Dr. Jim Dowling (McMaster): Non-rigid modeling of the lower extremity during impact (4 years), Dr. Jennifer Durkin (Waterloo): body segment parameter identification using DXA (2 years).
- Dr. Zhang has collaborated with Dr. Tamás Terlaky, McMaster University, on optimization algorithms and software since 2001.
- Dr. Hoda ElMaraghy chaired the organizing committee of the 53rd CIRP General Assembly and Conference held in Montreal in August 2003 (only the second time in Canada). International experts from academic and industry presented leading edge research in manufacturing systems. Some graduate students (Ph.D. and M.A.Sc.) from IMSE attended and benefited from this exposure.
- Dr. Waguih ElMaraghy is the Chair of the organizing committee for the 14th International CIRP Design Seminar on "Design in the Global Village", held in Cairo, Egypt in May 2004. Research in several manufacturing systems aspects highlighted in this proposal was presented and discussed by international experts. Some IMS researchers also presented papers in this conference.

2.4 Research Funding

The core faculty has been successful in attracting significant research funds. The agencies that have supported our research efforts include government agencies (NSERC, NCEs (e.g. Auto21), CFI, OIT, MMO, etc.), private industry, professional societies, and other sources. The total research funding in 1997-2004 exceeds $6.8 Million. This is an indicator of the quality of the research proposals, and the efforts of the faculty to strengthen and excel in research activities in Industrial and Manufacturing Systems. Dr. G. Zhang has been awarded a CFI new opportunities grant, entitled "LINUX PC cluster for computational studies and optimization of nano-mechanical and industrial systems," jointly with Dr. Vesselin Stoilov, MAME, in the amount of $64,323 and is included in Table 2.4.1. This award is eligible for

matching by OIT. New faculty hold start-up research grants from the University of Windsor to help them launch their research activities. Tables 2.4.1 & 2.4.2 show the research funds obtained from various agencies during the period 1997-2004. Details of the grants record for the core faculty members are included in their curricula vitae.

Table 2.4.1 Operating Research Funding from NSERC and Other Sources (1997-2004)

	Source of Funding [$]		
Year	**Granting Councils (NSERC)**	**Other Peer Adjudicated (NCE, CRC, CFI, MMO)**	**Contracts (Industrial)**
1997-98	284,315	348,667	120,000+ $25,000 USD
1998-99	161,095	440,591	30,000+ $35,000 USD
1999-00	203,574	926,609	23,500
2000-01	252,191	151,808	162,000
2001-02	224,722	130,889	52,500
2002-03	324,562	490,890	0
2003-04	347,562	382,259	111,405
2004-05	374,590	367,529	53,000
Total	$2,172,611	$3,239,242	$552,405 + $60,000 USD

Table 2.4.2 Other Research and Equipment Funding by Year (1997-2004)

Year	**Other (UoW Start-up and Equipment)**
1997-98	-
1998-99	-
1999-00	345,018
2000-01	38,269
2001-02	128,617
2002-03	320,640
2003-04	85,000
2004-05	25,000
Total	$942,544

2.5 Graduate Supervision

Career Number and Current Supervision of Master's and Doctoral students for the core faculty are summarized in Table 2.5.

Table 2.5 Graduate Research Supervision

Career and Current Numbers of Theses Supervised by Core Faculty Members								
	Career			**Current**				
Member	**Master's**	**Ph.D.**	**PDF**	**Master's**		**Ph.D.**		**PDF**
				IMSE	Other	IMSE	Other	
Category 1								
W. Abdul-Kader	2	0	0	3	0	0	0	0
H.A. ElMaraghy	26	14	15	0	0	4	3	4
W.H. ElMaraghy	19	5 + 1	6	8	0	0	3 + 1	1
R.S. Lashkari	22	4	0	2	0	1	0	0
L. Oriet	0	0	0	7	0	1	0	0
M. Wang	13	3	1	6	0	1	0	1
G. Zhang	0 + 2	0	0	1	0	0	0	0
X (New Faculty)	0	0	0	0	0	0	0	0
Category 3								
D. Andrews	5	0	0	4	0	0	0	0
F. Baki	0	0	0	0	0	0	0	0
R. Caron	6 + 6	1 + 1	0	0	1 + 4	0	0 + 1	0
X. Chen	4 + 2	0	0	0	4 + 1	0	3	0
J. Potvin	14	0	0	4	0	0	0	0
X. Yuan	4	0	1	5	0	0	0	0
TOTALS	**115 + 10**	**27 + 2**	**23**	**45 + 5**		**16 + 2**		**6**

The second (+) Number is the number of co-supervised students.

2.6 Graduate Courses And Teaching Assignments (2003-2004)

Available Graduate Courses

The graduate courses offered in the Department of Industrial and Manufacturing Systems Engineering and other selected related courses, some of which are offered by core faculty, complement the research focus of the core faculty in the area of *Industrial and Manufacturing Systems.* The minimum course requirement for the proposed multi-disciplinary Ph.D. Program is 4 courses. More may be required based on the students' research needs and background. In addition to the Seminar 91-595, at least 2 courses from Category A in Table 2.6.1.; and a minimum of one course from Category B in Table 2.6.2 must be completed. A selected number of these courses will normally be available each year, and the current list will be made available to the students.

Some courses in Category A are offered annually, others every couple of years. The 18 Category A courses listed in Table 2.6.1 have been offered at least once in the past three years. The list of courses in Category A is reflective of the multi-disciplinary nature of the proposed program. Category B graduate courses include those offered in other departments and faculties (some by participating faculty), that our graduate students have taken and found to be useful for enhancing their background and providing useful research tools.

Table 2.6.1 Category A Graduate Courses

91-500	Optimization
91-502	Manufacturing Systems Simulation
91-503	Production And Inventory Control Systems
91-504	Advanced Operations Research I
91-505	Advanced Operations Research II
91-507	Advances In Industrial Ergonomics
91-508	Reliability Engineering
91-510	Advanced Engineering Economy
91-512	Flexible Manufacturing Systems
91-514	Engineering Design, Methodology & Applications
91-515	Artificial Intelligence Applications In Manufacturing
91-590	Special Topics Current Topics Include: 1. Sustainable Manufacturing 2. Management Of Technology 3. Product Innovation & Design Management 4. Lean Manufacturing & Supply Chain Management 5. Advanced Algorithms/Numerical Methods 6. Product Design / Work Measurement 7. Manufacturing Systems: Modelling, Analysis And Performance Measures
91-595	Graduate Seminar [New]

Table 2.6.2 Category B Graduate Courses

Computer Science	60-541	Stochastic Processes
	60-540	Virtual Reality
	60-554	Advanced Algorithms
	60-561	Artificial Neural Networks
	60-570	Introduction To Artificial Intelligence
	60-576	Advanced Search Methods
Mathematics	62-568	Numerical Analysis I
	62-595	Mathematical Programming
	62-598	Integer Programming & Combinatorial Optimization
Statistics	65-546	Statistical Data Analysis
	65-552	Experimental Design
	65-556	Decision Theory
Management Science	73-602	Topics In Management Science
	73-603	Management Science Models
	73-604	Operations Management
Business Strategy	75-682	Manufacturing Strategy
Marketing	76-504	Quantitative Techniques In Management
	76-514	Management Information Systems
Electrical Engineering	88-524	Stochastic Processes
	88-533	Computational Intelligence
	88-536	Automotive Control Systems
Mechanical Engineering	92-540	Applied Finite Element Analysis
	92-542	Advanced Topics In Mechanical Design
	92-543	Product Design And Development
Environmental Engineering	93-532	Engineering And Environment
Kinesiology	95-522	Instrumentation and Modelling in Kinesiology
	95-524	Biomechanics In The Work Place

The above graduate courses are normally offered every 24 months.

Teaching Assignments (2003-2004):

Typical yearly teaching loads during the past three years for each core faculty member are summarized in Table 2.6.3. Adjustments made for sabbatical leaves are not shown. In addition, IMSE faculty members share the load of 91-400 (undergraduate project and seminar).

Table 2.6.3 Typical Core Faculty Teaching Load Per Year (Summer 2003 - Winter 2004)

Teaching Assignments for the Year Immediately Preceding the Appraisal				
Faculty Member	Rank	Undergraduate	Graduate	Comments
Category 1				
Dr. W. Abdul-Kader*	Associate Professor	85-313-01- 4cr 85-313-02- 4cr	91-502- 3cr	
Dr. H. ElMaraghy	Professor	91-431- 4cr	91-512- 3cr	Canada Research Chair
Dr. W. ElMaraghy	Professor	91-411- 4cr	91-514- 3cr 91-516- 3cr	Acting Head Nov 02 to July 03
Dr. R. Lashkari	Professor	91-312- 4cr 91-412- 4cr	91-504- 3cr 91-508- 3cr	
Dr. L. Oriet*	Associate Professor	91-315- 2.5cr 91-400- 3cr	91-590- 3cr	Department Head
Dr. M. Wang	Professor	91-327- 4cr 91-317- 4cr 91-430- 3cr	91-515- 3cr 91-590- 3cr	
Dr. G. Zhang*	Assistant Professor	91-413- 4cr 91-429- 4cr	91-500- 3cr 91-590-08- 3cr	
Category 3				
Dr. D. Andrews	Professor	95-265- 3.5cr 95-362- 3cr	95-524- 3cr	Human Kinetics
Dr. F. Baki	Assistant Professor	73-331-01- 3cr 73-331-02- 3cr 73-431- 0cr 73-305- 3cr 73-431- 3cr		Business
Dr. R. Caron	Professor	62-374- 3cr	62-598-15- 3cr	Dean Faculty of Science
Dr. X. Chen	Associate Professor	88-324- 3.5cr 92-321- 3.5cr 88-412- 3.5cr	88-535- 3cr	Electrical Eng.
Dr. J. Potvin	Associate Professor	95-522- 3cr 95-465- 3cr 95-280- 3cr		Human Kinetics
Dr. X. Yuan	Associate Professor	60-311- 3cr 60-411- 3cr	60-511- 3cr	Computer Science

* New Faculty (recent appointments)

The above table is representative of the teaching load of core faculty. New appointees

have introduced new courses (e.g. 91-500 Optimization, 91-590-09 Product Design/Work Measurement and 91-590-10 Manufacturing Systems: Modeling Analysis and Performance Measures.

Enrolment in Category A graduate courses offered in the past 3 years (2000-04) is shown in Table 4.4.

2.7 Commitments of Faculty from Other Graduate Programs and/or Other Institutions

Both Dr. F. Baki and Dr. J. Potvin are cross-appointed to IMSE. The contributions and collaboration of other core and non-core faculty is explained in section 2.1.

3.0 PHYSICAL & FINANCIAL RESOURCES

3.1 Library Resources

3.1.1 Introduction

The Leddy Library is the main library for the University of Windsor serving as the primary library for all disciplines except law. The Leddy Library has a collection of 1,492,982 print volumes; 20,920 electronic monographs; 1,506,453 microforms (microfilm and microfiche); 97,624 government documents (the Library is a full-depository for the Canadian government); 1,067 linear feet of manuscripts and archives, as well as 1,401 audio and 3,098 film and video holdings. A librarian member of the Leddy Library is assigned to work with the faculty and students in the Engineering programs in a liaison and collection management capacity.

Table 3.1.1 Library Funding – Engineering/Industrial and Manufacturing Systems Engineering1997/1998 to 2003/2004

Year	Print Serials[1]	Monographs[1]	Electronic Resources[2]	Electronic Resources Notes (selected examples)
1997/ 1998	$162,183 ($24,266 trans. to elect. res. & $7,000 added to base)	$6,120 $2,000 added to base this year + $3,500 one time funds	$60,000	• EI Village in lieu of Compendex on CDROM • Current Contents • Applied Science & Tech Index
1998/ 1999	$162,183	$6,120 + $3,000 one time funds	70,000	• EI Village • Academic Press IDEAL full text suite • MathsciNet • Math Reviews
1999/ 2000	$162,183	$6,120	$175,000	• EI Village • Inspec online • Metadex online • Pollution Abstracts online • Elsevier, full-text
2000/ 2001	$99,968 ($62,215 trans. to elect. resources)	$6,120	$200,000	• Web of Science • EI Village • Chemical Abstracts via SciFinder Scholar • Inst. Physics full text

2001/ 2002	$96,571 ($3,397 trans. to elect. resources)	$6,120	$350,000	• IEEE XPlore • Springer full text • Amer. Phys. Soc. full text • Assoc. Comp. Mach. full text • Amer. Chem. Soc. full text
2002/ 2003	$33,049 ($63,552 trans. to elect. resources)	$6,120 + $4, 400 one time funds	$370,000	• ASTM Standards • Digital Dissertations full-text • Nature & Science full-text • Lecture Notes in Comp. Sci full-text
2003/ 2004	$25,205 ($7,844 trans. to elect. resources)	$6,120	$400,000	• Cambridge, Oxford & Blackwell publishers full-text journal suites • Engineering Index backfile online (1884 – 1969) • Nature Academic journals, full-text

1. Serials funds from the 3 Engineering departments were merged to one serials fund for the entire faculty in 97/98. Figures reported in column 2 are for the entire Engineering faculty. Monograph funds for individual Eng. Dept. were maintained so the figures in Column 3 are for Industrial and Manufacturing Systems only.
2. Electronic Resources amounts are based on actual costs of Earth Science specific titles and estimates of percentages of other multi-disciplinary full-text electronic resources that target Earth Sciences subject areas.

Through its own initiatives as well as through consortia arrangements with its co-members of the Ontario Council of University Libraries (OCUL) and the Canadian National Site-Licensing Project (CNSLP) major objectives of the Leddy Library have been and continue to be the expansion of its electronic offerings. Resources that are now available to all users through the library system include the following:

- Engineering Information Village which includes COMPENDEX from 1970 to the present, access to standards, reports, employment opportunities and specialized Internet links (just signed the license to extend our Compendex online holdings back to 1884);
- IEL (IEEE/IEE Engineering Library) providing full-text online access to journals, proceedings and reports;
- Lecture Notes in Computer Science full-text online (over 200 volumes per year);
- Proquest Digital Dissertations full-text online (supplies the full-text of dissertations in all subject areas from 1997 onwards;
- Wilsonweb Omnifile (which includes General Science Index and part of Applied Science & Technology Index);

- Web of Science (Science Citation Index);
- Several hundred relevant full-text electronic journal titles from major science and engineering publishers including Elsevier, the Institute of Physics & American Physical Society, IDEAL (Academic Press journals), Kluwer, Wiley, Springer-Verlag, Blackwell, Oxford and Cambridge;
- Every JSTOR Collection (provides journals backfiles of over 200 scholarly journals);
- ABI/Inform - Business Periodicals Full Text;
- CISTI Source (document delivery services);
- Computer and Information Systems Abstracts, Computer Abstracts International Database, and Chemical Abstracts (through SciFinder Scholar).

Faculty and the liaison librarian work together closely to ensure that the funds provided are used to acquire the most relevant materials to support the curriculum and research needs of the Engineering program. *The Library, for example, subscribes to 85% of the top 20 journals in Industrial and Manufacturing Systems, 75% of the top 20 journals in robotics and automatic control, and 60% of the top 20 journals in manufacturing engineering as ranked by the Institute for Scientific Information's Journal Citation Reports*. As well the Library continues its efforts within the OCUL consortium, as well as with the Canada Foundation for Innovation/Canadian National Site Licensing Project to provide access to the greatest depth of scholarly publishing possible.

3.1.2 Access To Resources Held Locally

The Leddy Library uses a client server based system called Voyager. This system provides access not just to the Library's own online catalogue of records of locally held resources but also to a variety of connection options including online journal indexes and abstracts, full-text of journals in electronic format and access to the World Wide Web. Voyager is available at over 250 workstations located throughout the Library, as well as from home, office and laboratory. The Library is open 111 hours per week during term. The loan period for library books for graduate students is one month with up to 25 books available for semester loans. Journals do not normally circulate out of the library.

3.1.3 Access To Resources Not Held Locally

Graduate students in engineering have access to materials not located in the Leddy Library through our interlibrary loan services. Interlibrary Loan Unit has access to the two major Canadian union catalogues as well as to the preeminent North American union database, OCLC. Use of electronic messaging between these services (via the Internet or telecommunications lines) allows access to, and borrowing from, library holdings across North America and abroad. Document delivery is available to all graduate students in Industrial and Manufacturing Systems through CISTI source for all articles not held at Leddy Library but available at CISTI.

1. Interlibrary loan and document delivery service that assists users in locating and

borrowing/purchasing materials from other libraries. Interlibrary Loan Unit has access to the two major Canadian union catalogues as well as to the preeminent North American union database, OCLC. Use of electronic messaging between these services (via the Internet or telecommunications lines) allows access to, and borrowing from, library holdings across North America and abroad. Document delivery software and equipment in the Leddy Library is currently being upgraded to allow more rapid and efficient transmission of scanned material. The major sources for engineering materials through interlibrary loan service are CISTI Source (with an average turn-around time of 23 hours for articles), other major academic libraries, EI COMPENDEX, OCLC Genuine Article and Dialogue;

2. Faculty and graduate students have on-site borrowing privileges at Canadian university libraries and faculty have borrowing privileges at well over 100 major U.S. libraries through the Leddy Library's participation in a reciprocal program sponsored by the academic research libraries in OCLC;

3. Through the library's system, Voyager and on the campus network Internet access is available to library catalogues and a worldwide variety of other information sources.

3.1.4 User Assistance

The library provides reference service to the University of Windsor community at peak time during term for 68 hours per week. This service is an immediate one-to-one service at the Reference Help Centre staffed by librarians and library assistants. The librarian subject specialists offer in-depth research assistance is provided by. It includes mediation of online searches and in-depth training in the identification and use of relevant research resources. Librarians are available to provide bibliographic instruction either in the library or in class. There are, as well, general library orientation sessions which introduce the library building and services to those new to the University.

3.1.5 Conclusion

All available information concerning library resources and services for a Ph.D. program for Industrial and Manufacturing Systems Engineering has been examined. The rising costs of serials caused by inflation and currency exchange rates have placed the acquisition of current serials under great pressure.

The University is committed to considering the library acquisitions budget as a primary call on the academic university funds and has increased the support to library acquisitions in each of the past three years.

The Leddy Library is examining several means by which it can enhance its services to faculty and students. These means include both enhanced local access and expanded cooperative arrangements and resource sharing.

With the above noted commitment to library acquisitions and both present and planned services, Gwendolyn Ebbet, the University Librarian, believes [Appendix 6] that the Leddy Library can support a Ph.D. program in Industrial and Manufacturing Systems Engineering.

3.2 Laboratory Facilities

Major and auxiliary equipment, available to Ph.D. students in Industrial & Manufacturing Systems Engineering, according to their area of research, are found in several major laboratories such as: Computer Integrated Manufacturing and Concurrent Engineering; Computer Simulation and Data Processing; Industrial Ergonomics and Work Systems Design, Mechatronics and the Engineering Design Studio. An updated list of equipment and software currently available in each of these IMSE department laboratories is given in Tables 3.2.1 and 3.2.2. The facilities available in the three laboratories of the Intelligent Manufacturing Systems (IMS) Center for: 1) Flexible Automation & Robotics (FAR), Integrated Design & Manufacturing (IDM), and Advanced Manufacturing Research (AMR) are summarized in Appendix 1. The IMS research activities are well funded by NSERC, provincial and federal centers of excellence, Ontario and Federal Government as well as industry. Professor Hoda ElMaraghy, Director of the IMS Center, was awarded a Tier I Canada Research Chair (CRC) in Manufacturing Systems Engineering for seven years (renewable) starting October 2002. The Centre facilities have been enhanced by recent OIT & CFI grants.

This is in addition to other Laboratory facilities and equipment available to this Program through the participating faculties.

3.2.1 Equipment and Software

Table 3.2.1 Laboratories Equipment And Software

Industrial Ergonomics & Work Systems Design Lab [109-EH]
Height / width measurement devices (2) Healthometer weigh scales Meylon handheld tachometer

Microscope Bruel & Kjaer sound level meters (2), transducer and amplifier Biolink transmitters and receivers (2 EMG, 3 other) Personal computers Grass polygraph Oxylog II Quinton treadmill Arlink work tables Monark stationary bicycles Lafayette strength meter Ogikenb digital flicker tester Tektronix digital photometer Force sensor and signal conditioner Video cameras (2), 28" television, VCRs (2)
Data Processing Lab [115-EH]
Network PCs (24) Workstation Windows 2000 Windows 2000 Server Sun Blade Microsystems 2 Blade 1000 and 4 Blade 100 Printers (1) HP Scanner
Engineering Design Studio [B74-EH]
Sets of Bench Top Experimental Apparatus (4) PCs (Pentium Multimedia) (2) Collection of Industrial Catalogues Collection of Industrial Samples Color Printer
Mechatronics Lab [B72-EH]
OPIE Mobile Robots (6) 880-RA2 Pegasus II Robotic System with controller and teach pendant Scorbot ER V & ER VII robots with controllers and teach pendants Rhino robot with controller D&M CNC lathe and D&M 3-axis mill PC compatibles (2 with D&M controller interfaces) (4) Jet CNC Mill Fisher technik mechanical modeling kit Automat mechanical modeling kit Spiro meter Granite surface plate with support Force sensor and signal conditioner Mitutoyo dial indicator with stand
CIM and Concurrent Engineering Lab [119-EH]

SGI Workstations (2) Analogue to digital converter Sun Workstations (6) PCs (Pentium) (6) Macintosh PC CD ROM external drive HP postscript laser printer Tape backup drive
Machine Monitoring Lab [B22-EH]
3 axis Cincinnati Milacron CNC vertical mill Arrow 500
Biomechanical & Ergonomic Lab [HK-207]
Data Collection Pentium 2 PC's (9) Dell Laptop Computers (4) Macintosh Computer (1) HP LaserJet Printer (1) Digital Scanners (2) IBM Wireless Local Area Network Router (1) HP External DVD R&RW Writer (1) Backpack External CD R&RW Writer (1) National Instrument 12 bit Analog to Digital Conversion Cards (5) National Instrument 12 bit PCI Analog to Digital Conversion Card (1) National Instrument 16 bit PCI Analog to Digital Conversion Card (1) AMTI Computerized Biomechanical Platform System: Force Plate and Amplifier (1) Sensor Development Linear Load Cell 43.4 kg (100 lbs) with amplifiers (3) Transducer Techniques Linear Load Cell 226.8 kg (500 lbs) (2) Entran Linear Load Cell 9.1 kg (20 lbs) (1) Chattillon Portable Linear Load Cell 43.4 kg (100 lbs) (1) Linear Displacement & Velocity Transducer (1) Crossbow Triaxial Accelerometers (2) Entran Accelerometers (2) Angular Potentiometers (2) Channel Biometrics Goniometer Recording System (4) 20 MHz Instek Oscilloscope (1) VK Precision Triple Output DC Power Supply 24V max (1) MEGA Portable 4 Channel EMG System (1) Eight Channel Octopus EMG Cable Telemetry Systems (2) Sony Digital Video Cameral (1) Panasonic VHS Video Cameras (2) Zenith 19" Television/VCR Combination Set (1) Panasonic High Fidelity VCR (1) Matrox Super Video High Fidelity VCR & PCI Video Card Digital Capturing System (1)

Operational Research Lab [LAM 9112]
4 PC (DELL Workstations) Optimization Software: - CPLEX, MPL, MAPLE, and ESRI.

Table 3.2.2 Available Departmental Software Programs

Software Type/ Application	Name	Further Description
CAD/CAM Computer Aided Design/ Computer Assisted Manufacturing	AutoCad	Design / Drafting
	Autosolid	Solid Modelling
	IRDC- I-DEAS	Computer Aided Engineering
	D & M Mill	Milling Operation Software
	ALGOR	Finite Element Analysis
	Solid works 2001	CAD
	Cadkey 97	CADD (Design/Drafting)
	LS-DYNA	Finite Elements Analysis
	Flow	CFD Applicatiosn
	Masonry design software 2.0	Structural Analysis/Design
	Engineering Selector	Materials Selection
Simulation Software	ARENA	Simulation Software
	GPSS	Interactive Simulation
	MODSIM	Modeling & Simulation
	Slam II	Simulation Software
	Siman IV	Simulation Software
	Cinema IV	FMS Simulation / Animation
	MOST	Manufacturing Simulation
	Factory CAD	Factory Modeling
	Simfactory	Simulation Software
	Witness 2000	Simulation Software
	AutoMOD	Simulation Software
Ergonomics/ Work Modelling	Bodyworks	3D Human Anatomy software
	People Size	Visual Anthropometry software
	Mannequin	Ergonomic / Design
	Humancad	Ergonomics Simulation
Statistical Analysis	MINTAB	Statistical Software
	Statgraphics Plus	Integrated Statistical Package
Optimization	LINDO/LINGO 6	Linear And Integer Programming
	CPLEX	Solves large-scale linear programs

	Caneos	On-Line Optimization
	MatLab	Numerical Computations
	XPRESS-MP	Optimization Software
Enterprise Resource Planning	SAP	LS-DYNA
Materials Requirements Planning	MRP - DSS	Material Requirements Planning
Facilities Planning	Plant Layout	Layout Planning
	Manuplan	Manufacturing Systems Planning And Design
Mathematics/ Knowledge-Based	Maple 6	Symbolic Mathematics
	Vp expert	Knowledge-based (KB) system design
	Expert Choices Student ED	"
Miscellaneous Computer Applications	JAVA 3-D	Virtual Reality
	Vp expert	Knowledge-based (KB) system design
	Qaplus Control Panel	File Converter
	Access 2000	DataBase
	MS Word 2000	Word Processor
	WordPerfect 8	Word Processor
	Better Basic	Computer Language
	Borland C + +	Computer Language
	Microsoft Basic	Computer Language
	Excel 2000	Spreadsheet
	MS Office 2000	Professional
	Netscape	Internet Browser
	Explorer	Internet Browser
	Microsoft visual studio 6	Applications for MS Windows
	Microsoft Project 2000	Project planning software
	System Architect	Systems Analysis & Design
	x-win32	Terminal software
	MS Visio professional 2002	Computer Graphics
	ESRI	Graphical Information Systems
	Project 2000	Project Planning & Control
	LabView	Data Acquisition and Processing
Operating Systems	UNIX	Operating System
	MS-DOS 6.0	Operating System
	MS Windows2000	Professional & NT
	Windows 95 /98	Operating System

Linux Operating System

3.2.2 Technical Assistance And Shop Facilities

Two full-time technicians support the IMSE program. One has a background in electronics and instrumentation, and the second holds a B. Sc. in Mechanical Engineering from the University of Windsor, with a background in computers as well as manufacturing technology. They are responsible for the operation and maintenance of all computers, instrumentation and other equipment in the undergraduate and research laboratories in the IMSE Department. They also provide help to students regarding their senior year projects. In addition, the University of Windsor Technical Support Center provides additional technical help for the design and construction of specialized equipment when the need arises.

3.3 Computing Facilities

3.3.1 IMSE Computing Resources

Students in the Industrial & Manufacturing Systems Engineering program have access to a departmental data processing laboratory as well as the Faculty of Engineering CAD/CAM Center and the SGI CAD laboratory for design oriented courses. The Simulation and Data Processing lab contains 20 computers connected to a departmental file server under Windows 2000. All students in Industrial and Manufacturing Systems Engineering have access to this network, with its large hard disk and laser printer output. The department has several software packages that are available for use. The Department also has a 6 Sun Blade Unix environment that is equipped with disk resources and is networked to the campus mainframe facilities, which in turn, are connected to the Internet. With this arrangement, which is specifically devoted to research, graduate courses and capstone design projects the department can support graduate and professional research as well as important industry-university collaboration.

3.3.2 Faculty Of Engineering CAD/CAM Center And Current Plans

In addition to these laboratories, the Faculty of Engineering has extensive computing facilities for access by all Engineering faculty and students. It has a CAD/CAM facility, which is dedicated to undergraduate and graduate students. The CAD/CAM Center is a multi-vendor environment, spanning different architectures and operating systems. A new cluster of SGI UNIX workstations was added to the CAD/CAM Center in 1999 – but it will be dedicated to graduate use and all undergraduate SGI access is ending in 2004.

The CAD/CAM Center was restructured and refurbished in 2001-03 with the installation of new computers using the newest operating systems, hardware and software. The complement of computer hardware includes a recently added SUN Enterprise 450 server that currently

provides both UNIX and Windows NT services. There are, in addition to this collection, 90 Pentium II class PC Windows NT workstations, a virtual process or Windows NT server, Indys, 2 SUN Sparc 2s, a high capacity HP5 network laser printer, and a colour HP5 scanner.

The server hosts a wide variety of engineering and office tools: office tools such as StarOffice and the Microsoft Office suite: programming tools such as Matlab, Maple, and Microsoft compilers; design tools such as I-DEAS and CadKey; analysis tools such as Ansys, Algor, Hyper Mesh, and StaadPro; GIS tools such as ESRI's Arc Info suite; web services such as Lotus Notes Domino server.

In addition to meeting the University's teaching and research needs the CAD/CAM Centre acts as a vehicle for increased University-Industry interaction and cooperation. Senior undergraduate engineering students and graduate students have been involved with CAD/CAM projects developed jointly with industry. These cooperative projects with industry not only meet many smaller firms' immediate needs, but also act as a long-term mechanism for continuing technology transfer.

3.3.3 University Computing Facilities

The University of Windsor has a high-speed Ethernet backbone network connecting all faculty and staff offices, classrooms and laboratories. Most buildings connect with one or more Gigabit links to a central, high capacity switch/router located in the University Computer Centre. Dedicated Fast Ethernet (100 Mbps full duplex) switched connections are available in almost every office on campus. The Faculty of Engineering, located in Essex Hall, has a Gigabit switched Ethernet network. The backbone connects to a 22.5 Mbps link to the Internet using redundant suppliers and also has a seamless dedicated high-speed connection to the CA*Net4 network. The University is also connected to the ORION research network.

The campus implemented a wireless network pilot in September 2003. Thirteen different students–centered gathering points have secured wireless hotspots available. These locations included portions of the CAW Student Centre, Leddy Library, Law Library, the University Computing Centre (UCC), the Odette School of Business, and the Faculty of Human Kinetics. A large expansion of the service is planned for the Fall, 2004 semester. In addition, the CAW Student Centre, both Leddy and Law Libraries and many labs including the UCC lab have laptop connections for students to connect to the Internet.

The academic research computer at Information Technology (IT) Services is a UNIX based SUN V880 system with four 950 Mhz CPUs. It is used extensively by researchers for statistical analysis and application and compiled programs. SAS and SPSS are both available on this system. Popular software compilers include Fortran, C, C++ and packages such as IMSL.

IT Services manages a public computer lab containing over 150 networked Pentium PCs for student use in the University Computer Centre. The lab is open from 8:00 a.m. to 2:00 a.m. during the Fall and Winter semesters. During other periods, it operates on reduced hours. A

student consultant is available at all times the lab is open. A portion of the area may be configured for instruction by using movable partitions. Available software includes Windows 98 and Windows XP, CorelDraw, Microsoft Word and Excel, WordPerfect, Quatro Pro, Paradox, SPSS/PC, Maple, etc. Two high-speed laser printers and a colour printer are available for student use.

In addition to the IT Services lab, IT Services provides student consultant support at two other general-purpose labs. Assumption University has a 20-seat lab available 10:00 a.m. – 7:00 p.m. Monday to Thursday and 10:00 a.m. – 4:00 p.m. Friday. Leddy Library has over 100 publicly accessible workstations that are available during the Library's normal operating hours. Available software is the same as in the UCC lab. All locations include laser printers.

Two computer classrooms are available for instructional use. The IT Services lab has a separate computer classroom available with 16 Pentium PCs for students and 1 PC for the instructor. Laser printing is available in the classroom. Additionally a classroom is available in Leddy Library with 42 PCs. Both classrooms may be reserved for hands-on instruction in any course. It is possible in the IT Services lab to double-up students at each PC. The IT Services lab is equipped with a device which allows the instructor to take control of the student PCs by projecting the display of one PC onto the others.

IT Services supports a Helpdesk that serves the faculty, staff and students of the university by being the central point of contact for information delivery and problem management and resolution, for services and products offered by IT Services. Help is available through the phone, e-mail, and walk-in clients, as well as on the web. The Helpdesk is open in the Fall and Winter semester from 8:00 a.m. to 9:00 p.m. Monday to Thursday, 8:00 a.m. to 6:00 p.m. on Friday and 12:00 p.m. – 4:00 p.m. on Saturday. The Helpdesk is open 8:00 a.m. – 6:00 p.m. in the Spring/Summer session.

External and Research Network Resources

The University of Windsor WEDnet™ department supports high-speed external research network access for research use and for those involved in all programs of the University. A Cisco certified CCNA is on staff to assist with projects. Through WEDnet™, the University has acquired an Asynchronous System Number (ASN) that permits direct network peering arrangements on class B and class C public IP address blocks. BGP4 peers exist with commercial carriers in the region (Telus and MaXess Networx) to permit a scalable access to commercial Internet bandwidth, with the opportunity for direct access to Internet bandwidth possible. The current available Internet access is 60 mbps sustained, but additional bandwidth can be provided as needed, as dual OC3 interfaces at 131 mbps are available. Peering also exists with the Optical Regional Advanced Network for Ontario (ORION) and with CA*net4, which permits direct VLANs to be established for projects with other Ontario universities and

institutes also directly connected to the research networks. Connections are also facilitated to Internet2 in the United States. These research network connections are at a minimum OC12 (622 mbps) access, with multiple gigabit Ethernet accesses also available.

The optical network architecture connecting to the University with support from WEDnet™ consists of Nortel Optera 1600 LH Dense-Wave Division Multiplex switches and Gigabit Cisco 7600 series routing located in Windsor and as part of the ORION infrastructure. WEDnet™ supports OC12 and Gigabit access ports on Cisco 7600 and 7200 series router interfaces, as well as OC 12 LS1010 accesses to ORION and to the redundant commercial Internet peers. Termination to the campus for these accesses involves 20-year dark fiber Indefeasible Rights of Use (IRUs), which describes the longevity of the capability of the physical infrastructure. Network traffic from those areas of the campus involved in collaborative interactions with other universities and compute resources (e.g. AUTO 21 and SHARCNET), use WEDnet™ resources to connect to external resources and to enrich their access environment to resources off campus.

At the present time, desktop and compute machines on the campus seamlessly access both the commercial Internet and the research networks. Best effort routes are selected in the core of the network and the most efficient paths for the transport of information are accepted. Failover and redundant network peering arrangements exist for most of the major accesses available, providing for the most part, a 24/7 operating environment with 99.95% availability or better. Mean Time To Repair (MTTR) for major equipment failures, including fibre splicing in the event of breakage are contracted to be less than 4 hours.

WEDnet™ also supports a set of collaborative web-based resource tools that can be used to assist program and collaborative interactions among faculty and research groups. Access is provided with assistance from the department to facilitate interactions among collaborators that require secure login and authentication to databases that incorporate scheduling, calendaring, document sharing and electronic voting capability. An integrated community based project called Connecting Windsor-Essex™ will provide the collaborative environment for interactions with major local businesses in the region with researchers, staff and students on the campus, while providing real-time interactions for access to resources on the research networks, at other institutions, and among key sector business in the region.

3.4 Space

The laboratory space available in Industrial & Manufacturing Systems Engineering is:

1. Advanced Manufacturing Research (AMR) Lab 72 sq.m.
2. Computer Integrated Manufacturing Laboratory 55 sq.m.
3. Data Processing Laboratory 50 sq.m.
4. Engineering Design Studio 70 sq.m.
5. Flexible Manufacturing & Robotics (FAR) Lab 144 sq.m.

6. Integrated Design & Manufacturing (IDM) Lab 144 sq.m.
7. Industrial Testing Laboratory 20 sq.m.
8. Machine Automation Research Lab (MAR) 47 sq.m.
9. Mechatronics Laboratory 71 sq.m.
10. Work Design & Human Factors Laboratory 65 sq.m.
    (Includes space for Manufacturing Systems Modelling Research Group)

This is in addition to other Laboratory space and facilities available to graduate students in this Program through the participating Faculties.

In the renovation budget for the Faculty of Engineering (2002-2004), a total of $74,167 was earmarked for renovating some laboratories in Industrial & Manufacturing Systems Engineering laboratories (Essex Hall rooms B-22, 115, and 109).

Each full-time faculty member has a private office of approximately 15 sq. m.; the support staffs also have their own individual offices. The IMSE departmental office has two large rooms and is occupied by the Chair, one secretary and office equipment. Both IMSE technicians have individual office space. Most of the graduate students occupy a large room partitioned into separate offices. The rest of the graduate students have offices within the various laboratories.

3.5 Financial Support Of Graduate Students

The University offers financial assistance to graduate students on competitive basis in the form of: (i) Scholarship with stipends, (ii) Tuition Scholarship, (iii) Visa Differential Fee Waiver, and/or (iv) Summer Research Scholarship, which consists of a tuition bursary for the summer term and $1000. The University also offers Conference Travel Awards to facilitate graduate students presenting papers in national and international conferences. The students can also compete for external scholarships such as those offered by NSERC, and OGS (open and institutional) and the OGSST (Ontario Graduate Scholarships in Science & Technology). It may be noted that visa students are ineligible to apply for NSERC scholarships and OGS institutional awards. The Ontario Graduate Scholarship, valued at $15,000.00 annually ($5,000 per term), is designed to encourage excellence in graduate studies. They may also apply for OGS open scholarships, but a very limited number are awarded to engineering.

Students are also eligible for Graduate Teaching Assistantships and Research Assistantships. Graduate Teaching Assistantships are offered on the basis of availability of funding from the University. A Research Assistantship is the stipend paid to a graduate student from his or her supervisor's research grants or contracts. The value of this stipend is primarily at the discretion of the concerned faculty member. Every effort is made to ensure that all full time graduate students receive some Research Assistantship. In some instances, foreign students join the program with a scholarship from their respective countries. Table 3.5.1 and 3.5.2 provides details of various forms of financial support to graduate students.

Table 3.5.1 Graduate Students Financial Support / Master's

Financial Support for Master's Students								
	$ Amount of Support From						Students Funded	
Year	External Scholarship (#)	Univ Scholarship (#)	TAs (#)	Ras (#)	Other* (#)	Total	# (%)*	Av $
1997/98	-	-	87,891 (13.5)	115,200 (20)		203,091	20 (100%)	10,155
1998/99	-	3,403 (2)	82,750 (12.5)	84,855 (15)		171,008	17 (100%)	10,059
1999/00	11,859 (1)	23,215 (8)	101,400 (15)	57,567 (11)		194,041	17 (100%)	11,414

2000/01	-	33,622 (10)	95,547 (14)	16,033 (5)		145,202	20 (100%)	7,260
2001/02	30,000 (2)	14,097 (5)	80,070 (11)	34,599 (6)		158,766	14 (100%)	11,340
2002/03	-	7,495 (4)	87,232 (12)	63,733 (11)		158,460	17 (100%)	9,321
2003/04	15,000 (1)	8,496 (2)	73,922 (9.5)	80,934 (13)		178,352	20 (100%)	8,917

* The number of students funded is based on the fulltime enrolment in the Program
A footnote explaining the drop in 2000, 2002 and 2003 should be provided

Table 3.5.2 Graduate Students Financial Support / Doctoral

Financial Support for Doctoral Students								
	$ Amount of Support From						**Students Funded**	
Year	**External Scholarship (#)**	**Univ Scholarship (#)**	**TAs (#)**	**RAs (#)**	**Other (#)**	**Total**	**# (%)***	**Av $**
1997/98	-	24,984 (8)	79,850 (11)	87,900 (9)		192,734	17 (100%)	11,337
1998/99	30,959 (2)	18,553 (6)	62,650 (8.5)	93,005 (10)		205,167	17 (100%)	12,068
1999/00	11,859 (1)	15,691 (5)	49,270 (6.5)	69,250 (8)		146,070	12 (100%)	12,172
2000/01	11,859 (1)	1,610 (1)	27,193 (3.5)	32,350 (4)		73,012	7 (100%)	10,430
2001/02	15,000 (1)	12,616 (4)	54,000 (7)	38,000 (7)		119,616	10 (100%)	11,961

2002/03	15,000 (1)	20,004 (5)	69,120 (8)	76,133 (7)		180,257	8 (100%)	22,532
2003/04	25,000 (2)	25,488 (6)	69,346 (8)	96,367 (8)		216,201	8 (100%)	27,025

*The number of students funded is based on the fulltime enrolment in the Program
A footnote highlighting the increased funding in 2002 and 2003 should be provided

The above tables summarize funding for both M.A.Sc. and Ph.D. students enrolled in the program. Levels of support for graduate students have varied considerably in 2000-2001, but have steadily increased for the past three years. All full-time M.A.Sc. and Ph.D. students have received a teaching assistantship and most have received an external scholarship or an internal scholarship, as well as research assistantship. With the hiring of new faculty members, the amount of research funds available will continue to increase, allowing better funding of graduates, specifically the Ph.D. students.

In recent years our students have done well in attracting OGS (Ontario Graduate Scholarships). For instance in the 2004-05 OGS competition 74 University of Windsor students have been selected for this scholarship. It is also worth noting that the University of Windsor proposed budget includes an additional $2.5 Million for graduate scholarships over the next 3 years.

4. PROGRAM REGULATIONS AND COURSES

4.1 The Intellectual Development And Educational Experience Of The Student

All graduate students in the program are strongly encouraged to attend every colloquium, seminar and thesis/dissertation defense organized within the Program. They are encouraged to ask questions and follow up with guest speakers who may have been invited to present a seminar after the regular meeting. They are also provided with information about professional societies such as the Institute of Industrial Engineers (IIE), Society of Manufacturing Engineers (SME), Canadian Society for Mechanical Engineering (CSME), Society of Automotive Engineering (SAE), and American Society for Quality (ASQ), the Canadian Operational Research Society (CORS), and the Association of Canadian Ergonomists (ACE) that are active in the campus; several of our graduate students are members of one or more of these societies.

Graduate students are required to meet their supervisors regularly in every semester and with their supervisory committee at least once a year. The Faculty of Graduate Studies and Research require an annual performance review report about the progress of each graduate student. Given that our M.A.Sc. and Ph.D. programs emphasize research accomplishments through Theses dissertations (and in some exceptional cases, major papers), the respective faculty supervisors engage their students in periodic discussions even during the first and second semesters of their program, when the graduate students are primarily involved in completing their course requirements (a minimum of four graduate courses). In general, every graduate student has the supervisory committee in place within 12 months of joining the program. The student is required to make a public presentation about the proposed research, followed by a meeting with the PhD. Supervisory Committee. Once the specific research program commences in earnest for a particular graduate student, the concerned supervisor generally expects periodic written reviews about the progress of the investigations until a proposal is ready to be presented to the supervisory committee. For students enrolled in the Ph.D. program, an annual seminar outlining the progress of their research studies is mandatory. The Program Chair/Department Head meets all graduate students once a year to discuss outstanding problems related to course availability, conduct of the program, changed rules and regulations, available sources of funding and other similar matters of an administrative nature. Meetings with individual students can also be initiated at the request of either party.

Examples of the type of scholarly interactions encouraged within the program are illustrated in Appendix 2 where a sample of the seminars and research meetings are listed.

Graduate students are also encouraged to present their research findings in various scientific meetings, Seminars and Conferences where refereed papers are published. A sample of graduate students publications is shown in section 5.3. Some of these Conferences are International and the world leaders in their category. For example, Ms. Jill Urbanic, currently a Ph.D. Student, who graduated (M.A.Sc. Degree) in May 2002, made a presentation of her investigations into "Modelling of Manufacturing Systems Complexity", at the 52nd International CIRP (International Institution for Production Engineering Research) annual General Assembly

held in Montreal, Canada in August 2003. The paper was very well received by top international researchers (Published in the Annals of CIRP, Vol. 53/1, pp. 363-366). Ms. Urbanic was encouraged to continue her doctoral studies with the same research group at the University of Windsor.

4.2 Proposed Multi-Disciplinary Ph.D. Program Regulations

The Ph.D. program in Industrial and Manufacturing Systems Engineering will be governed by the general regulations regarding the Ph.D. degree of the Faculty of Graduate Studies. Detailed regulations are provided in the University of Windsor Graduate Calendar.

4.2.1 Admission Policy & Requirements

Applicants will have a suitable background and qualifications for studies at the Ph.D. level in Industrial and Manufacturing Systems Engineering. Applicants who do not have an engineering degree and wish to be admitted to the Ph.D. program, would be required to complete additional courses, with grade of B or better, to remedy identified gaps in their Applied Science background. The Program's Graduate Studies Coordinator, in consultation with the Graduate Admissions Committee (consisting of the Graduate Studies Coordinator, IMSE Head and a faculty member), decides the number and type required remedial of courses. All applicants whose native language is not English are required to satisfy the English proficiency requirement.

Satisfaction of the requirements does not automatically guarantee admission to the Ph.D. program. The Graduate Studies Co-ordinator first scrutinizes all applications for the Ph.D. program. Applicants who do not satisfy the following minimum requirements are screened out at that stage:

- A TOEFL score of 560 or equivalent (for applicants from countries where English is not the first language). For alternative ways to satisfy this requirement, refer to the Graduate Calendar Section 1.3.2.
- Average grade of 70% or higher in the Bachelor's program for students from reputable North American Universities.
- Average grade of 75% or higher in the Bachelor's program for all other students.
- Average grade of 75% or higher at the Master's level for Doctoral program applicants.
- A thesis option or equivalent at the Master's level for Doctoral program applicants.

All Core faculty members then review the remaining files. The following criteria are used to admit students:

i) At least two thirds of the available core faculty members should agree to an "admission", and

ii) At least one faculty member must agree to supervise the student.

It should be noted that core faculty members can supervise/co-supervise students in the proposed Ph.D. program. Collaborating faculty participate in the graduate program, through

the offering of graduate courses, and participation in joint research and membership in supervisory and examination committees.

4.2.2 Area of Specialization

It is proposed to offer a graduate Program leading to a Ph.D. degree in the field of Industrial and Manufacturing Systems Engineering, managed through the Department of Industrial & Manufacturing Systems Engineering, in collaboration with faculty from the Faculties of Engineering, Science, Business, and Human Kinetics.

Research within the Industrial and Manufacturing Systems Ph.D. program focuses on modern manufacturing systems that are flexible and well integrated. It deals with various modules such as: 1) physical components of the system (machines, robots, inspection devices, material handling equipment, etc.), 2) effective information systems for controlling, monitoring, scheduling and operating in a dynamically changing environment, 3) human related issues such as ergonomics, interaction among people and between people and machines as well as human modelling, 4) management of technologies and operational issues throughout the manufacturing enterprise, and 5) integration of all elements to ensure achieving the desired competitiveness. The specific areas of research are driven by the interest and activities of individual faculty members and are outlined in Section 1.6 and Tables 2.1 and 2.2.

4.2.3 Candidacy

Admission to graduate study does not imply admission to candidacy for a degree. The candidacy of a student normally will be determined within the second year after initial registration in the doctoral Program. Candidacy will be granted to students who meet all of the following requirements:

(a) Satisfactory completion of the comprehensive examination;

(b) Demonstration to the doctoral committee of ability to conduct independent research;

(c) Acceptance by the doctoral committee of the research proposal.

The doctoral committee will assess the student's competence to continue research on the basis of (a), (b) and (c) above, and make a recommendation accordingly to the Dean of Graduate Studies and Research through the Chair of the Graduate Committee.

4.2.4 Program Requirements

The specific minimum Program requirements for the Ph.D. degree include the successful completion of:

1) **Course requirements:** Satisfactory completion of at least four graduate courses, comprising a minimum of twelve semester hours, beyond the courses required for the Master's degree. See Section “4.2.5 Graduate Courses” below for requirements details.

2) **A comprehensive examination.** (See details under examinations)

3) **Satisfactory progress in research within each review period.** The doctoral committee will conduct a periodic review, which will include at least one formal seminar a year,

after the first year of residency, to establish that adequate progress in research has been accomplished by the candidate. The doctoral committee will also grant permission to write the dissertation when it decides that the candidate has achieved sufficient competence in carrying out research and when the candidate has done substantial research. During the annual seminar, Ph.D. students will be required to review their research progress and results. It is proposed that this will be part of the credit evaluation of the student performance in his/her Ph.D. The Credit will be assigned to a new course, number: 91-595 Graduate Seminar. Students will be required to register and give presentations, and all students will be expected to attend each seminar (no less than 75% of all seminars). The course will be graded on a PASS/FAIL basis (1 Lecture Hour a week). This course will include presentations by graduate students, staff, and visiting scientists. The Ph.D. Supervisory Committee will complete the evaluation.

4) **A dissertation on the research.** A dissertation embodying the results of an original investigation in the field of specialization is required of all candidates for the degree of Doctor of Philosophy. Each candidate will be required to make an oral presentation of the dissertation research and will be examined orally on the subject of the dissertation and related fields.

Residence and Time Limits: Every student will undertake a full Program of study for a minimum of three years beyond the Baccalaureate of Engineering or its equivalent. Credit for one of these years may be given for the time spent in proceeding to a Master's degree. Credit for one of these years may also be given for work done at another institution. A student admitted to a Ph.D. Program requiring the student's attendance for a minimum of three years must complete all requirements within seven years. Students requiring a minimum of two years' residence must complete all requirements within six years.

Committees: Research undertaken as part of a doctoral Program is directed and supervised by a doctoral committee, which is assigned within the first term of registration. Whereas the student's advisor provides day-to-day guidance and direction, this committee is ultimately responsible for the overall supervision to ensure that adequate progress is being maintained. The doctoral committee will consist of at least four members, with the student's advisor, who is a member of the graduate faculty, as chairperson and two other faculty members in the program, and at least one member shall be from a department within the University of Windsor other than his/her supervisor's department.

The student's advisor will recommend the members of the doctoral committee, whose appointment must be approved by the Executive Committee of Graduate Studies and Research.

Examinations:

- ***Qualifying Examination.*** At the discretion of the doctoral committee, a qualifying examination may be required. A qualifying examination is one in which the student is asked to demonstrate a reasonable mastery of the fundamentals in the major subject; it is designed to test the student's preparation for advanced graduate work. If such an examination is required, it must be administered and passed before the student registers

for the second year of Ph.D. work.

- ***The Proposal.*** Normally within the first 2 years, the student will present in the form of a seminar an outline of his or her proposed thesis research. This will be presented to the doctoral committee who must approve, with or without modifications, or reject the proposal. Thereafter, at least once a year the student will report his or her progress in the form of a seminar.

- ***Comprehensive Examination.*** Students who have previously obtained a Master's degree must attempt this examination very early between twelve to eighteen months of registering for the Ph.D. Program. Other students must take it within twenty-four months of registration for the Ph.D. Program. A comprehensive examination committee will conduct the comprehensive examination. The committee will consist of the chair, three members of the supervisory committee, including the supervisor, and an additional member who has a scholarly interest in the student's general area of specialization.

This set of examinations requires the students to demonstrate an adequate background in the general discipline of applied science, and an advanced knowledge in their fields of specialization and research.

The comprehensive examinations will be conducted in two parts:

a) In the first part, a scheduled supervised written portion, of three hours duration, designed to test the student's general knowledge on core subjects in the field of study as approved by the examination committee, with questions set and answers evaluated by the examination committee;

b) An oral examination to be evaluated by the examination committee. The objective of this part of examination is to evaluate the student's ability to integrate general knowledge from different areas into their research plan. The candidate will be required to submit a report, up to 25 pages in length, on the proposed research program. The report must include: (i) a critical survey of the directly related literature in the field, and (ii) an outline of the proposed research program, including its justification, the approach to be taken, specific analytical or experimental methods, perceived or anticipated problems, and a proposed timetable to accomplish the task. Five copies of the report must be in the hands of the examining committee at least seven days prior to the date of the oral examination. The oral examination will be conducted in two sessions. In the first part, the candidate will be required to present his/her report in a summary fashion to the committee followed by questions directly related to the proposal and the candidate' s specific area of research. The second part of the oral examination will emphasize the candidate's comprehension as well as breadth and depth of knowledge of his/her discipline area. The duration of the two parts of the oral examination is expected to be about one and half hours each, separated by a recess of half an hour .

It is the responsibility of the examining committee chair to call a meeting of the committee at least seven days prior to oral examination to: (i) examine the candidate's records and the type of background necessary to carry on his/her research successfully, and (ii) assign the preparation of the written questions for the first part, to members of the committee, other than the supervisor. The supervisor will not participate in the preparation of the written questions but is expected to participate in the oral examination.

The Committee Examination will determine the student's overall performance and success in the comprehensive examination. If the student is unsuccessful, the committee may require:

i. That the student repeats all or part of the comprehensive examination at a specified time;

ii. That the student take and pass remedial course work before repeating all or part of the examination; or

iii. After consultation with, and approval by, the doctoral committee that the student withdraws from the program.

➢ ***Final Examination.*** The final appraisal of the dissertation and the conduct of the final oral examination of the dissertation will be carried out by an examining committee. The examining committee will consist of the doctoral committee, the Dean of Graduate Studies and Research (or designate) as chairperson (non-voting) and an external examiner. The final examination normally follows a public seminar by the candidate, open to all members of the university. The passing of the final oral examination of the dissertation requires both an adequate dissertation and a satisfactory defense of the dissertation. The examining committee will conduct this examination, in accordance with the Faculty of Graduate Studies and Research procedures.

This set of examinations requires the students to demonstrate an adequate background in the general discipline of Industrial and Manufacturing Systems, and an advanced knowledge in their fields of specialization.

4.2.5 Graduate Courses

The graduate course offerings through the Department of Industrial and Manufacturing Systems Engineering and selected related courses from other areas are designed to complement the research focus of the core faculty in the area of *Industrial and Manufacturing Systems Engineering*. The minimum course requirement for the proposed multi-disciplinary Ph.D. Program is 4. In addition to the Graduate Seminar 91-595, at least 2 from the 16 courses listed in category A and a minimum of one from category B would be selected. Other relevant courses are listed in Category B (Table 2.5.1 & 2.5.2 & Appendix 4). Only a selected number of these courses will normally be available each year, and the current list will be made available to the

students.

Graduate students in the Program will work on specific research topics within the scope of the Industrial and Manufacturing Systems area, and their Program of studies will be formulated in consultation with their graduate advisor(s) and approved by the Program Graduate Committee Chair.

4.3 Part-Time Studies

Students who completed their "Residency" requirements may need to transfer to part-time status for special circumstances. Normally about 10% of the graduate students' population falls in this category.

4.4 Graduate Courses Recently Offered

The IMSE courses offered to Graduate Students in the past few years are listed in Table 4.4 for reference.

Table 4.4 Enrolment in Category A Graduate Courses (2002-04)

Course	Faculty Member Responsible	2002			2003			2004		
		W	S	F	W	S	F	W	S	F
91-500-01	G. Zhang					14				
91-501-01	R.S. Lashkari									
91-502-01	W. Abdul-Kader						9			
91-503-01	S. Taboun	8								
91-504-01	R.S. Lashkari†						4			
91-507-01	S.P. Dutta									
91-507-01	S. Taboun									
91-508-01	R.S. Lashkari							4		
91-509-01	T. Lahdhiri*				15					
91-510-01	S. Taboun		6							
91-511-01	R.S. Lashkari									
91-512-01	H.A. ElMaraghy	8			6			5		
91-514-01	W.H. ElMaraghy			12			11			
91-515-01	M. Wang					5				
91-516-01	W.H. ElMaraghy	7			4			3		
91-590-01	M. Wang						4			
91-590-02	T. Lahdhiri*					5				
91-590-03	W.H. ElMaraghy									
91-590-04	M. Wang									
91-590-06	H.A. ElMaraghy			1						
91-590-07	A. Atmani*	6								
91-590-08	G. Zhang							7		
91-590-09	L. Oriet							18		
91-590-09	S. Taboun									
91-590-10	W.H. ElMaraghy									
91-590-14	S.P. Dutta									
91-590-15	M. Wang									
91-590-17	A. Alfa									

Note: There has been significant change in the participating faculty in the program in the last 2 years. Three (3) departed and 3 were added in IMSE and others from various disciplines joined the core group. Hence, the above list of graduate courses, offered during this transition period, do not fully represent those that are proposed for the new Ph.D. program.

Figures in Columns 3, 4, 5, 6 & 7 indicate enrolment numbers.

† Four (4) professors: Drs. Ahmadi, Caron, Lashkari, and Gencay, offered this course.

* Sessional Instructor

5. OUTCOMES

5.1 Enrolment And Graduations

5.1.1 Master's Program

A Master's and M.Eng. Degrees in Industrial Engineering approved by OCGS, are being offered. The scope and objectives of these degrees are outlined in Appendix 4. For information, Tables 5.1.1.1, 5.1.1.2, 5.1.1.3, and 5.1.1.4 present the Cohort data and Flow Through data for graduates in our M.A.Sc. Program in Industrial Engineering from 1997 to 2004.

Note: In previous submissions the data in all tables was reported for full-time and part-time students combined, and a calendar year was used instead of an academic year, hence some differences might be noticed.

Table 5.1.1.1 Cohort Data, Master's Program (Full Time)

New Enrolments, Withdrawals and Graduations in the Master's Program by Year of Admission (Full Time)									
Year	**New**	**within 6 terms**				**within 9 terms**			
		Trans Ph.D.	**Withd**	**Compl**	**IP**	**Trans Ph.D.**	**Withd**	**Compl**	**IP**
1997-1998	9	0	1	3	5	0	1	8	0
1998-1999	6	0	1	2	3	0	1	5	0
1999-2000	8	0	0	4	4	0	1	6	1
2000-2001	9	0	3	4	2	0	3	5	1
2001-2002	5	0	1	1	3	0	1	1	3
2002-2003	7	0	0	1	6	0	0	1	6
2003-2004	9	0	0	0	9	0	0	0	9

Table 5.1.1.2 Flow Through Data, Master's Program (Full Time)

Master's Total Enrolments, Transfers, Withdrawals and Graduations by Year (Full Time)							
Year	**Total Enrol** [2]	**# female (%)** [3]	**# visa (%)** [4]	**Total Transfers** [5]	**Total Withdrawals** [6]	**Total Graduations** [7]	**Total Continuing** [8]
1997	20	8	3	0	1	8	11
1998	17	7	6	0	1	7	9
1999	17*	3	6	0	3**	3	11
2000	20	4	6	0	3***	8	9
2001	14	6	6	0	1	3	10
2002	17	8	7	0	1	5	11
2003	20	10	6	0	0	6	14

*One student transferred from Ph.D. to Master's program
**3 students changed status from Full to Part Time
***1 student changed status from Full to Part Time

Table 5.1.1.3 Cohort Data, Master's Program (Part Time)

New Enrolments, Withdrawals and Graduations in the Master's Program by Year of Admission (Part Time)									
Year	**New**	**within 6 terms**				**within 9 terms**			
		Trans Ph.D.	**Withd**	**Compl**	**IP**	**Trans Ph.D.**	**Withd**	**Compl**	**IP**
1997-1998	0	0	0	0	0	0	0	0	0
1998-1999	0	0	0	0	0	0	0	0	0
1999-2000	2	0	1	1	0	0	1	1	0
2000-2001	3	0	0	0	3	0	0	1	2
2001-2002	1	0	0	0	1	0	0	0	1
2002-2003	2	0	0	0	2	0	0	0	2
2003-2004	2	0	0	0	2	0	0	0	2

Table 5.1.1.4 Flow Through Data, Master's Program (Part Time)

Master's Total Enrolments, Transfers, Withdrawals and Graduations by Year (Part Time)							
Year	**Total Enrol**	**# female (%)**	**# visa (%)**	**Total Transfers**	**Total Withdrawals**	**Total Graduations**	**Total Continuing**
1997	8	3	0	0	0	1	7
1998	7	4	1	0	0	2	5
1999	8*	3	0	0	1	0	7
2000	13**	4	0	0	0	5	8
2001	9	2	0	0	1	1	7
2002	9	1	0	0	0	3	6
2003	8	2	0	0	0	0	8

*One student status change from Full to Part Time
**3 students status change from Full to Part Time

5.1.2 Doctoral Program (Discontinued)

Tables 5.1.2.1, 5.1.2.2, and 5.1.2.3 present the Cohort data and the Flow Through data respectively for the now discontinued Ph.D. program in Manufacturing Systems in Industrial Engineering and Manufacturing Systems between 1994 and 2004. Since then 15 students have successfully completed their doctoral programs. Currently, there are 8 students in progress; it is expected that they would graduate within the next 12-18 months.

Table 5.1.2.1 Cohort Data, Doctoral Program (Full Time)

New PhD Enrolments, Withdrawals and Graduations by Year of Admission (Full Time)										
Year	**New**	**Within 12 terms[1]**			**Within 18 terms[1]**			**Within 21 terms**		
		Withd	**Compl**	**IP**	**Withd**	**Compl**	**IP**	**Withd**	**Compl**	**IP**
1994-1995	4	0	1	3	1	2	1	1	3	0
1995-1996	8	1	3	4	1	7	0	1	7	0
1996-1997	4	1	3	0	1	3	0	1	3	0
1997-1998	1	1*	0	0	1*	0	0	1*	0	0

1998-1999	1	1	0	0	1	0	0	1	0	0
1999-2000	1	0	0	1	0	0	1	0	0	1
2000-2001	2	0	0	2	0	0	2	0	0	2
2001-2002	5	1	0	4	1	0	4	1	0	4
2002-2003	1	0	0	1	0	0	1	0	0	1
2003-2004	2	0	0	2	0	0	2	0	0	2

* Student transferred to Master's Program

Table 5.1.2.2 Flow Through Data, Doctoral Program (Full Time)

PhD Total Enrolments, Withdrawals and Graduations by Year (Full Time)						
Year	**Total Enrolments**	**# female (%)**	**# (visa (%)**	**Total Withdrawals**	**Total Graduations**	**Total Continuing**
1994	4	0	1	0	0	4
1995	12	0	7	0	0	12
1996	16	0	11	0	0	16
1997	17	1	9	0	1	16
1998	17	1	8	1*	5	11
1999	12	0	6	5**	2	5
2000	7	1	1	0	2	5
2001	10	2	3	1	2	6
2002	8	2	4	2	0	6
2003	8	2	3	0	0	8

*Status change from Full to Part Time

**One student transferred to Master's Program and 3 students changed status from Full to Part Time

Table 5.1.2.3 Flow Through Data, Doctoral Program (Part Time)

PhD Total Enrolments, Withdrawals and Graduations by Year (Part Time)						
Year	**Total Enrolments**	**# female (%)**	**# (visa (%)**	**Total Withdrawals**	**Total Graduations**	**Total Continuing**
1994	0	0	0	0	0	0
1995	0	0	0	0	0	0
1996	0	0	0	0	0	0
1997	1*	0	0	0	0	1
1998	2**	0	0	0	0	2
1999	3**	1	0	0	1	2
2000	4***	0	0	1	0	3
2001	3	0	0	0	2	1
2002	3***	0	0	2	0	1
2003	1	0	0	0	0	1

* Only one student was admitted to part-time status between 1994 and 2004 therefore a cohort table for part-time doctoral students is not provided.
**One student changed status from Full to Part Time
***Two students changed status from Full to Part Time

Table 5.1.2.4 Mean and Median Times to Completion

Mean (range) and Median Times to Completion of Master's and Ph.D. Programs		
Completion Time - Master's 1997-2003		
Field (#)	**Mean (range) Years**	**Median Years**
Industrial Engineering (*n* = 36) M.A.Sc.	2.25 (1.3 - 4)	2.25
Completion Time - Ph.D. 1994-2003		
Field (#)	**Mean (range) Years**	**Median Years**
Manufacturing Systems (*n* = 12) Ph.D.	4.61 (3 – 6.6)	4.67

5.2 Post-Graduation Employment

INDUSTRIAL & MANUFACTURING SYSTEMS ENGINEERING GRADUATES AND EMPLOYMENT (1995 - 2003)

(i) **Ph.D. Graduates:**

NAME/GRADUATION DATE	EMPLOYMENT
Mr. Abduelghani Abduelmola Ph.D. (MSE) 2000 [2000W]	Ford Motor Company Detroit, MI. U.S.A.
Mr. Abdulfatah A. Altumi Ph.D. (MSE) 2001 [2001S]	DaimlerChrysler Canada Inc. Detroit, MI. U.S.A.
Mr. Ali Bondok Ph.D. (MSE) 2000 [1999F]	DaimlerChrysler Canada Inc. Windsor, ON. Canada
Mr. Vijayakanthan Damodaran Ph.D. (ME) 1996	General Motors Corporation 1 Pontiac Plaza Pontiac, MI. 48340 U.S.A.
Mr. Yasser El-Deeb Ph.D. (MSE) 1999 [1999W]	The Ford Motor Company Product Development Centre 21500 Oakwood Boulevard Dearborn, MI. 48120 U.S.A.
Mr. Farag Elfeiture Ph.D. (MSE) 2000 [2000S]	University of Tripoli Lybia
Mr. Tarek El-Mekkawy Ph.D. (MSE) 2001 [2001W]	Assistant Professor Department of Mechanical and Manufacturing Engineering University of Manitoba Manitoba, Canada

Mr. Michael Johnson Ph.D. (MSE) 2002 [2001F]	BCIT, UBC Senior Lecturer Vancouver, B.C.
Mr. Mike Kolish Ph.D. (MSE) 2000 [2000S]	Johnston Technologies Detroit, MI. U.S.A.
Mr. Hsu-Tung Lee Ph.D. (MSE) 1999 [1998F]	Assistant Professor Long-hua Institute of Technology Taipei, Taiwan
Mr. Abdelmonem Mohammad Murtadi Ph.D. (MSE) 20002 [2001F]	Schukra of North America Walker Road Windsor, ON. Canada
Mr. Leo Oriet Ph.D. (MSE) 1997	Chair Department of Industrial & Manufacturing Systems Engineering University of Windsor Windsor, ON. N9B 3P4 Canada
Mr. Chun-Yu Tung Ph.D. (MSE) 1999 [1999W]	Plant Manager An-Feng Steel Company Taiwan
Mr. Abbas Vafaeesefat Ph.D. (MSE) 1998 [1997F]	Associate Professor Amir Kabir University Iran

(ii) M.A.Sc. Graduates

NAME/GRADUATION DATE	**EMPLOYMENT**
Mr. Dan Albu M.A.Sc. (IE)	Automation Manager Walbro Automotive Corp. 949 McDougall Windsor, ON. N9A 1L9 Canada
Mr. Tarik Hussein Badi M.A.Sc. (IE) 1999	Working for an Engineering company in the country

Mr. Baskar Balakrishnan M.A.Sc. (IE)	Senior Industrial Engineer Sterling Truck Corp., St. Thomas, ON. Canada
Mr. Shubhabrata Biswas M.A.Sc. (IE) 1995	Systems Analyst Production Modeling Corp. Dearborn, MI. U.S.A.
Mr. Ramanpreet Boparai M.A.Sc. (IE) 2001	MBA Student York University Toronto, ON. Canada
Mr. Aleksandar Boskovic M.A.Sc. (IE) 2001	Unknown
Mr. Pedro Bravo De Laguna 2000	Unknown
Mr. S.M. Brown M.H.K. 2003	Ph.D. Student Department of Kinesiology University of Waterloo Waterloo, ON. Canada
Mr. Matt Butson M.A.Sc. (IE) 1996	Engineering Manager Sterling Truck (Freight Liner) St. Thomas, ON. Canada
Mr. Kwanghui Chai M.A.Sc. (IE) 1997	Logistic Officer Korean Army South Korea
Mr. Athelstan Choi M.A.Sc. (IE) 1995	Manager, I.E. Operations Synex Computer Vancouver, B.C. Canada
Ms. Catharine Copot M.A.Sc. (IE) 2001	Methods Engineer DaimlerChrysler Canada Inc. 3035 Pillette Road Windsor, ON. N9A 4H6 Canada

Mr. Roger Cortina M.A.Sc. (IE) 1997	Industrial Engineering Supervisor DaimlerChrysler Corporation 1000 Chrysler Drive Auburn Hills, MI. 48326-2766 U.S.A.
Ms. Ana Djuric M.A.Sc. (IE) 1999	Flow Software Technologies 3070 Jefferson Blvd. Windsor, ON. Canada Ph.D. Grad Student, Department of Mechanical & Automotive Materials Engg. - University of Windsor Windsor, ON. Canada
Mr. Hugo Dominguez M.A.Sc. (IE) 2002	In Mexico Whereabouts Unknown
Mr. Adel ElAraby M.A.Sc. (IE) 2001	President AH Computer Consulting Inc. 19228 Autumn Maple Lane Gaithersburg, MD. 20879 U.S.A.
Mr. Diaa ElKott M.A.Sc. (IE) 2001	Ph.D. Student McMaster University Hamilton, ON. L8S 4L8 Canada
Mr. Franklin Foulger M.A.Sc. (IE) 1997	Industrial Engineer General Motors of Canada Limited 570 Glendale Avenue St. Catharines, ON. L2R 7B3 Canada
Mr. D. Fraser M.H.K. 1999	Headliner Engineering Program Manager, Lear Corporation Southfield, MI. U.S.A.
Ms. Mary-Ann (Buconjic) Fuduric M.A.Sc. (IE) 2003	Industrial Engineering Engineer DaimlerChrysler Corporation Technology Centre - 800 Chrysler Drive Auburn Hills, MI. 48326 U.S.A
Mr. Bo Gao	Unknown

M.A.Sc. (IE) 2002	
Mr. Xiaobing Gao M.A.Sc. (IE) 1998	Johnson Controls Inc. 477 Jutras Drive Tecumseh, ON. N8N 5C4 Canada
Mr. D. Grondin M.H.K. 2003	Student at the Canadian Memorial Chiropractic College
Mr. Waseem Habash M.A.Sc. (IE) 1997	Operations Manager LDM Technologies Co. LDM Technologies Box 640 4 Senaca Road Leamington, ON. Canada
Ms. Melinda Harmos M.A.Sc. (IE) 1999	Assembly Manager Ford of Canada Troy, MI. U.S.A.
Mr. M.L. Haumann M.H.K. 2002	Program Ergonomist, Vehicle Operations Ford Motor Company Essex Engine Plant Windsor, ON. Canada
Mr. Dean Hsieh M.A.Sc. (IE) 1998	Senior Industrial Engineer Ford Motor Company Essex Engine Plant Windsor, ON. Canada
Ms. Ying Huang M.A.Sc. (IE) 1999	Whereabouts Unknown
Mr. Albert Hui M.A.Sc. (IE) 1995	Process Development Engineer Nortel Networks 8200 Dixie Road, North Brampton, ON. LV1 2M6 Canada
Mr. Venkatraman Jaganathan M.A.Sc. (IE)	Delphi Automotive Systems Corporation 5725 Delphi Drive

1998	Troy, MI. 48098 U.S.A.
Mr. Michael Roger Johnson M.A.Sc. (IE) 1994	Ph.D. Student IMSE Program University of Windsor Windsor, ON. N9B 3P4 Canada
Mr. Mike Kolich M.A.Sc. (IE) 1999	Ph.D. Student IMSE Program University of Windsor Windsor, ON. N9B 3P4 Canada
Mr. Chris Kourtis M.A.Sc. (IE) 1995	Human Factors Specialist Ergonomics Plus 650 Eglinton W. Wallaceburg, ON. N8A 4L8 Canada
Mr. Evgeny Leshchinsky M.A.Sc. (IE) 2003	Design Engineer DaimlerChrysler Corporation Inc. Windsor, ON. Canada
Mr. Setiadi Lesmana M.A.Sc. (IE) 2003	Professor Malasia
Ms. Qingwen Li M.A.Sc. (IE) 1998	Whereabouts Unknown
Mr. Rodrigo R. Llerena M.A.Sc. (IE) 1997	Has returned to his country of origin (Peru)
Ms. Yahong Liang M.A.Sc. (IE) 2001	Unknown
Mr. Rodrigo Llerena M.A.Sc. (IE) 1997	Unknown
Mr. Jia Ma M.A.Sc. (IE)	Manufacturing Engineer American Axle & Manufacturing

1997	Auburn Hills, MI. U.S.A.
Mr. Ramesh Majety M.A.Sc. (IE) 2003	Manager, Simulation Group, GM Detroit, USA, also P.T. Ph.D. Graduate Student University of Windsor Windsor, ON. N9B 3P4 Canada
Mr. Noel Manchulenko M.A.Sc. (IE) 2001	Engineer General Motors of Canada Limited 2800-3300 Bloor Street, West Etobicoke, ON. M8X 2X5 Canada
Mr. Abani Mandal M.A.Sc. (IE) 2001	R & M Engineer Valiant Machine & Tool Inc. Corporate Offices 9355 Anchor Drive Windsor, ON. N8N 5A8 Canada
Mr. David Marsh M.A.Sc. (IE) 1994	Knowledge Engineer For software company in Toronto, ON.
Mr. Ali A. Mohamed M.A.Sc. (IE) 1996	Magna Systems International Ouellette Ave.- Windsor, ON. Canada Ph.D. Graduate Student, University of Windsor Department of Industrial & Manufacturing Systems Engineering Windsor, ON. N9B 3P4 Canada
Mr. M. Murphy M.H.K. 1999	Plant Ergonomist Ford Motor Company Oakville Assembly Plant, U.S.A.
Mr.Nandula Murali M.A.Sc. (IE) 1999	Member Technical Staff Centre for Electronic Commerce - ERIM, Ann Arbor, MI. U.S.A.
Mr. Paolo Novelletto M.A.Sc. (IE) 2001	PMC 3 Parklane Blvd. Dearborn, MI. 48126 U.S.A.

Mr. Dean Orlando M.A.Sc. (IE) 2002	SIMIN Engineering Services Windsor, ON. Canada
Mr. Alper Ozdemir M.A.Sc. (IE) 1995	Management Consultant Ernst & Young LLP P.O. Box 251 T.D. Centre Toronto, ON. MJK 1J7 Canada
Mr. B. Parcero M.H.K. 2000	Ergonomist Engineer Lear Corporation Southfield, MI. U.S.A.
Mr. Vishwas Patel M.A.Sc. (IE) 1997	IE Simulation Exprt, GM Truck Group, London, Ont. (currently with GM in Michigan,U.S.A.)
Mr. Jorge Paulo M.A.Sc. (IE) 2000	Quality Safety Systems 255 Patello Road Windsor, ON. Canada
Ms. Graciela Pelayo M.A.Sc. (IE) 2000	Siemens VDO Automotive 2775 Saint-Etienne Blvd. Windsor, ON. Canada
Mr. Abi Philipose M.A.Sc. (IE) 1995	Control Engineer General Motors of Canada Limited Transmission Plant 1150 Kildare Road Windsor, ON. N8Y 4S1 Canada
Mr. Roozbeh Rahimpour M.A.Sc. (IE) 1997	Senior Engineer Hatch Associates Ltd. 2800 Speakman Drive Mississauga, ON. L5K 2R7 Canada
Mr. Koushik Ray M.A.Sc. (IE) 1996	Applications Engineer Production Modeling Corporation 910W-3 Park Lane Blvd. Dearborn, MI. 48126 U.S.A.

Mr. Chris Rolls M.A.Sc. (IE) 2000	Engineering Design Analyst Ford Motor Co. U.S.A. Dearborn, MI. U.S.A.
Ms. Nandini Saha M.A.Sc. (IE) 1996	Industrial Engineering Manager Ford Motor Company of India Ltd. Chennai, India
Ms. Nicole Seal M.A.Sc. (IE) 2001	DaimlerChrysler Corporation Inc. 3035 Pillette Road Windsor, ON. N9A 4H6 Canada
Mr. Essam Shalash M.A.Sc. (IE) 1997	Has returned to United Emirates
Mr. Hong Shao M.A.Sc. (IE) 1997	Unknown
Mr. Fazlullah Sharief M.A.Sc. (IE) 1997	Applications Engineer Production Modeling Corporation Dearborn, MI. U.S.A.
Mr. S.W. Tolmie M.H.K. 2002	Corporate Ergonomics Coordinator DaimlerChrysler Detroit, MI. U.S.A.
Ms. Jill Urbanic M.A.Sc. (IE) 2003	Ph.D. Graduate Student Department of Mechanical, Automotive, & Materials Engineering University of Windsor Windsor, ON. N9B 3P4 Canada
Mr. Tingzhou Wu M.A.Sc. (IE) 2002	Project Engineer Eaton Aeroquip-Automotive Fluid Connectors Clinton Township, MI. U.S.A.
Mr. L. Yan	Unknown

M.A.Sc. (IE) 1997	
Mr. Bo Yang M.A.Sc. (IE) 2003	Unknown
Mr. Ted Yang M.A.Sc. (IE) 2001	Quality Assurance Manager The Narmco Group Corporate Offices Airport Road Windsor, ON. Canada
Ms. Xiaoyong Yang M.A.Sc. (IE) 2002	Unknown
Mr. Bing Ye M.A.Sc. (IE) 1999	Unknown
Mr. Xin Yuan M.A.Sc. (IE) 1997	Unknown
Mr. Bin Zhang M.A.Sc. (IE) 1993	Software QA Manager Rightworks Co. 10075 E. Brokaw Road San Jose, CA. 95131 U.S.A.
Ms. Zhiqi Zhong M.A.Sc. (IE) 2001	Unknown
Ms. Barbara Zhou M.A.Sc. (IE) 1995	Senior Engineer Software Compnay Boston, MA. U.S.A.
Mr. Michael Agnew 2003 [2003F] M.H.K.	Ph.D. Student Queen's University Kingston, Ontario, Canada
Ms. Nadia Azar 2004 [2004S] M.H.K.	Ph.D. Student Wayne State University Detroit Michigan, USA

Ms. Janice Flynn 2003 [2003F] M.H.K.	Ph.D. Student University of Waterloo Waterloo, Ontario, Canada
Mr. Jeffrey Holmes Ontario 2003 [2003F] M.H.K.	Ph.D. Student University of Western London, Ontario, Canada
Ms. Christa Lauder 2002 [2002F] M.H.K.	Ergonomist, General Motors, Michigan, USA

5.3 Sample Of Graduate Students Publications

The following is a sample of Graduate students Publications. The names of the students are in **bold** letters.

Papers in Refereed Journals & Book Chapters

1. Wang, M. H., **Johnson, M. R.,** a chapter on "Disassembly Economics", in the Mechanical Life Cycle Handbook, edited by Mahendra Hundal, Publisher: Marcel Dekker, ISBN 0824705726, 2001.
2. **Lee, H**.; Wang, M. H.; Maev, R., and Maeva, E., A Study on Using Scanning Acoustic Microscopy and Neural Network Technique to Evaluate the Quality of Resistance Spot Welds, in print, International Journal of Advanced Manufacturing Technology, 2003.
3. **Johnson, M.** and Wang, M. H., Evaluating Policies and Automotive Recovery Options According to the European Union's Directive on End-of-Life Vehicles, Journal of Automobile Engineering, Vol. 216 Part D, pp. 723-739, 2002.
4. **Tung, C. Y.,** Wang, M. H., Comparison of Environmental Performance Between Plastic and Steel Fuel Tanks, Journal of Engineering Manufacture, Vol. 216 Part B, pp. 1443-1457, 2002.
5. Huang, H. T., Wang, M. H., and **Johnson, M.,** Disassembly Sequence Generation Using A Neural Network Approach, Journal of Manufacturing Systems, Vol. 19, pp. 73-82, 2000.
6. **Johnson, M.** and Wang, M. H., Economic Scheduling of Disassembly Operations for Recycling, Remanufacturing, and Reuse, International Journal of Production Research, Vol. 36, pp.3227-3252, 1999.
7. **Spicer, A.,** Wang, M. H., Optimal Disassembly Sequence Generation for Complex Products: An Artificial Intelligence Approach, International Journal of Cleaner Production, Vol. 5, pp. 193-198, 1997.
8. **Spicer, A.,** Wang, M. H., Zamudio-Ramirez, P., Daniels, L., Disassembly Modeling Used to Assess Automotive Recycling Opportunities, SAE Technical Paper 970416, SAE Transactions, 1997.
9. Potvin, J.R., **Brown, S.H.M**, Less is more: High pass filtering out up to 99% of the surface EMG signal power improves EMG-based biceps brachii muscle force estimates. In press: Journal of Electromyography and Kinesiology 2004.
10. **Brown, S.H.M**., Potvin, J.R. Constraining spine stability levels in an optimization model leads to the prediction of trunk muscle co-activity and improved predictions of spine compression. In press: Journal of Biomechanics 2004.
11. **McKean, C**., Potvin, J.R. Effects of a simulated industrial bin on lifting and lowering mechanics. International Journal of Industrial Ergonomics. 28:1-15, 2001
12. Potvin, J.R., **Chiang, J., McKean, C**., Stephens, A. A psychophysical study to determine acceptable limits for repetitive hand impact severity during automotive trim installation. International Journal of Industrial Ergonomics. 26:625-637, 2000.

13. **Dominguez, H**., Lashkari, R.S., A Model for Integrating the Supply Chain of an Appliance Company: A Value of Information Approach, Int'l. Journal of Production Research. (Accepted for publication, September 30, 2003).

14. Lashkari, R.S., **Boparai, R., Paulo, J**., Towards an Integrated Model of Operation Allocation and Materials Handling Selection in Cellular Manufacturing System, Int'l. J. of Production Economics, 87:115-139, 2004

15. **Dominguez, H**., Lashkari, R.S., The Value of Information in the Operation of Integrated Supply Chain Management Systems, Journal of Industrial Engineering and Management Systems, 2:151-161, 2003.

16. X. Chen, **A. Tahmasebi** and G. Gu, "Local Robustness of Bifurcation Stabilization with Application to Jet Engine Control", in *Bifurcation Control: Theory and Applications*, edited by R. Chen et al, Spring-Verlag, 2003.

17. J. Shen, X. Chen, A. Masrur, V. K. Garg, and **A. Soltis**, "Optimal Power Management and Distribution in Automotive System", in *Handbook of Automotive Power Electronics and Motor Drives*, edited by A. Amadi et al, Marcel Dekker, 2005.

18. Henry Hu, **Fang Chen**, Xiang Chen, Yeou-li Chu and Patrick Cheng, "Effect of Cooling Water Flow Rates on Local Temperature and Heat Transfer of Casting Dies", to appear in *Journal of Materials Processing Technology*.

19. **Ali Tahmasebi** and Xiang Chen, "Robustness of Rotating Stall Control for Axial-Flow Compressors", *ASME J. Dynamic Systems, Measurement and Control*, Vol. 125, No. 3, pp. 424-428, 2003.

20. ElMaraghy, W.H., and **Urbanic J.R**., 2004, "Systems Modeling for Participatory Manufacturing", The Annals of CIRP, Vol. 54/1, pp. TBA.

21. ElMaraghy, W.H., and **Urbanic J.R**., 2003, "Modelling of Manufacturing Systems Complexity", The Annals of CIRP, Vol. 53/1, pp. 363-366.

22. ElMaraghy, W.H., and **Rolls, C.,** 2001, "Quality Product Digitization by Design", The Annals of CIRP, Vol. 51/1, pp. 93-96.

23. **ElDeeb, Y.**, and ElMaraghy, W.H., 1998, "Optimal Control of a Single Link Manipulator Including Motor Dynamics", Journal of Computer Integrated Manufacturing Systems, Vol.11, No.3, pp. 199-205.

24. **ElDeeb, Y.**, and ElMaraghy, W.H., 1998, "Robust Adaptive of a Robotic Manipulator Including Motor Dynamics", Journal of Robotic Systems, Vol.15, No. 11, 661-669.

25. **ElDeeb, Y.**, and ElMaraghy, W.H., 1997, "Off-line Programming and Control of Robotic Manipulator", Journal of Manufacturing Systems, Vol. 16, No. 4, pp. 291-296.

26. ElMaraghy, H.A., **Yang, X**., 2003, "Computer-Aided Planning of Laser Scanning of Complex Geometries", 53rd CIRP Annals, Vol. 52, No. 1, pp. 411-414.

27. ElMaraghy, H.A. and **ElMekkawy, T.Y**., 2002, "Deadlock-free Rescheduling in Flexible Manufacturing Systems", CIRP Annals, Vol. 51/1, pp. 371-374.

28. **ElKott, D**., EMaraghy, H.A. and ElMaraghy, W.H., 2002, "Automatic Sampling for CMM Inspection Planning of Free Form Surfaces", Int. J. of Production Research (IJPR), pp. 2733-2756.

29. **Vafaeesefat, A**. and ElMaraghy, H.A., 2001, "Rough Pocketing of Multi-Sculptured Surfaces Cavities", IMechE Journal of Engineering Manufacture, vol. 215 Part B, pp. 745-753.

30. ElMaraghy, H.A., **Patel, V**. and Ben Abdallah, I., 2000, "Scheduling of Manufacturing Systems under Dual-resource Constrains Using Genetic Algorithms", SME Journal of Manufacturing Systems, Vol. 19, No. 3, pp. 186-201.

31. **Vafaeesefat, A**. and ElMaraghy, H.A., 2000, "Automated Accessibility Analysis and Measurement Clustering for CMMs", Int. Journal of Production Research (IJPR), Vol. 38, No. 10, pp. 2215-2231.

32. Vafaeesefat, A. and ElMaraghy, H.A., 2000, "Optimal Work piece Orientations for Machining of Sculptured Surfaces", IMechE Journal of Engineering Manufacture, vol. 214 Part B. pp. 671-681.

33. Flynn, J.M., Holmes, J.D., and Andrews, D.M. The effect of localized leg muscle fatigue on tibial impact acceleration. In press: Clinical Biomechanics, 2004.

Papers in Refereed Conference Proceedings

1. **Baki, F**. and Wang, M. H., Management of Sustainable Development Innovation: Integration of TRIZ and QFD under the Framework of Soft Systems Methodology, CD-ROM Proceedings of 2003 International Society of Industrial Ecology Conference, Ann Arbor, MI, U.S.A..

2. **Johnson, M. R.** and Wang, M. H., Optimizing End-of-Life Economics within the Environmental Constraints of Extended Producer Responsibility, CD-ROM Proceedings of 2003 International Society of Industrial Ecology Conference, Ann Arbor, MI, U.S.A..

3. **Baki, F.** and Wang, M. H., Inclusion of Sustainable Development Principles in Product Development: Challenges and Opportunities, CD-ROM Proceedings of 2003 International Society of Industrial Ecology Conference, Ann Arbor, MI, U.S.A.

4. **Baki, F.,** and Wang, M. H., Sustainable Development Innovation (SDI): Beyond Traditional Innovation, CD-ROM Proceedings of the 4th Asia Pacific Conference on Industrial Engineering and Management Systems, 2002, Dec. 18-20, Taipei, Taiwan.

5. **Johnson, M.** and Wang, M. H., Sustainability and Management of End-of-life Vehicles (ELVs) within the European Union's Directive on ELVs, Proceedings of the SAE Environmental Sustainability Conference, Graz, Austria, November, Paper No. 2001-02-3735, 2001.

6. **Lee, H.**, Wang, M. H., On the Search of Workstations Arrangement in Pull Production Systems, CD-ROM Proceedings of the 5th Annual International Conference on Industrial Engineering, Paper #197, December 13-15, 2000, Taipei, Taiwan.

7. Wang, M. H., **Majety, R.,** Procedure Framework for Product Life Cycle Assessment Using Enterprise Network Approach, Paper#13024, CD-ROM Proceedings of 2000 Japan USA Symposium on Flexible Automation, July 23-26, Ann Arbor, MI, USA.

8. Wang, M. H., **Majety, R**., A Computer Template for Enterprise Network Life Cycle Assessment, CD-ROM Proceedings of the Canadian Society for Civil Engineering 2000 Conference, June 7-10, London, Ontario.

9. Wang, M. H., **Spicer, A.,** A Product Disassembly Planning Tool Using Genetic Algorithms, Proceedings of the 3rd International Conference on Engineering Design and Automation, pp. 222-229, August 1-4, 1999, Vancouver, B.C., Canada.

10. **Tung, C.,** Wang, M. H., Life-Cycle Cost Comparison between Plastic and Steel Fuel Tanks, Proceedings of the 3rd International Conference on Engineering Design and Automation, pp. 388-395, August 1-4, 1999, Vancouver, B. C., Canada.

11. **Spicer, A., Johnson, M.,** and Wang, M. H., Inverse Manufacturing Systems Optimization Through Disassembly Analysis, Proceedings of 1st IEEE International Symposium on Environmentally Conscious Design and Inverse Manufacturing, Tokyo, Japan, February, 1999.

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19. Djurdjevic, M.B., **Francis, R**., Lashkari, R.S., Ngom, A., Sokolowski, J.H. Application of Artificial Neural Networks in the Prediction of the Aluminum Silicon Modification Level of W319 Aluminum Alloys, Proc. of the American Foundry Society 107th Casting Congress, Milwaukee, WI, April 26-29, 2003.

20. **Dominguez, H**., Lashkari, R.S., The Value of Information in the Operation of Integrated Supply Chain Management Systems, Proc. of the 4th Asia-Pacific Conference on Industrial Engineering and Management Systems (APIEMS'02), Taipei, Taiwan, December 18-20, 2002.

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31. **ElKott, D.**, ElMaraghy, H.A., and ElMaraghy, W.H., 2000, "Computer-aided Free Form Surfaces Sampling System (CASampler)", 2000 Pacific Conference on Manufacturing (PMC'2000), Sept. 6-8, Southfield, MI

32. **Rolls, C.,** ElMaraghy, W.H. and ElMaraghy, H.A., 1999, "Towards Combining Digitization Techniques in the Generation of Reverse Engineering Data Sets", 1999 ASME Int. Computers and Information in Engineering Conference, Paper #CIE-9130, September 12-15, Las Vegas, Nevada

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34. **Shabaka, A.I**., ElMaraghy, H., "Structural Mapping Between Operation Clusters and Machine Configuration for RMS", Advanced Manufacturing Technologies 2004, AMT 2004, London, June 1-2 (*Accepted March 2004)*

35. **Kuzgunkaya, O.**, ElMaraghy, H., "Lifecycle Cost Evaluation of Re-Configurable Manufacturing Systems", Advanced Manufacturing Technologies 2004, AMT 2004, London, June 1-2 (*Accepted March 2004)*

36. **Nada, O**., ElMaraghy, H., ElMaraghy, W.H., "A Conceptual Framework for Six-Sigma Manufacturing System Configuration Quality Zone", Advanced Manufacturing Technologies 2004, AMT 2004, London, June 1-2 (*Accepted March 2004).*

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38. **Godin, C.**, Andrews, D.M., and Callaghan, J.P. Cumulative low back loads of non-occupational tasks using a 3-dimensional video-based posture sampling approach. CD-ROM Proceedings of XXIV Association of Canadian Ergonomists Conference, London, Ontario, 2003.

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5.4 Projected Doctoral Graduate Enrolments

The Ph.D. graduate enrolment targets for the next five years are as indicated in Table 5.4 below.

Table 5.4 Projected Doctoral Graduate Enrolments

PROJECTED INTAKE AND ENROLMENTS Doctoral Program					
Year	Full-Time		Part-Time		Total Enrolment
	Intake	Enrolment	Intake	Enrolment	
2004	0	9	0	0	9
2005	5	10	0	0	10
2006	5	15	0	0	15
2007	5	20	0	0	20
2008	5	20	0	0	20
2009	5	20	0	0	20
2010	5	20	0	0	20

These targets are based on the supervision capacity of the core faculty who are part of this application. An additional faculty member in IMSE will soon be in place. Furthermore, we believe that this multi-disciplinary model will attract more faculty participants once the program is in place.

APPENDIX 1

INTELLIGENT MANUFACTURING SYSTEMS (IMS) CENTRE

The IMS Centre was established in 1994 and comprises three state-of-the-art research Laboratories dealing with manufacturing systems design and operation, product design, and intelligent automation. The Center research is supported by NSERC, Auto 21, CFI & OIT. Collaborators include industry NRC/IMTI, and many University researchers nationally and internationally.

Canada Research Chair in Manufacturing Systems Engineering

Dr. Hoda ElMaraghy became a Canada Research Chair in 2002. The research program emphasizes automotive applications and aims at investigating: Modern Manufacturing Systems design and operation, physical and logical re-configuration, Integrated design of products and systems, Harmonized human-oriented manufacturing systems, Innovative design & rapid product development and manufacture.

MAJOR IMS CENTRE FACILITIES:

Flexible Automation And Robotics (FAR) Lab (EH 305)

- Automated Bosch conveyor system and flexible assembly work cell
- Adept-One and Puma-560 Robot Systems
- Vision, force, acceleration, torque, and tactile-array sensors
- Experimental flexible-joint and links robots and controls
- Allen-Bradley PLC and vision system
- Software: Arena/Siman, Witness, SimNet, Lingo, Image WorkFrame
- Unix workstations: SUN and SGI

Integrated Design And Manufacturing (IDM) Lab (EH 307)

- Sunfire 280R server networked with all 3 labs
- Sunblade 2000 workstations
- Simulation: SIMAN, CINEMA, WITNESS
- Geometric Modeling: I-DEAS, AutoCAD
- Analysis: MatrixX, XMath, Macsyma, MAPLE, MatLab
- Robocell, RPE, RobCIM, Sysbond, etc.

Advanced Manufacturing Research (AMR) Lab (EH B-24)

- Industrial robots: COMAU S2, COMAU 6.60R
- Coordinate measuring machine (DEA Mistral)
- Rapid prototyping machine: Stratasys - Prodigy FDM
- Vision system: PCs, CCD cameras and ImageWork Frame
- Laser scanner (Metris/3D)
- PCs and workstations (SUN, SGI).

- Reverse engineering software: SURFER, TUTOR, HYSCAN, IMAGEWARE
- Geometric modeling software:I-DEAS/Unigraphics
- Workcell simulation software, off-line programming: TELEGRIP, WORKSPACE

RESEARCH SCOPE

Manufacturing Systems Engineering

The effective design and operation of manufacturing systems, in particular Flexible (FMS) & Reconfigurable Manufacturing Systems (RMS), are important for competitiveness and productivity. They present many challenges.

Research Topics

- Modern, Flexible and Re-configurable Manufacturing Systems design and operation.
- Complexity, changeability and reconfigurability.
- Capacity and functional scalability.
- Assembly, dis-assembly & DFA
- Flexible Automation and Robotics.
- Economic life cycle analysis and justification.
- Dynamic process planning.
- Production planning and scheduling.
- Optimal systems configuration and performance.
- Quality issues in the design and implementation of RMS.
- Participatory manufacturing systems including humans and machines.
- Intelligent Manufacturing Systems design, modeling and simulation.

Integrated Design and Manufacture

Brilliant product designs are important in a Global manufacturing environment. The ability to bring a superior product to market faster and at a lower cost than a competitor is a major advantage.

Research Topics

- Design innovation.
- Design theories and methodologies.
- Collaborative design.
- Design for Rapid Manufacture and Inspection.
- Adaptive and integrated machining and inspection.
- Physical and virtual prototyping for Auto-applications.
- Assemblability evaluation and validation of the designer's intent.
- Design tolerance analysis and synthesis – Virtual tolerance selection and assessment models.
- Design of sculptured surfaces.
- CMM and laser inspection and planning, digitization and reverse engineering.

- Design for Assembly, dis-assembly and design for composites.
- Design for rapid tooling for both prototyping and production.
- Vehicle design, dynamic analysis and control

Reconfigurable Control Process for Manufacture (RCPM)

This NSERC-funded strategic project aims at developing new configurable control process and tools to adapt easily to reconfigured products or manufacturing systems. This is important to cope with the manufacturing paradigm shift to mass customization, flexibility and changeability and to maximize productivity. A unified Reconfigurable Open Control Architecture, UROCA, is being developed for application to products, machines and manufacturing systems.

Research Topics

- Modular reconfiguration of products and systems.
- Unified reconfigurable open architecture control.
- Concurrent bi-directional, hierarchical and intelligent supervisory control.
- Reactive, deliberative and hybrid control.
- Real-time control of products and systems with Hardware-in-the-Loop simulation and verification.
- Demonstration/simulation for a range of industrial robots, selected classes of CNC machine tools, manufacturing systems and automobile modules as well as their control test benches.
- Experimental validation and industrial applications

APPENDIX 2

RESEARCH GROUPS ACTIVITIES

I) OPERATIONAL RESEARCH

1) Windsor 2003 Student Operational Research Day

Graduate students, Sienny Sujono, Kanchan Das, and N.K.Vidyarthi of the Manufacturing Systems Design and Modeling Research Group, presented papers at the Windsor 2003 Student Operational Research Day on Thursday, August 28, 2003. Dr. Katta G. Murty gave keynote speech. The faculty members of the Group and the Operational Research Group attended the meeting.

2) Summer 2003 Get-Together (Industrial Engineering Professor Honoured by Peers, Students)

Dr. Reza Lashkari was honoured for 25 years of dedicated contribution to research and teaching at the University of Windsor by his colleagues from the Manufacturing Systems Design and Modeling Research Group and the Operational Research Group at an event held on campus on June 27, 2003. The annual summer get together was attended by the members of the two research groups including the director of the OR Group and Dean of Science, Dr. Richard Caron. Graduate students of IMSE, Navneet Vidyarthi, Sienny Sujono, Niloofar Mahmoudi and Kanchan Das arranged the event.

3) Operational Researchers hold Windsor session at MOPTA '03

Dr. Guoqing Zhang, Industrial and Manufacturing Systems, organized and chaired a Windsor session with three talks by Dr. Fazle Baki, himself, and Mr. Xiaowu Ke. Dr. Richard Caron, Mathematics and Statistics, chaired two sessions in the MOPTA '03 conference held in Hamilton, July 30 - August 1, 2003.

II) INTELLIGENT MANUFACTURING SYSTEMS (IMS)

The IMS Centre offers regular meetings for the member graduate students and researchers to stimulate discussion and deeper understanding of research topics of interest. It also hosts seminars by visiting speakers and internal presenters. A selection of such seminars follows:

Sample IMS Research Group Meetings in 2004

Date	Presenter and Subject
Wed., April 21, 2004 10:00 a.m.-12:00 p.m. OB 207	Seminar: **Dr. Youssef Abbaszadeh**, University of California (Intelligent Process Planning)
Tues., April 20, 2004 1:30 p.m.-3:00 p.m. OB 209	Seminar: **Mr. Tamer Abdulmaguid**, University of Southern California (Heuristic approaches for integrated inventory distribution)
Tues., April 13, 2004 1:30 p.m.-3:00 p.m. OB 209	Presentations: **Ahmed ElShenawy** (Optimization and Visualization of Rapid Prototyping Parameters)
Tues., April 6, 2004 1:30 p.m.-3:00 p.m. OB 209	Presentations: **Miss Min Xu**, Graduate Student, University of Regina (ChanCe constrained programming approach to capacity estimation when machine performances are unreliable)
Wed., March 31, 2004 12:00 p.m.-1:00 p.m. Lambton Tower G141	Seminar: **Dr. Jian Wang**, Katholieke Universiteit Leuven (Robust Tracking Controller Design with Application to the Motion Control of an X-Y Feed Table for High-Speed Machining)
Tues., March 23, 2004 1:30 p.m.-3:00 p.m. Lambton Tower G141	Seminar: **Dr. Ali Ahad**, University of Wisconsin, Milwaukee (Multi Constraint Based Intelligent Scheduling and Wed Enabled Integration Systems)
Tues., March 16, 2004 1:30 p.m.-3:00 p.m. OB 209	Presentations: **Anas Kazaal** (Implementation Systems Analysis and Design Modeling For Managing Complexity in Manufacturing Systems)
Tues., March 9, 2004 1:30 p.m.-3:00 p.m. OB 209	General Research Meeting **Dr. Hoda ElMaraghy –** Changeable Manufacturing
Tues., March 2, 2004 1:30 p.m.-3:00 p.m. OB 209	Seminar: **Dr. Yuping He**, University of Waterloo (A Design Methodology for Mechatronic Systems: Application of Multidisciplinary Optimization, Multibody Dynamics, and Genetic Algorithms)
Tues., February 17, 2004 2:00 p.m.-3:00 p.m. OB 209	Presentations: **Ayman Youssef** (Development of a Reconfiguration Smoothness Metric: A Brain Storming Session)
Tues., February 10, 2004 2:00 p.m.-4:00 p.m. OB 209	Presentations: **Jing Gao** (Engineering Collaborative Design and Negotiation)
Wed., February 4, 2004 1:00 p.m.-3:00 p.m. OB 207	General Research Meeting **Dr. Waguih ElMaraghy –** Manufacturing Complexity

Sample IMS Research Group Meetings in 2003

Date	Presenter and Subject
Wed., December 10, 2003 10:00 a.m.-12:00 p.m. OB 207	Presentations: **Rami Shahin** (Reconfigurable Control for NC Machines)
Thurs., December 4, 2003 2:30 p.m.-3:30 p.m. EH 107E	Presentations: **Dr. E. ElBeheiry** (Re-configurable Control Process for Manufacturing-UROCA)
Thurs., November 27, 2003 2:00 p.m.-3:30 p.m. EH 107E	Presentations: **Ana Djuric** (Reconfigurable Control for Robotic Systems)
Thurs., November 20, 2003 2:00 p.m.-3:30 p.m. EH 107E	Presentations: **Omayma Nada** (Quality Issues in the Design and Implementation of Reconfigurable Manufacturing Systems) **Onur Kuzgunkaya** (A Multi-criteria Decision Making Approach for the Selection of a Reconfigurable Manufacturing System)
Thurs., November 13, 2003 2:00 p.m.-3:30 p.m. EH 107E	Presentation: **Marvin Zhong** (A Data Exchange System in E-Manufacturing) **Jill Urbanic** (Integrated Design and Manufacturing)
Thurs., November 6, 2003 2:00 p.m.-3:30 p.m. EH 107E	Presentations: **Ayman Youssef** (Design of System Configuration for Reconfigurable Manufacturing Systems)
Thurs., October 30, 2003 2:00 p.m.-3:30 p.m. EH 107E	Presentation: **Amr Shabaka** (Process Planning for Reconfiguration)
Wed., October 29, 203 2:00 p.m.-3:30 p.m. EH 107E	Presentation: **Ahmed ElShenawy** (Visualization of Rapid Prototyping Processes)
Thurs., October 23, 2003 1:30 p.m.-2:30 p.m. Lampton Tower G141	Web Seminar: OPAL RT “Virtual Prototyping of Aircraft Control Systems With HIL”
Wed. October 16, 2003 1:00 p.m.-4:00 p.m. EH 107E	Presentation: **Dr. Tarek Lahdhiri** (UROCA Workshop Leader; “Hardware-in-the-loop”)
Wed. October 8, 2003	Presentation: **Davide Faccenda** (Optimization of Process Parameters for Rapid Prototyping)

Wed. October 1, 2003	Presentation: **Ahmed Deif** (Design and Control of Reconfigurable Manufacturing Systems - Capacity Scalability Modeling)
Tues. June 24, 2003	Seminar: **Dr. H. Fathy** "Combined Plant and Control Optimization: Theory, Strategies,and Application to Car Suspensions, Elevators, and RMT Geared DC Spindle Drives?"
Tues. May 29, 2003	**MMO Speaker Series Seminar:** **Dr. Jay Lee** – Distinguished Lecturer Series "Web-enabled Infotronics Technologies for E-Maintenance and E-Manufacturing"
Wed. May 5, 2003	Presentations: **Omayma Nada** (Quality Issues in the Design and Implementation of Reconfigurable Manufacturing Systems)

APPENDIX 3

GRADUATE COURSES FOR PROPOSED MULTI-DISCIPLINARY PH.D PROGRAM IN INDUSTRIAL AND MANUFACTURING SYSTEMS ENGINEERING

All students in the Ph.D. program are required to take **a minimum of two courses** from those graduate courses offered by IMSE (**Category A**), **and a minimum of one from the courses** offered by other Departments/Faculties at the graduate level **(Category B).**

Category A: Graduate Courses

91-500. Optimization
Classical theory of optimization. Kuhn-Tucker conditions. Unconstrained optimization; gradient methods, conjugate gradient methods, variable metric methods, search techniques. Constrained optimization. Approximation methods, projection methods, reduced gradient methods; penalty function methods; computational algorithms. Recent advances in optimization. Use of computer software packages. (Prerequisite: 91-312 or equivalent.) (3 lecture hours a week.)

91-501. Industrial Experimentation and Applied Statistics
Distributions of functions of variables, estimations and tests of hypotheses, power of tests, non-parametric tests, sampling techniques, analysis of variance, randomized blocks. Latin squares and factorial experiments. (Prerequisite: 91-227 or equivalent.) (3 lecture hours a week.)

91-502. Manufacturing Systems Simulation
Discrete-event system simulation. Random number generation. Stochastic variate generation. Input parameters; identification and estimation. Output analysis. Static and dynamic output analysis; initial and final conditions; measures of performance and their variance estimation; confidence interval. Design of experiments. Various sampling techniques. Single and multifactor designs. Fractional designs. Response surfaces. Regeneration method for simulation analysis; Monte Carlo optimization. (3 lecture hours a week.)

91-503. Production and Inventory Control Systems
Analysis of production-inventory systems. Inventory systems; deterministic, single-item and multi-item models; quantity discounts; stochastic, single-period models; periodic review and continuous review models. Production planning. Static demand models; product mix and process selection problems; multi-stage planning problems. Dynamic demand models; multi product and multistage models. Operations scheduling; job shop scheduling; line balancing. New directions in production systems research. (Prerequisite: 91-413 or equivalent.) (3 lecture hours a week.)

91-504. Advanced Operations Research I
Theory and computational techniques for solving linear and integer programming problems. Theoretical foundations of the simplex algorithm. Duality, sensitivity analysis and parametric programming. Network flow methods. Integer programming problems. Cut algorithms, branch and bound, and implicit enumeration methods. Dynamic programming. Recent developments. (Prerequisite: 91-312 or equivalent.) (3 lecture hours a week.)

91-505. Advanced Operations Research II
Probabilistic O.R. models. Markovian decision process. Queueing theory. Single channel and multichannel queueing systems. Queues with general arrival and service patterns. Bulk queues and priority queues. Applications of queuing models. Probabilistic dynamic programming. (Prerequisite: 91-412 or equivalent.) (3 lecture hours a week.)

91-507. Advances in Industrial Ergonomics
Ergonomics and work design; human workload measurement in industry; visual display terminals at the workplace; signal detection and visual inspection; user-computer interaction; human factors aspects of flexible manufacturing systems; effects of individual and combined environmental stressors on human performance. (Prerequisite: 91-415 or equivalent.) (3 lecture hours a week.)

91-508. Reliability Engineering
Basic reliability distributions. Constant failure rate models-exponential reliability function, Poisson process. Time dependent failure models-the Weibull, normal, lognormal distributions. State-dependent systems-Markov analysis. System reliability-system structure function. Reliability growth testing-noon-parametric methods, censored testing and accelerated life-testing. Design for reliability-specification, reliability allocation, failure analysis, system safety. Maintainability and availability. (Prerequisite: 91-327 or equivalent.) (3 lecture hours a week.)

91-509. Computer-Integrated Manufacturing
Development of CIM; the CIM pyramid-key functions. System integration; standards for communications-MAP. Data base as the hub of CIM-types of data base. Role of simulation and support systems-decision support systems and expert systems. Sensor technology, robot vision, and group technology. Impact of CIM. Factory of the future. (Prerequisite: 91-411 or equivalent.) (3 lecture hours a week.)

91-510. Advanced Engineering Economy
Principles and methods for engineering analysis of industrial projects and operations. Criteria for economic decisions, project investment analysis, gain and loss estimating and techniques for economic optimization under constraint are included. Emphasis is placed on the construction and use of analytical models in the solution of engineering economy problems. Elements of risk and uncertainty are included through use of probabilistic techniques. (Prerequisite: 85-313 or equivalent.) (3 lecture hours a week.)

91-511. Stochastic Processes
Stochastic processes. The Poisson process-relationship to exponential, Erlang and uniform probability distributions. Markov chains-basic limit theorem. Continuous time Markov chains--birth-and-death processes, time-dependent probabilities, limiting probabilities, relationship to the exponential distribution, uniformization. Renewal theory-limit theorems, renewal reward processes, regenerative processes, computing the renewal function. Brownian motion and stationary processes. (Prerequisite: Statistics 91-412 or equivalent.) (3 lecture hours a week.)

91-512. Flexible Manufacturing Systems
Production Systems, Flexible Automation, Computer-Integrated Manufacturing, Group Technology, Cellular Manufacturing, Flexible Manufacturing Systems, Assembly Systems, Materials and tools handling, Robotics In Manufacturing, Principles Of Design For Manufacture, Process Planning And Concurrent Engineering, New Trends-Lean, Agile And Re-Configurable Manufacturing Systems. (Prerequisite: 91-413, 91-502, 91-509 or equivalent/permission of instructor.) (3 lecture hours a week.)

91-513. Advanced Manufacturing Technology
Developments in nontraditional methods in EDM and ECM. Trends in automation. Recent developments in manufacturing processes; micromanufacturing—integrated circuits and laser machining. Advances in computer technology, CAD and CAM. Kinematics of manipulation robots, artificial intelligence, monitoring and vision systems. (Prerequisite: 91-321 or equivalent.) (3 lecture hours a week.)

91-514. Engineering Design, Methodology & Applications
Engineering Design is a creative, iterative and often open-ended process subject to constraints. Topics include: design creativity & problem solving, engineering conceptual design & embodiment design, practices for product realization design theories and methodologies, parametric design, probabilistic design, industrial design, design and manufacturing integration, concurrent engineering, materials selection in design, design for x (*e.g.* manufacturing, assembly), engineering design communication. Significant time is devoted to the applications of design theories and methodologies and to a product/process design realization.(3 lecture hours a week.)

91-515. Artificial Intelligence Applications in Manufacturing
The objective of this course is to teach graduate students how artificial intelligence techniques can be applied to manufacturing operations. Detailed topics to be discussed in this course include: basic knowledge representation methods and problem solving techniques; different search algorithms; introduction to AI high level languages; introduction to the CLIPS shell; AI application in Design; AI application in Operation Management; AI application in Diagnosis; and, AI application in Control.(Prerequisite: 91-503 or 91-504 or equivalent.) (3 lecture hours a week.)

91-516. Computer-Aided Design (CAD)
This course will focus on computer-aided methods and applications. The lectures present basic and generic principles and tools, supplemented with significant hands-on practice and engineering applications. Various topics are studied and practiced using CAD/CAE software, such as engi- neering design and the role of CAD, geometric modelling systems, representation of curves and surfaces, surface modelling, solid modelling and applications, parametric representations, assembly modelling, computer-aided engineering (CAE) and applications, distributed collaborative design, and digital mock-up. (Prerequisite: 91-411 or equivalent.) (2 lecture hours a week and 2 laboratory hours a week.)

91-590. Special Topics
Selected advanced topics in the field of Industrial Engineering. (3 lecture hours a week.)
Current topics include:
Sustainable Manufacturing
Industrial Control & Robotics
Management of Technology
Product Innovation & Design Management
Recent Advances in Industrial Ergonomics
Computer-Aided Modeling of Complex Surfaces
Lean Manufacturing & Supply Chain Management
Advanced Algorithms/Numerical Methods
Product Design / Work Measurement

91-595. Graduate Seminar
Presentations by graduate students, staff, and visiting scientists on current research topics. Graduate students are required to register and give a presentation in the semester prior to thesis defence. All graduate students are expected to attend each and every seminar and no less than 75% of all seminars. This course will be graded on a PASS/FAIL basis.(1 lecture hour a week.)

Category B: Other Related Graduate Courses

88-533 Computational Intelligence
88-536 Automotive Control Systems
92-540 Applied Finite Element Analysis
76-504 Quantitative Techniques in Management
76-514 Management of Information Systems
73-603 Management Science Models
73-604 Operations Management
60-554 Advanced Algorithms
60-561 Artificial Neural Networks
60-576 Advanced Search Methods
62-568 Numerical Analysis I
62-595 Mathematical Programming

62-598 Integer programming & combinatorial optimization
65-546 Statistical Data Analysis
65-552 Experimental Design
65-556 Decision Theory
95-522
95-524

APPENDIX 4

THE IMSE MASTER'S DEGREE PROGRAMS

A Masters and M.Eng. Degrees in Industrial and Manufacturing Systems Engineering are offered by the IMSE Department. The ***M.A.Sc. is a thesis-based*** Degree that provides graduates with the options of pursuing a Doctorate Degree or to further advance their careers with a state of the art new knowledge base in their industries which enhances Canada's global competitiveness. The ***M.Eng. is a course- based*** Degree that satisfies the need for continuing professional development among practicing engineers. The goals and learning objectives of both degrees are described in the following sections.

1. IMSE M.A.SC. PROGRAM SUMMARY

The IMSE department is pleased to offer the opportunity to earn advanced academic qualifications of a M.A.Sc. Degree in Industrial Engineering. This advanced thesis-based degree provides graduates with the options of pursuing a Doctorate Degree or to further advance their careers with a state of the art new knowledge base in their industries that enhances Canada's global competitiveness.

The program attracts excellent people from throughout the Windsor-Essex County, from the USA and from many nations from around the world. A strong market for this program exists now, and will only grow in the future as the value of advanced education becomes more widely recognized in industry. The IMSE department is uniquely positioned to offer a graduate industrial, supply chain and manufacturing systems curriculum of interest to advanced researchers and many working engineers.

IMSE M.A.Sc. Academic Goal

Overall aim

The goal of IMSE's M.A.Sc. Degree program is to provide students with the opportunity to extend the understanding of engineering principles involved in specific disciplines beyond the coverage possible in an undergraduate program, and to enhance their grasp of the application of these principles to the solution of complex, research driven solutions to problems.

The program is normally offered on a part-time and full time basis to engineers with a Bachelor's degree (or equivalent). The research knowledge they will acquire will enable them to integrate IMSE engineering and management knowledge, techniques and skills to achieve desired goals in theoretical research, and in engineering or service organization.

What the program accomplishes

This IMSE program provides an M.A.Sc. Degree that better accommodates part time and full time students who wish to pursue a career in advance research / academia as well as those from industry seeking to earn an advanced thesis based Masters of Applied Science Degree.

Enhancing engineering skill sets.

The Industrial and Manufacturing Systems Engineering (IMSE) degree is unique and innovative. It provides a broad-based graduate level curriculum of practical material that further develops graduate engineering skills for which demand exceeds supply in industry, manufacturing and the business world. Our graduates - who are in demand globally - are employed in areas such as product engineering, process engineering, plant / facility engineering, tool engineering, industrial engineering, and human factors. They manage and improve performance for banks, railroads, petroleum, airlines, insurance companies and hospitals to name a few. This research thesis-based M.A.Sc. provides the combination of industry experience, cutting-edge research and a skills-driven curriculum that prepares and challenges students to top performance.

IMSE M.A.Sc. Learning Objectives

Students will have an opportunity to extend their understanding of engineering principles involved in research, industrial and business sectors beyond the coverage possible in an undergraduate program.

Successful students will be qualified to accept leadership roles and responsibilities of:

Manufacturing systems design, operation and control
Automotive Assembly Engineering
Designing And Building Product For Profit
Supply Chain Engineering
Corporate Logistics
Warehousing And Inventory Management
Facility/Plant Engineering
Tool Engineering
Manufacturing Driven Product Design
Process Engineering
Manufacturing Engineering
Industrial Engineering
Ergonomics Engineering
Integrate Human Factors In Product Design

and lead / manage engineering staffs, division and manufacturing facilities. This M.A.Sc. degree will prepare the foundations for more advanced studies at the Doctorate level for those who choose to prepare for an advanced academic or research career.

Relationship of IMSE M.A.Sc. Goals and Objectives to University and Other Priorities

The University of Windsor has always had a strong focus on the Automotive Sector by virtue of its location in the automotive capital of Canada, a successful co-op engineering education program and a fine record of research in automotive engineering, manufacturing engineering and business.

In 1997, the University identified Automotive Engineering as one of its pinnacles of academic excellence and launched Canada's first dedicated university level education program in Automotive Engineering. Since that time, the automotive engineering program, through its partnerships with industry and other educational institution, has proven to be a resounding success. It has attracted significant international attention and continues to produce graduates who are in consistently high in demand in this important sector. The M.A.Sc. is an industrial and manufacturing based graduate degree that supports the identified University pinnacle of academic excellence in automotive manufacturing engineering.

2. IMSE MEng PROGRAM SUMMARY

Continuing professional development is a specific requirement of all professions in Canada and the engineering profession is no exception to this rule. Keeping practicing engineers in industry, commerce and government service up to date with the latest developments and giving them an opportunity to earn advanced academic qualifications helps them to do their jobs more effectively, advance their careers and the state of the art in their industries which enhances Canada's global competitiveness.

Assisting in achieving these goals is a key motivator for the IMSE department to develop the M.Eng. Degree programs described below. The program will attract excellent people from throughout the Windsor-Essex county area as well as from the USA. IMSE is confident that a strong market for this program exists now and will only grow in the future as the value of advanced education becomes more widely recognized in industry. The IMSE department is uniquely positioned to offer a graduate industrial, supply chain and manufacturing curriculum of interest to many working engineers.

IMSE MEng Academic Goal

<u>Overall aim</u>

The goal of IMSE's M.Eng. Degree program is to provide students (mostly practicing engineers) with the opportunity to extend the understanding of engineering principles involved in specific disciplines beyond the coverage possible in an undergraduate program, and to enhance their grasp of the application of these principles to the solution of complex, practical problems.

The program will therefore be normally offered on a part-time basis to engineers with a Bachelor's degree (or equivalent) who would normally be in employment. They will be considered as mature students who will advance their research knowledge and will be capable of integrating IMSE engineering and management knowledge, techniques and skills to achieve desired goals in an engineering or service organization.

What the program accomplishes

This new IMSE program will provide a new M.Eng. Degree that better accommodates part time students from industry seeking to earn a course-based non-thesis Masters degree.

Enhancing engineering skill sets

The Industrial and Manufacturing Systems M.Eng. Degree is unique and innovative. It provides a broad-based graduate level curriculum of practical material that further develops graduate engineering skills for which demand exceeds supply in industry, manufacturing and the business world. Our graduates - who are in demand globally - are employed in areas such as product engineering, process engineering, plant / facility engineering, tool engineering, industrial engineering, and human factors. They manage and improve performance for banks, railroads, petroleum, airlines, insurance companies and hospitals to name a few. This new M.Eng. provides a combination of industry experience, cutting-edge research and a skills-driven curriculum that prepares and challenges students to top performance.

IMSE MEng Learning Objectives

Students will have an opportunity to extend their understanding of engineering principles involved in industrial and business sectors beyond the coverage possible in an undergraduate program.

Successful students will be qualified to accept leadership roles and responsibilities of:
Manufacturing systems design, operation and control
Automotive Assembly Engineering
Designing And Building Product For Profit
Supply Chain Engineering
Corporate Logistics
Warehousing And Inventory Management
Facility/Plant Engineering
Tool Engineering
Manufacturing Driven Product Design
Process Engineering
Manufacturing Engineering
Industrial Engineering
Ergonomics Engineering
Integrate Human Factors In Product Design, and
Lead / Manage Engineering Staffs, Division And Manufacturing Facilities

Relationship of IMSE M.Eng Goals and Objectives to University and Other Priorities

The University of Windsor has always had a strong focus on the Automotive Sector by virtue of its location in the automotive capital of Canada, a successful co-op engineering education program and a fine record of research in automotive engineering, manufacturing engineering and business.

In 1997, the University identified Automotive Engineering as one of its pinnacles of academic excellence and launched Canada's first dedicated university level education program in Automotive Engineering. Since that time, the automotive engineering program through its partnerships with industry and other educational institution has proven to be a resounding success. It has attracted significant international attention and continues to produce graduates who are in consistently high in demand in this important sector. This M.Eng. program creates a new industrial and manufacturing based graduate degree that supports the President's pinnacle of academic excellence in automotive manufacturing engineering.

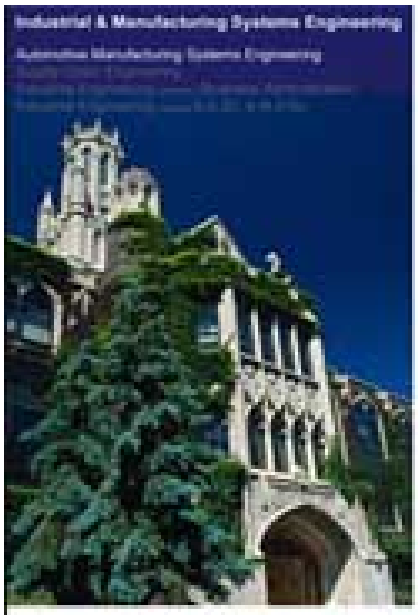
Justification/Rationale

In this era of global competitiveness, every organization in Canada needs to ensure that its management and technical personnel are continuously provided with opportunities to upgrade their knowledge base. In all fields of engineering, it has now been recognized that a Bachelor's degree is insufficient preparation for a career in any given discipline. For this reason, licensing organizations across Canada that regulate the practice of engineering are examining ways of requiring engineers to demonstrate on-going continued education to assure continuing competence to practice.

Organizations that employ engineers are therefore strongly encouraging schools of engineering to offer graduate programs which allow practicing engineers to obtain advanced degrees, such as an M.Eng. without excessive demands within their normal working hours. This demand is particularly strong in locales such as Windsor and in the automotive, tool and die and general manufacturing industries.

APPENDIX 5

RESTRUCTURED IMSE UNDERGRADUATE PROGRAM WITH OPTIONS IN AUTOMOTIVE MANUFACTURING SYSTEMS, SUPPLY CHAIN MANAGEMENT AND IE WITH MINOR IN BUSINESS



Automotive Manufacturing Systems Engineering

An Unique Undergraduate Engineering Option
Designed to Meet Manufacturing Demands

We invite you to consider an innovative manufacturing assembly curriculum that prepares graduates for high growth potential careers in which the demand exceeds the supply in the automotive industry, manufacturing, and the business world.

Our graduates are employed globally in areas including:

- Manufacturing Systems
- Product Engineering
- Plant / Facility Engineering
- Human Factors / Ergonomics
- Process Engineering
- Tool Engineering
- Fastening Engineering
- Senior Corporate Management

WINDSOR Engineering

Industrial and Manufacturing Systems Engineering Department

First Year - the Fall and Winter terms are common to all Engineering programs

Second Year - Industrial Engineering (Automotive Manufacturing Systems Engineering)

Fall Term		Lecture	Lab
85-211	(Comp. Aided Analysis II)	3	1.5
85-212	(Thermodynamics)	3	1.5
85-214	(Circuit Analysis II)	3	1.5
85-217	(Mech. of Deformable Bodies)	3	2.0
85-219	(Intro. to Engineering Materials)	3	2.0
82-215	(Vector Calculus)	3	1.0

Winter Term		Lecture	Lab
85-222	(Treatment of Experimental Data)	3	1.0
85-233	(Fluid Mechanics I)	3	1.0
82-216	(Differential Equations)	3	1.0
71-140	(Principles of Management)	3	0

Two Non-Technical Electives

Third Year – Industrial Engineering (Automotive Manufacturing Systems Engineering)

Fall Term		Lecture	Lab
91-312	(Operations Research I)	3	2.0
85-313	(Engineering Economy)	3	2.0
91-327	(Product Quality & Reliability)	3	2.0
91-301	(Human Factors)	3	2.0
91-317	(Systems Analysis & Design)	3	2.0

One Automotive Manufacturing Technical Elective

Winter Term		Lecture	Lab
91-333	(Industrial Health and Safety)	3	2.0
91-321	(Auto Manufacturing Process)	3	2.0
91-332	(Statistical Methods, DOE for Mfg.)	3	2.0
91-315	(Mfg. Driven Product Design)	3	0
91-311	(Computer Aided Design & Mfg.)	3	2.0

One – Non-Technical Elective

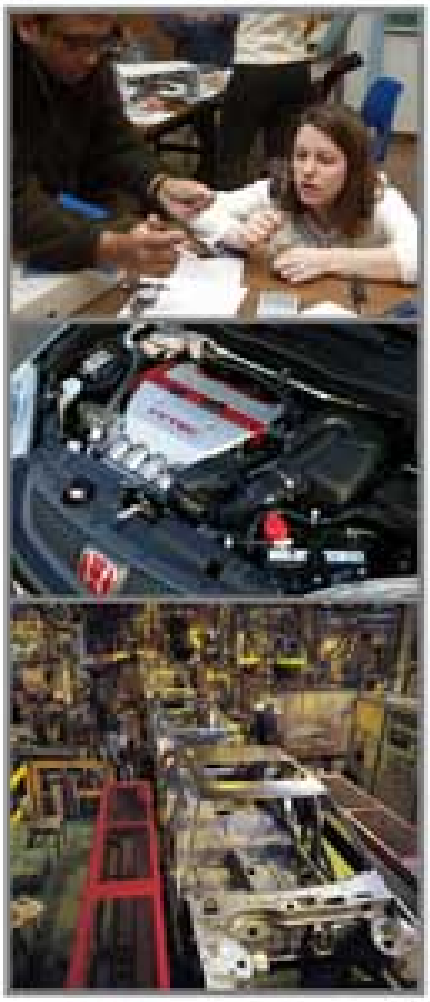
Fourth Year – Industrial Engineering (Automotive Manufacturing Systems Engineering)

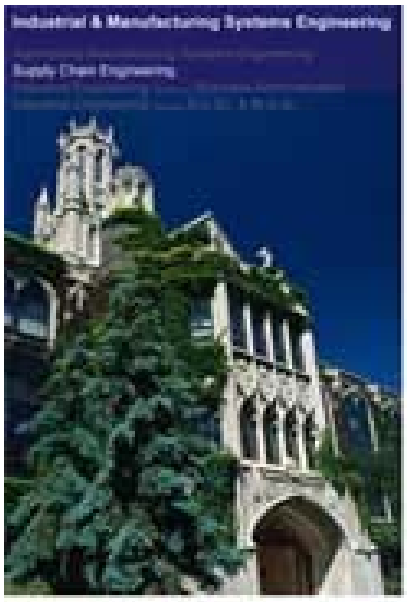
Fall Term		Lecture	Lab
91-400	(Capstone Design Project)	1	6.0
91-422	(Simulation of Industrial Systems)	3	3.0
91-413	(Automotive Production Analysis)	3	1.0
91-429	(Facilities & Material Handling)	3	2.0
82-321	(Control Theory I)	3	1.0

One Automotive Manufacturing Technical Elective

Winter Term		Lecture	Lab
91-400	(Capstone Design Project)	1	6.0
85-421	(Engineering & Society)	3	0
91-431	(Flexible Mfg. Systems)	3	2.0
91-424	(CAM & Measurement)	3	3.0

One Automotive Manufacturing Technical Elective





Supply Chain Engineering

*A High Tech Engineering Option**
Providing High Visibility Opportunities

This is your opportunity to obtain an advanced education in leading edge simulation technologies used by manufacturers and providers of transportation world wide. In this curriculum you will learn how to effectively use leading technology in beating the competition.

Our graduates are employed globally in areas including:

Transportation Systems
Airline Industry
International Logistics Systems
Corporate Material Handling
Auto Parts Manufacturing
Auto Assembly Operations
Courier Transportation Systems
Hospital / Health Care Logistics

Industrial and Manufacturing Systems Engineering Department

First Year - the Fall and Winter terms are common to all Engineering programs

Second Year – Industrial Engineering (Supply Chain Engineering)

Fall Term	Lecture	Lab
85-211 (Comp. Aided Analysis II)	3	1.5
85-212 (Thermodynamics)	3	1.5
85-214 (Circuit Analysis II)	3	1.5
85-217 (Mech. of Deformable Bodies)	3	2.0
85-219 (Intro. to Engineering Materials)	3	2.0
62-216 (Vector Calculus)	3	1.0

Winter Term	Lecture	Lab
85-222 (Treatment of Experimental Data)	3	1.0
85-223 (Fluid Mechanics II)	3	1.0
62-218 (Differential Equations)	3	1.0
71-140 (Principles of Management)	3	0
Two Non-Technical Electives		

Third Year – Industrial Engineering (Supply Chain Engineering)

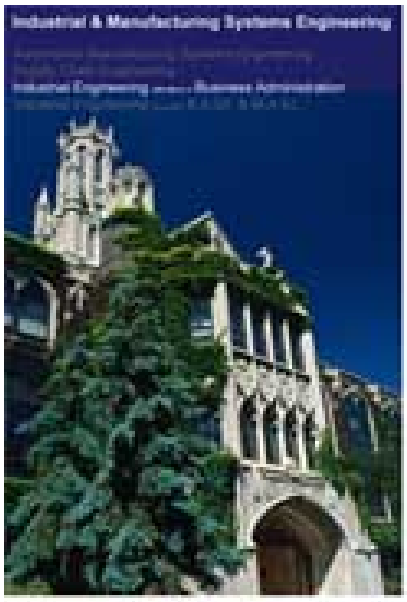
Fall Term	Lecture	Lab
91-312 (Operations Research I)	3	2.0
85-313 (Engineering Economy)	3	2.0
91-327 (Product Quality & Reliability)	3	2.0
91-301 (Human Factors)	2	2.0
91-317 (Systems Analysis & Design)	3	2.0
One Supply Chain Technical Elective		

Winter Term	Lecture	Lab
91-333 (Industrial Health and Safety)	3	2.0
91-300 (Introduction to Supply Chain Engg.)	3	2.0
91-332 (Statistical Methods, DOE for Mfg.)	3	2.0
91-316 (Mfg. Driven Product Design)	3	0
One – Supply Chain Technical Elective		
One – Non-Technical Elective		

Fourth Year – Industrial Engineering (Supply Chain Engineering)

Fall Term	Lecture	Lab
91-400 (Capstone Design Project)	1	6.0
91-422 (Simulation of Industrial Systems)	2	3.0
91-413 (Automotive Production Analysis)	3	1.0
91-409 (Facilities & Material Hand)	2	2.0
62-321 (Control Theory I)	3	1.0
One Supply Chain Technical Elective		

Winter Term	Lecture	Lab
91-400 (Capstone Design Project)	1	6.0
85-421 (Engineering & Society)	3	0
91-409 (Decision Support Systems)	3	1.0
91-412 (Operations Research II)	3	2.0
91-402 (Logistics and Distribution)	3	2.0



Industrial Engineering with Minor in Business Administration

A Multi-disciplinary Undergraduate Curriculum
Designed to Prepare Engineers to be Management Leaders

Consider an integrated business / engineering curriculum that prepares graduates for high growth potential management careers in industry, manufacturing, and the business world all within 4 years!

Our graduates are employed globally managing groups in:

- Product Engineering
- Plant/Facility Engineering
- Industrial Engineering
- Human Factors / Ergonomics
- Corporate Management
- Process Engineering
- Tool Engineering
- Health Care
- Manufacturing Engineering
- Plant Management

WINDSOR Engineering

Industrial and Manufacturing Systems Engineering Department

First Year - the Fall and Winter terms are common to all Engineering programs

Second Year - Industrial Engineering - Minor in Business Administration

Fall Term		Lecture	Lab
85-211	(Comp. Aided Analysis II)	3	1.5
85-212	(Thermodynamics)	3	1.5
85-214	(Circuit Analysis II)	3	1.5
85-217	(Mech. of Deformable Bodies)	3	2.0
85-219	(Intro. to Engineering Materials)	3	2.0
82-216	(Vector Calculus)	3	1.0

Winter Term		Lecture	Lab
85-222	(Treatment of Experimental Data)	3	1.0
85-223	(Fluid Mechanics II)	3	1.0
82-216	(Differential Equations)	3	1.0
71-140	(Principles of Management)	3	0

Two Non-Technical Electives

Third Year – Industrial Engineering - Minor in Business Administration

Fall Term		Lecture	Lab
91-312	(Operational Research I)	3	2.0
85-313	(Engineering Economy)	3	2.0
91-327	(Product Quality & Reliability)	3	2.0
91-301	(Human Factors)	2	2.0
91-317	(Systems Analysis & Design)	3	2.0
70-151	(Financial Accounting I)	3	0

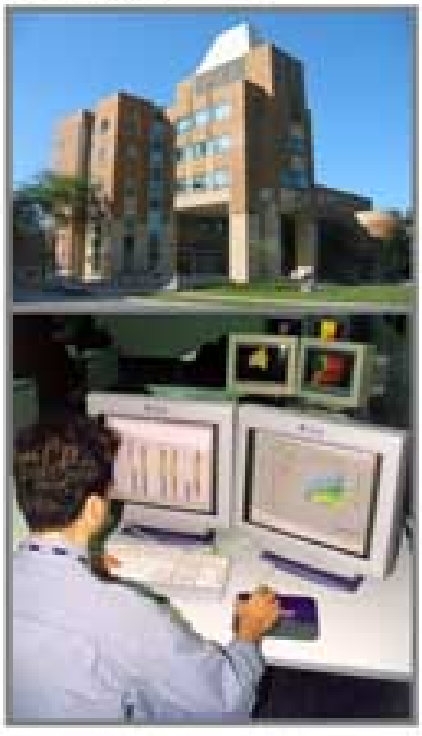
Winter Term		Lecture	Lab
91-333	(Industrial Health and Safety)	3	2.0
91-300	(Introduction to Supply Chain Engg.)	3	2.0
91-332	(Statistical Methods, DOE for Mfg.)	3	2.0
91-315	(Mfg. Driven Product Design)	3	0
70-152	(Financial Accounting II)	3	0

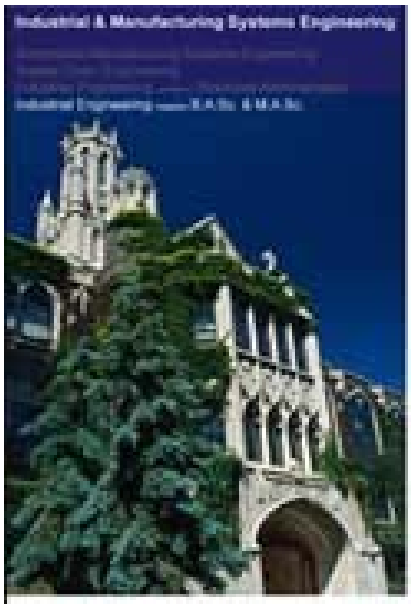
One – Non-Technical Elective

Fourth Year – Industrial Engineering – Minor in Business Administration

Fall Term		Lecture	Lab
91-400	(Capstone Design Project)	1	6.0
91-402	(Simulation of Industrial Systems)	2	3.0
91-413	(Automotive Production Analysis)	3	1.0
91-409	(Facilities & Material Handling)	2	2.0
82-321	(Control Theory I)	3	1.0
71-243	(Human Resource Management)	3	0
70-256	(Managerial Cost Accounting)	3	0

Winter Term		Lecture	Lab
91-400	(Capstone Design Project)	1	6.0
85-401	(Engineering & Society)	3	0
91-429	(Decision Support Systems)	3	1.0
91-412	(Operations Research II)	3	2.0
74-[illegible]	(Principles of Marketing)	3	0





Industrial Engineering Integrated B.A.Sc. & M.A.Sc.

An Accelerated Integrated Engineering Program
Designed to Fast Track Two Degrees in Five Years

Consider a Bachelor's - Master's Integrated Engineering Degree program which allows students with outstanding academic ability to achieve both a B.A.Sc. and M.A.Sc. degree in a time period as short as five years. This requires special effort and it can be done!

Our graduates are employed globally in areas including:

- Product Engineering
- Plant/Facility Engineering
- Industrial Engineering
- Manufacturing Management
- Process Engineering
- Tool Engineering
- Fastening Engineering
- Senior Corporate Management

WINDSOR Engineering

Industrial and Manufacturing Systems Engineering Department

First Year - the Fall and Winter terms are common to all Engineering programs

Second Year - Industrial Engineering – Integrated B.A.Sc. & M.A.Sc.

Fall Term	Lecture	Lab
85-211 (Comp. Aided Analysis II)	3	1.5
85-212 (Thermodynamics)	3	1.5
85-214 (Circuit Analysis II)	3	1.5
85-217 (Mech. of Deformable Bodies)	3	2.0
85-219 (Intro. to Engineering Materials)	3	2.0
82-215 (Vector Calculus)	3	1.0

Winter Term	Lecture	Lab
85-222 (Treatment of Experimental Data)	3	1.0
85-223 (Fluid Mechanics I)	3	1.0
82-216 (Differential Equations)	3	1.0
71-140 (Principles of Management)	3	0
Two Non-Technical Electives		

Third Year – Industrial Engineering - Integrated B.A.Sc. & M.A.Sc.

Must apply in 1st year and have GPA > 10

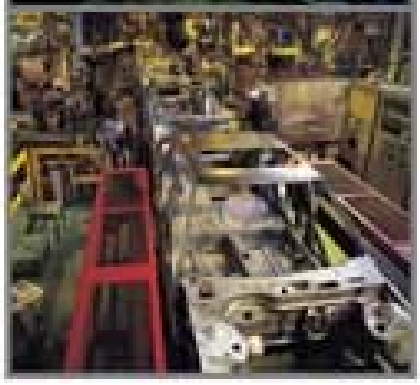
Fall Term	Lecture	Lab
91-312 (Operations Research I)	3	2.0
85-213 (Engineering Economy)	3	2.0
91-327 (Product Quality & Reliability)	3	2.0
91-301 (Human Factors)	3	2.0
91-317 (Systems Analysis & Design)	3	2.0
One IMSE Technical Elective		

Winter Term	Lecture	Lab
91-333 (Industrial Health and Safety)	3	2.0
91-350 (Introduction to Supply Chain Engg.)	3	2.0
91-332 (Statistical Methods, DOE for Mfg.)	3	2.0
91-315 (Mfg. Driven Product Design)	3	0
One – Non-Technical Elective		

Fourth Year – Industrial Engineering – Integrated B.A.Sc. & M.A.Sc.

Fall Term	Lecture	Lab
91-400 (Capstone Design Project)	1	6.0
91-422 (Simulation of Industrial Systems)	2	3.0
91-413 (Automotive Production Analysis)	3	1.0
91-429 (Facilities & Material Handling)	2	2.0
92-321 (Control Theory I)	3	1.0
One IMSE Graduate Course		

Winter Term	Lecture	Lab
91-400 (Capstone Design Project)	1	6.0
85-421 (Engineering & Society)	3	0
91-429 (Decision Support Systems)	3	1.0
91-412 (Operations Research II)	3	2.0
One IMSE Graduate Course		



Fifth Year – Industrial Engineering – Integrated B.A.Sc. & M.A.Sc.
Graduate University of Windsor Graduate Courses + IMSE Thesis

APPENDIX 6

LIBRARY's SUPPORT LETTER FOR THE PROPOSED Ph.D. PROGRAM

INTRODUCTION

The Leddy Library is the main library for the University of Windsor serving as the primary library for all disciplines except law. The Leddy Library has a collection of 1,492,982 print volumes; 20,920 electronic monographs; 1,506,453 microforms (microfilm and microfiche); 97,624 government documents (the Library is a full-depository for the Canadian government); 1,067 linear feet of manuscripts and archives, as well as 1,401 audio and 3,098 film and video holdings. A librarian member of the Leddy Library is assigned to work with the faculty and students in the Engineering programmes in a liaison and collection management capacity.

COLLECTIONS AND FUNDING

The Library collections in all engineering subject areas include approximately 14,500 monographs with over 5,000 titles relevant to industrial engineering. The library now holds over 11,000 electronic journal subscriptions of which approximately 1,250 titles are in engineering. The library also holds another 71 paper format current serial subscriptions in Engineering. These holdings are supplemented by holdings in pertinent fields such as Computer Science, Business Administration and Mathematics. The following table shows the expenditures made by the Library to support Engineering/Industrial Engineering programmes over the past seven years.

Library Funding – Engineering/Industrial Engineering 1997/1998 to 2003/2004

Year	Print Serials[1]	Monographs[1]	Electronic Resources	Electronic Resources Notes (selected examples)
1997/ 1998	$162,183 ($24,266 trans. to elect. res. & $7,000 added to base)	$6,120 $2,000 added to base this year + $3,500 one time funds	$60,000	• EI Village in lieu of Compendex on CDROM • Current Contents • Applied Science & Tech Index

1998/ 1999	$162,183	$6,120 + $3,000 one time funds	70,000	• EI Village • Academic Press IDEAL full text suite • MathsciNet • Math Reviews
1999/ 2000	$162,183	$6,120	$175,000	• EI Village • Inspec online • Metadex online • Pollution Abstracts online • Elsevier full-text
2000/ 2001	$99,968 ($62,215 trans. to elect. resources)	$6,120	$200,000	• Web of Science • EI Village • Chemical Abstracts via SciFinder Scholar • Inst. Physics full text
2001/ 2002	$96,571 ($3,397 trans. to elect. resources)	$6,120	$350,000	• IEEE XPlore • Springer full text • Amer. Phys. Soc. full text • Assoc. Comp. Mach. full text • Amer. Chem. Soc. full text
2002/ 2003	$33,049 ($63,552 trans. to elect. resources)	$6,120 + $4, 400 one time funds	$370,000	• ASTM Standards • Digital Dissertations full-text • Nature & Science full-text • Lecture Notes in Comp. Sci full-text
2003/ 2004	$25,205 ($7,844 trans. to elect. resources)	$6,120	$400,000	• Cambridge, Oxford & Blackwell publishers full-text journal suites • Engineering Index backfile online (1884 – 1969) • Nature Academic journals full-text

3. Serials funds from the 3 Engineering departments were merged to one serials fund for the entire faculty in 97/98. Figures reported in column 2 are for the entire Engineering faculty. Monograph funds for individual Eng. Dept were maintained so the figures in Column 3 are for Industrial Engineering only.
4. Electronic Resources amounts are based on actual costs of Earth Science specific titles and estimates of percentages of other multidisciplinary full-text electronic resources that target Earth Sciences subject areas.

Through its own initiatives as well as through consortial arrangements with its co-members of the Ontario Council of University Libraries (OCUL) and the Canadian National Site Licencing Project (CNSLP) major objectives of the Leddy Library have been and continue to be the expansion of its electronic offerings. Resources which are now available to all users through the

library system include the following:

- Engineering Information Village which includes COMPENDEX from 1970 to the present, access to standards, reports, employment opportunities and specialized Internet links (just signed the license to extend our Compendex online holdings back to 1884);
- IEL (IEEE/IEE Engineering Library) providing full-text online access to journals, proceedings and reports
- Lecture Notes in Computer Science full-text online (over 200 volumes per year);
- Proquest Digital Dissertations full-text online (supplies the full-text of dissertations in all subject areas from 1997 onwards;
- Wilsonweb Omnifile (which includes General Science Index and part of Applied Science & Technology Index);
- Web of Science (Science Citation Index);
- several hundred relevant full-text electronic journal titles from major science and engineering publishers including Elsevier, the Institute of Physics & American Physical Society, IDEAL (Academic Press journals), Kluwer, Wiley, Springer-Verlag, Blackwell, Oxford and Cambridge;
- Every JSTOR Collection (provides journals backfiles of over 200 scholarly journals);
- ABI/Inform - Business Periodicals Full Text;
- CISTI Source (document delivery services);
- Computer and Information Systems Abstracts, Computer Abstracts International Database, and Chemical Abstracts (through SciFinder Scholar).

Faculty and the liaison librarian work together closely to ensure that the funds provided are used to acquire the most relevant materials to support the curriculum and research needs of the Engineering programme. The Library, for example, subscribes to 85% of the top 20 journals in industrial engineering, 75% of the top 20 journals in robotics and automatic control, and 60% of the top 20 journals in manufacturing engineering as ranked by the Institute for Scientific Information's Journal Citation Reports. As well the Library continues its efforts within the OCUL consortium, as well as with the Canada Foundation for Innovation/Canadian National Site Licensing Project to provide access to the greatest depth of scholarly publishing possible.

ACCESS TO RESOURCES HELD LOCALLY

The Leddy Library uses a client server based system called Voyager. This system provides access not just to the Library's own online catalogue of records of locally held resources but also to a variety of connection options including online journal indexes and abstracts, full-text of journals in electronic format and access to the World Wide Web. Voyager is available at over 250 workstations located throughout the Library, as well as from home, office and laboratory. The Library is open 111 hours per week during term. The loan period for library books for graduate students is one month with up to 25 books available for semester loans. Journals do not normally circulate out of the library.

ACCESS TO RESOURCES NOT HELD LOCALLY

Graduate students in engineering have access to materials not located in the Leddy Library through our interlibrary loan services. Interlibrary Loan Unit has access to the two major Canadian union catalogues as well as to the preeminent North American union database, OCLC. Use of electronic messaging between these services (via the Internet or telecommunications lines) allows access to, and borrowing from, library holdings across North America and abroad. Document delivery is available to all graduate students in industrial engineering through CISTI source for all articles not held at Leddy Library but available at CISTI.

USER ASSISTANCE

The library provides reference service to the University of Windsor community at peak time during term for 68 hours per week. This service is in the form of immediate one to one service at the Reference Help Centre staffed by librarians and library assistants. In-depth research assistance is provided by librarian subject specialists. This in-depth assistance includes mediation of online searches and in-depth training in the identification and use of relevant research resources. Librarians are available to provide bibliographic instruction either in the library or in class. There are, as well, general library orientation sessions which introduce the library building and services to those new to the University.

Prepared By:

Leila Wallenius
Engineering Librarian

CONCLUSION

All available information concerning library resources and services for a PhD programme for Industrial and Manufacturing Systems Engineering has been examined.

The rising costs of serials caused by inflation and currency exchange rates have placed the acquisition of current serials under great pressure. The University is committed to considering

the library acquisitions budget as a primary call on the academic university funds and has increased the support to library acquisitions in each of the past three years.

The Leddy Library is examining several means by which it can enhance its services to faculty and students. These means include both enhanced local access and expanded cooperative arrangements and resource sharing.

With the above noted commitment to library acquisitions and both present and planned services, I believe that the Leddy Library can support a PhD program in Industrial and Manufacturing Systems Engineering.

Gwendolyn Ebbett
University Librarian