UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING

Report No. 3421 Revised

MEMORANDUM

To: Executive Committee of Faculty Council

From: Professor Hani Naguib
Department of Mechanical & Industrial Engineering
Department of Materials Science and Engineering

Date: March 19, 2014 for March 11, 2014 Faculty Council Meeting

Re: **Establishment of the Toronto Institute of Advanced Manufacturing (TIAM) as an Extra-Departmental Unit:C (EDU:C)**

REPORT CLASSIFICATION

This is a major policy matter that will be considered by the Executive Committee for endorsing and forwarding to Faculty Council for vote as a special motion (requiring a 2/3 majority of members present and voting to carry and circulated to Faculty Council at least 14 days in advance).

MOTION

> THAT the Faculty establish the Toronto Institute of Advanced Manufacturing (TIAM) as an Extra-Departmental Unit:C (EDU:C), effective immediately, with the mandate to provide innovation and leadership in advanced manufacturing through research and development, training and education in Ontario, Canada, and worldwide.

1. INTRODUCTION

The manufacturing sector in Canada is regarded by economists as being vital for economic growth and innovation. The manufacturing sector resulted in $280 billion in exports and 30% of the business tax revenues in 2012. Furthermore, manufacturing is the most intensive research and development economic sector in Canada, accounting for 75% of all private sector research expenditures. Unfortunately, Ontario's established position as a manufacturing hub is under threat from global competitors, particularly from developing countries, who already have an advantage in labor supply and due to the strong Canadian dollar, and now are quickly acquiring conventional manufacturing knowledge. In order to maintain and further establish Ontario's position in manufacturing excellence, new processes and products must be developed that add value and growth to the existing manufacturing base.

The University of Toronto is Canada's premier research university, and the Southern Ontario region is the major manufacturing hub in Canada.

The establishment of the Toronto Institute of Advanced Manufacturing (TIAM) as an EDU:C will leverage the University's knowledge and expertise in advanced manufacturing and its partnerships with the Canadian manufacturing industry. TIAM, working with its partners, will create and scale up advanced manufacturing technologies and will develop innovative manufacturing practices for the 21st century.

TIAM will become a world-renowned research institute in advanced manufacturing innovation and will serve to advance and increase the global competitiveness of Canadian manufacturing.

2. MISSION

TIAM's mission is to expedite the research and development of advanced manufacturing technologies by creating a multi-disciplinary, multi-departmental network focused on sharing knowledge, ideas and resources. It aligns with the University of Toronto and FASE strategic priority area *Enabling Technologies for the 21st Century*. TIAM will strive for global leadership in advanced manufacturing by translating lab-based technologies into commercial, scaled-up processes, and contributing to education and the training of highly qualified personnel in the manufacturing sector.

3. POSITIONING

A number of existing institutes and research groups in Canada deal with manufacturing. These focus on traditional industrial manufacturing techniques and processes, including machining on a large scale. TIAM will focus instead on new technologies, advanced materials and processes that enable technology transfer from an idea to a final product.

TIAM will leverage advancements underway in nanotechnology, biotechnology, energy and sustainability. It will transform these into value-added products through three major themes in advanced manufacturing:

1. manufacturing of advanced materials
2. advanced manufacturing processes and systems
3. manufacturing planning and management

Theme 1: Manufacturing of Advanced Materials – this theme covers the complete range of knowledge involving the processing, structure, properties, performance, manufacturing and design of advanced materials. In particular, TIAM will focus on the development of an innovative and new class of materials with unique properties and far-reaching applications in the key sector of manufacturing, which includes nanostructured, coatings, composites and hybrids, and foams. The development of a cost-effective process for mass producing these high performance materials could potentially result in a large number of applications that are innovative, multi-functional, sustainable, environmentally benign, high performing, and reduce material consumption.

Theme 2: Advanced Manufacturing Processes and Systems – these are knowledge- and capital-intensive techniques and facilities employed to manufacture classes of materials and structures in a novel, more efficient or more effective manner. The manufactured goods may themselves be advanced, or they may be traditional products that are improved through the use of advanced processes. Examples are additive manufacturing, otherwise known as rapid prototyping or 3-D printing, which can build, layer by layer, a three-dimensional object from a digital model. Another example is advanced processes for complex structures, in which many advanced materials can be designed to obtain their desirable properties through tailoring of their structures. In order to achieve optimal performance for these processes, precise placement of material and space are required. Advanced manufacturing systems are applicable to many processes and materials, and add further knowledge intensity to organize or control a set or series of manufacturing processes.

Theme 3: Manufacturing Planning and Management – in addition to research in physical materials and processes, TIAM's research will focus on the representation of knowledge in advanced manufacturing processes, materials and products. Such representation will support automated reasoning and analysis techniques, leading to better predictive and diagnostic models. This knowledge-based approach will enable the integration of data and knowledge from physics-based models of processes and materials, to engineering and control systems used in making decisions about design and production within the enterprise.

TIAM will be formed through a highly multi-disciplinary partnership of non-budgetary, cross-appointed faculty from FASE departments and institutes whose expertise encompasses the three branches of advanced manufacturing. These include:

- Chemical Engineering and Applied Chemistry
- Electrical and Computer Engineering
- Materials Science and Engineering
- Mechanical and Industrial Engineering (lead department)
- Aerospace Studies
- Biomaterials and Biomedical Engineering

4. ACADEMIC RATIONALE AND GOALS

Manufacturing research at the University of Toronto directly addresses the University and FASE major research priority of "ENABLE: Technologies for the 21st Century". TIAM's research scope will encompass the strategic research cluster of advanced materials and manufacturing, emphasizing nanotechnology, biotechnology, energy and sustainability. The University is promoting its strategic research plan to the manufacturing field through the allocation of new faculty members and research chairs, state-of-the-art infrastructure, major funding initiatives and the training of highly qualified personnel.

The establishment of TIAM and fulfilment of its mandate will create a portal to leading infrastructure in advanced manufacturing at UofT and a world-renowned research centre in advanced manufacturing innovations and serve to advance and increase the global-competitiveness of Canadian manufacturing.

The goals of TIAM are to:

- strengthen the Faculty's leading role in advanced manufacturing in Ontario, in Canada, and worldwide by emphasizing and capitalizing on our major areas of strength in the field of advanced manufacturing: advanced materials, advanced processes and knowledge based manufacturing;

- further strengthen partnerships with the manufacturing sector in Ontario and in Canada, in particular in key industrial sectors in such as automotive, aerospace, electronics and biomedical;

- enhance collaboration and actively foster partnerships with leading research and development institutes and groups throughout the world. This will include formal collaborations through jointly funded projects, student co-supervision, visits to and from these institutes, and the hosting of research leaves and highly-qualified personnel (HQP) visits; and seminar series; and

- build a knowledge-based training and educational system in advanced manufacturing. At the graduate level, this will include creating a cross-departmental MEng emphasis in advanced manufacturing. At the undergraduate level, this will include creating a specialized fourth-year capstone design course with projects in the area of advanced manufacturing, and an option in Advanced Manufacturing in the Division of Engineering Science that will be an updated version of the Manufacturing option that was offered in the past.

5. OBJECTIVES, BENCHMARKS AND MEASURES OF SUCCESS

One of the main objectives of TIAM is to contribute substantially to the field of advanced manufacturing through research and innovation. Benchmarks of success will include:

- high-impact publications and a high level of citation in TIAM's three research themes: advanced materials, advanced processes and knowledge-based manufacturing;

- the development of multiple innovative classes of technologies with unique properties and far-reaching applications in sectors such as automotive, aerospace, electronics and biomedical. These technologies can be grouped in the three themes of advanced manufacturing, and have the potential to be further developed, scaled-up and commercialized at TIAM;

- a benefit to Canadians and Ontarians through new manufactured products, disruptive technologies, advanced training, and job creation. The end applications of several of these technologies are in the biomedical, healthcare, automotive, aerospace and electronics industries – industries which constitute most of Ontario's manufacturing sector. New products or disruptive technologies in these industries over the long run will be a key litmus test for the survivability of domestic manufacturers in the face of global competition and consolidation; and

- close collaboration and alignment with domestic and international institutional partners and domestic industrial partners. This well-established domestic network will enable an effective transfer of advance manufacturing knowledge across Canada, resulting in the direct implementation of new technologies.

A second objective of TIAM is to provide essential training in advanced manufacturing to a large number of HQPs. A benchmark of success in this regard will be:

- based on past data regarding HQPs trained at various UofT research programs, it is expected that more than 80% of TIAM-trained HQPs will be hired by Canadian industry. Companies will be keen on hiring HQPs trained by TIAM, who will have a background in or exposure to advanced manufacturing knowledge, thereby facilitating technology transfer to Canadian industry.

6. STRUCTURE

6.1 Name

The name of the Institute reflects FASE's expertise in the area of manufacturing, and the specialized advances in materials, processes and knowledge-based manufacturing that are unique to Toronto. "Toronto" also reflects the University affiliation and the geographic distinction of the new Institute.

6.2 Director

Professor Hani Naguib will be appointed Director of TIAM. Professor Naguib is jointly appointed to the departments of Mechanical and Industrial Engineering, and Materials Science and Engineering and is cross-appointed to the Institute of Biomaterials and Biomedical Engineering.

In an EDU:C, the Director is not appointed under the University's *Policy on Academic Administrative Appointments*. As a consequence, an EDU:C may not administer research funds or enter directly and on its own authority into commitments / agreements / contracts. All monies and research funding will flow through the Department of Mechanical and Industrial Engineering or through the Dean's Office in line with the Faculty's normal practice. Any research contracts or agreements similarly require approval and the signature of the Chair.

The Director, with the guidance of the Advisory Board appointed by the Dean, is responsible for policies, administrative operations and financial operations to the Dean.

The Director will:

- Coordinate with the Dean and Vice-Dean, Research on Faculty-level strategic vision
- Liaise with senior University administrators
- Constitute and chair the Academic Steering Committee and Advisory Board and manage them to further TIAM's mission
- Coordinate with FASE departments regarding specialized capstone courses, MEng emphasis, graduate collaborative program and an Engineering Science option in Advanced Manufacturing
- Recruit new faculty and student members
- Strengthen, and attract new industrial partnerships
- Pursue group funding from government agencies and industrial partnerships
- Promote the goals of TIAM to the external community

In an EDU:C, the Director will report to the Dean and future appointments of the Director will be made at the Faculty level according to standard Faculty practice.

6.3 Academic Steering Committee

The TIAM Director will work with an Academic Steering Committee to help define the Institute's academic direction. The Committee will consist of:

- The Director, who will chair the Committee meetings
- Faculty members from the FASE departments and institutes most closely involved in TIAM activities (such Chemical Engineering and Applied Chemistry, Electrical and Computer Engineering, Materials Science and Engineering, Mechanical and Industrial Engineering, Aerospace Studies, and Biomaterials and Biomedical Engineering)
- The FASE Vice-Dean, Research
- The Chair of the Advisory Board
- One graduate student from the FASE Departments and Institutes associated with TIAM, who will be elected by the committee on a yearly basis

The Committee is expected to meet two to three times a year, and the term of Committee members will be three years.

6.4 Advisory Board

In accordance with the *Provost's Statement on the Role of Advisory Bodies (April 30, 1998),* the Dean, with input from TIAM and the Vice-Dean Research, will appoint an Advisory Board to provide non-binding advice to the Institute, and to provide strategic connections between TIAM researchers and industry/government leaders in the manufacturing sector; fund research through industry research contracts and partnership programs; and raise philanthropic funds for the EDU.

The Board will consist of the Director and senior industrial representatives from key manufacturing sectors in Canada that focus on the advanced manufacturing technologies being developed at the Institute, such as automotive, aerospace, electronics and biomedical.

It will meet semi-annually and meetings will be chaired by the Institute's Director. The administration of the Board will be managed by the Department of Mechanical and Industrial Engineering.

6.5 Faculty and Student Membership

It is proposed that TIAM be established as an EDU:C type of extra-departmental unit. As such, TIAM will not be authorized to make primary teaching appointments, but may hold non-budgetary, cross-appointed faculty.

TIAM membership will be based on multi-disciplinary partnerships of faculty members from the following units, whose expertise spans the three themes of advanced manufacturing. Graduate students and postdoctoral fellows of associated faculty can become members on the recommendation of their advisor.

- Chemical Engineering and Applied Chemistry
- Electrical and Computer Engineering
- Materials Science and Engineering
- Mechanical and Industrial Engineering
- Aerospace Studies
- Biomaterials and Biomedical Engineering

To date, members from each of these departments and institutes have agreed to join the Institute as non-budgetary, cross-appointed faculty; these are listed in Appendix A. A similar invitation will be extended to faculty members in FASE and other departments of Physics and Chemistry within the Faculty of Arts and Science.

In addition to these core faculty members at the University of Toronto, TIAM will seek ties with partners institutes at key Canadian manufacturing hubs in Ontario, Quebec and Alberta, to create a portal of leading expertise in advanced manufacturing. These partners are current collaborators with TIAM's core faculty members, and are listed in Appendix B.

7. TEACHING ROLE

As an EDU:C, TIAM will not offer academic programs, but cross-appointed faculty in TIAM may offer courses that are core or elective courses in appropriate programs.

TIAM will contribute to training and education in the area of advanced manufacturing at the University of Toronto by:

- establishing a cross-departmental MEng emphases in advanced manufacturing that will encompass the syllabi and existing courses from the departments most closely involved with TIAM;

- working with the Faculty's NSERC Chair in Multidisciplinary Design to establish a multi-disciplinary faculty-wide capstone design course related to advanced manufacturing that will assemble projects related to the field, and integrate projects from industrial partners;

- developing a new engineering option in Advanced Manufacturing in the Division of Engineering Science, which will be based on the manufacturing option that was offered in the past. This new option will focus on major industrial research and development in Canada; and

- offering an Industrial Seminar Series which bring leading experts from key industrial sectors in Canada.

8. RESOURCES

An initial funding for three years will be requested from the Dean for the launch of TIAM as an EDU:C. TIAM is currently applying for group funds: ORF round 7, CFI New Innovation and Feddev Advanced Manufacturing Fund. This will also assist in the sustainability of the Institute. The Director and the Steering Committee will be working on leading TIAM financial independence from Faculty and University sources. This commitment is reflected in the goals and objectives of the Unit as well as the vision and strategic planning of the Advisory Board. The requested funding will be critical, however, to the operation and growth of the Unit.

9. CONSULTATION

In developing its vision, membership, and strategic plan, TIAM consulted with the Faculty's Dean, Vice-Dean Research, and representatives from the departments of Mechanical and Industrial Engineering, Materials Science and Engineering, Electrical and Computer Engineering, Chemical Engineering and Applied Chemistry, and the institutes of Aerospace Studies, and Biomaterials and Biomedical. Letters of support are attached.

An overview of the proposed EDU was also presented at a meeting of FASE Chairs and Directors in February 2014. The feedback from this meeting was positive and recommendations have been accommodated in this proposal. TIAM's vision is attached.

10. GOVERNANCE AND REVIEWS

The governance and periodic reviews of the EDU:C will be conducted in accordance with the guidelines established by the University of Toronto Governing Council's *Guidelines for Administrative Functions and Protocols for Extra-Departmental Units* (February 26, 2007) and the Faculty's *Framework for Review of Institutes and Centres* (September 2013).

In line with normal practice, an EDU:C is subject to periodic review (normally every five years) by the lead Dean. Any review would normally assess the EDU's sustainability, performance and achievements relative to the goals set out at its establishment. Possible outcomes of the review could include closure.

APPENDIX A: LIST OF FASE FACULTY JOINING TIAM

Name and Title	**Affiliation** *(department or faculty and institution)*
Hani Naguib, Professor	Mechanical and Industrial Engineering / Materials Science and Engineering, University of Toronto
Javad Mostaghimi, Professor	Mechanical and Industrial Engineering, University of Toronto
Chul B. Park, Professor	Mechanical and Industrial Engineering, University of Toronto
Kamran Behdinan, Professor	Mechanical and Industrial Engineering, University of Toronto
Jan Spelt, Professor	Mechanical and Industrial Engineering, University of Toronto
Tobin Filleter, Assistant Professor	Mechanical and Industrial Engineering, University of Toronto
Edmund Young, Assistant Professor	Mechanical and Industrial Engineering, University of Toronto
Uwe Erb, Professor	Materials Science and Engineering, University of Toronto
Eli Sone, Assistant Professor	Materials Science and Engineering, University of Toronto
Benjamin Hatton, Assistant Professor	Materials Science and Engineering, University of Toronto
Peter Herman, Professor	Electrical and Computer Engineering, University of Toronto
George Eleftheriades, Professor	Electrical and Computer Engineering, University of Toronto
Ramin Farnood, Professor	Chemical Engineering and Applied Chemistry, University of Toronto
Mark Kortschot, Professor	Chemical Engineering and Applied Chemistry, University of Toronto
Paul Santerre, Professor	Institute of Biomaterials and Biomedical Engineering, University of Toronto (Faculty of Dentistry)
Marc Grynpas, Professor	Institute of Biomaterials and Biomedical Engineering, University of Toronto (Mount Sinai Hospital)
Craig Steeves, Professor	University of Toronto Institute for Aerospace Studies, University of Toronto

APPENDIX B: COLLABORATING INSTITUTES AND PARTNERS OF TIAM

Name of Institution
McGill University
McMaster University
Queens University
Ryerson University
Shebrooke University
University of Alberta
University of Calgary
University of Ontario Institute of Technology
University of Ottawa
University of Quebec in Chicoutimi
University of Waterloo

Toronto Institute of Advanced Manufacturing (TIAM)

Who we are

The Toronto Institute of Advanced Manufacturing TIAM is a multidisciplinary institute across the Faculty of Applied Science and Engineering (FASE) at the University of Toronto. Situated in the heart of Toronto, TIAM's mission is to deal with the ever increasing demand of enabling technologies in the 21st century by providing innovation and leadership through research and development, training and education in Ontario, Canada and worldwide. As part of the University of Toronto's strategic vision, TIAM is focusing on new technologies, advanced materials, processes and engineering techniques to enable technology transfer generated from an idea to a final product. TIAM possess an expert database of faculties and groups in various areas such as: manufacturing of advanced materials, processes and systems, and knowledge based manufacturing.

What we do

TIAM has three main themes of activities: i) manufacturing of advanced materials, ii) advanced manufacturing processes and systems and iii) knowledge-based manufacturing.

Our Goal

- To strengthen our leading role in advanced manufacturing in Canada and worldwide
- To continue establishing strong partnership with the Manufacturing sector
- To enhance collaboration with similar international Institutes
- To continue building an expertise database and infrastructure in the area of Advanced Manufacturing
- To build a knowledge based training and educational system in Advanced Manufacturing

Where we Lead

TIAM possess an expert database of faculties and groups

- Advanced Nanotechnology
- Nanomaterials in Manufacturing Innovation
- Advanced Coating Technologies
- Microcellular Plastics Manufacturing
- Cellular Hybrid Materials
- Smart & Functional Materials
- Materials and Process Mechanics
- Organic Optoelectronics
- Laser Photonics Fabrication
- Materials for Microelectronics
- Integrative Biology and Micro-engineering
- Applied Bioscience and Bioengineering
- Hydrometallurgy Research
- Pulp & Paper
- Advanced Aerospace Structures
- Multifunctional Lightweight Structures
- Semantic Technology
- Intelligent Decision Engineering

How to reach us

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February 24, 2014

Professor Hani Naguib
Department of Mechanical & Industrial Engineering
University of Toronto
Toronto, ON M5S 3G8

Re: Letter of Support to Establish TIAM

Dear Professor Neguib:

On behalf of the Department of Mechanical and Industrial Engineering (MIE), I write to express my strong support to your proposal on establishing a new EDU:C unit, Toronto Institute for Advanced Manufacturing (TIAM).

Ontario has been the central base of manufacturing in Canada for many years but has gone through many challenges in the manufacturing area due to intense global competitions. To keep such a manufacturing hub position in Ontario, industry must innovate and develop advanced manufacturing technologies. With many resources and innovations at the University of Toronto, the new Toronto Institute for Advanced Manufacturing will help pull research talents and new technologies together to help industry gain competitive edge.

MIE has several world-renowned researchers in the advanced manufacturing areas including advanced coating, injection molding areas, and micro/nano technologies. TIAM will help bring these researchers under the same umbrella and present a united force to work together with industry and government in the advanced manufacturing area.

Should you need any further information, please feel free to reach me at (416) 978-7198 or at zu@mie.utoronto.ca.

Best wishes to the success of your proposal.

Yours sincerely,

Jean W. Zu

Jean W. Zu
Professor and Chair

Materials Science & Engineering
UNIVERSITY OF TORONTO

March 6, 2014

Professor Hani Naguib
Department of Mechanical & Industrial Engineering
University of Toronto
Toronto, ON M5S 3G8

Re: Letter of Support to Establish TIAM

Dear Professor Naguib:

The Department of Materials Science and Engineering (MSE) strongly supports your proposal of the Toronto Institute for Advanced Manufacturing (TIAM) as a EDU:C unit.

Our Department has several initiatives in the area of materials in manufacturing with currently the largest being our ORF-RE funded project "Nanomaterials – Enabled Products for the Ontario Manufacturing Sector. This project involves 10 researchers in 4 different departments (Materials Science and Engineering, Mechanical Engineering, Chemistry and Pharmacy). In MSE we have many researchers in the area of advanced materials (e.g. sustainable materials processing, new materials for energy applications, opto-electronic materials, biomaterials), who would benefit enormously from the leadership that TIAM can provide to support closer collaboration with the manufacturing sector in Ontario and other parts of the country. In addition, the renovations of the space for our new electron microscopy facilities under the Ontario Center for Characterization of Advanced Materials (OCCAM) are currently underway. OCCAM will give us the resources to do world-class research in materials characterization. TIAM would also help us in our efforts to establish closer ties with colleges such as George Brown.

Please don't hesitate to contact me if you need any further information to support this excellent and timely proposal.

Sincerely yours,

Uwe Erb
Professor and Chair

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