Item No. 5

Governance Executive Summary
Action Item

Agenda Title	Canadian Centre for Welding and Joining (CCWJ)

Motion

THAT GFC Academic Planning Committee, acting with delegated authority from General Faculties Council, approve the establishment of the Canadian Centre for Welding and Joining (CCWJ) as an academic institute at the University of Alberta.

Item

Action Requested	☒ Approval ☐ Recommendation
Proposed by	Fraser Forbes, Dean, Faculty of Engineering
Presenter(s)	Fraser Forbes, Dean, Faculty of Engineering Patricio Mendez, Director of CCWJ & Professor of Chemical and Materials Engineering Goetz Dapp, Associate Director of CCWJ

Details

Responsibility	Faculty of Engineering
The Purpose of the Proposal is (*please be specific*)	The proposal is before the committee for approval after being forwarded by the Faculty of Engineering and reviewed by the Centres and Institutes Committee.
Executive Summary (*outline the specific item – and remember your audience*)	**Strategic impact:** The CCWJ will fill a gap in Western Canada and offer an interdisciplinary resource to create and disseminate in-depth knowledge in the areas of materials joining, welding specifications and design, metallurgy, and joining process development. These areas are central to the development of manufacturing, construction, and natural resources in Alberta and Canada at large. The CCWJ will equal or surpass existing facilities worldwide in terms of the scope of its interdisciplinary research, state-of-the-art infrastructure, collaboration with industry, and education and training of welding engineering and researchers. The CCWJ **addresses a need** in these industries by providing expertise in multiple disciples to develop knowledge and technologies to increase productivity, lower costs, and find new applications (diversification). The CCWJ will provide a framework to promote and make accessible the welding expertise at the UofA in many different disciplines beyond the particular expertise of its members, and provide a forum to interact with associations and professional societies. It will **enhance the training and experience of students** in an environment fostering EDI and **strengthen the position of researchers** by reducing the duplication of efforts and providing credibility to early-career researchers and established researchers who are expanding their focus in an interdisciplinary context. 2020 will mark the 10th anniversary of the Welding Research Lab which was established through an industry initiative, the Weldco/Industry Chair in Welding and Joining, which anticipated the development of the CCWJ. The lab has consistently grown and developed an interdisciplinary network of researchers. This has included two large grants from WED, including a $1.75 million project shared with AITF, and an ongoing 5-year $1.1 million-project that brings together welding and automation expertise

	to develop a new technology for high-mix/low-volume applications which is urgently needed in the province. The CCWJ will provide a structure to increase this type of multidisciplinary grants, and is anticipated to take on also an advising role on policy in areas of advanced manufacturing and materials selection, including codes and standards. **The risks and financial implications for the UofA are minimal**, as the Centre will operate as a self-sustaining entity, leveraging the earnings of the Weldco/Industry Chair in Welding and Joining to guarantee continuity and structure of the CCWJ. As the CCWJ grows, revenue will be generated through research grants, workshops, and a limited amount of service work for industry.
Supplementary Notes and context	*<This section is for use by University Governance only to outline governance process.>*

Engagement and Routing (Include meeting dates)

Consultation and Stakeholder Participation (parties who have seen the proposal and in what capacity) <For information on the protocol see the Governance Resources section Student Participation Protocol>	*Those who are actively **participating**:* • Faculty of Engineering • Department of Chemical and Materials Engineering
	*Those who have been **consulted**:* • Chair of the Department of Chemical and Materials Engineering • Dean of the Faculty of Engineering • Centres and Institutes Committee • Associate Vice President (Research) and Associate Vice President (Academic), Randy Goebel
	*Those who have been **informed**:* • Industrial Advisory Board • Collaborators and stakeholders
Approval Route (Governance) (including meeting dates)	GFC Academic Planning Committee – October 23, 2019

Strategic Alignment

Alignment with *For the Public Good*	Please note the Institutional Strategic Plan objective(s)/strategies the proposal supports.	
Alignment with Core Risk Area	Please note below the specific institutional risk(s) this proposal is addressing.	
	☐ Enrolment Management ☐ Faculty and Staff ☒ Funding and Resource Management ☐ IT Services, Software and Hardware ☐ Leadership and Change ☐ Physical Infrastructure	☐ Relationship with Stakeholders ☒ Reputation ☐ Research Enterprise ☐ Safety ☒ Student Success
Legislative Compliance and jurisdiction	Post-secondary Learning Act GFC Academic Planning Committee terms of reference Centres & Institutes Policy and Establishment Procedure	

1. Attachment 1 (Proposal for the establishment of CCWJ, incl. letter of support – Faculty of Engineering)

Prepared by: Goetz Dapp, Associate Director CCWJ, dapp@ualberta.ca

University of Alberta Template for Proposals to Establish New Academic Centres and Institutes

Proposers will complete and submit this template to the Office of the Provost for approval in accordance with UAPPOL Policy. This template may be used in two ways:

1) **As a cover document attached to a completed proposal which has already been approved by the University for submission for external funding. In this case, the template must present the academic arguments for establishing an academic centre or institute, and provide required information that is absent from the original proposal.**
2) **As an expandable template to be completed. In this case, the completed template may be up to 8 to 10 pages in length (not including letters of support or other appendices relevant to the proposal).**

Before developing a proposal and completing this template, please contact the Office of the Provost to discuss the scope of the proposed initiative and to discuss steps for review under the UAPPOL Centres and Institutes Policy, as well as associated procedures for academic centres and institutes – www.uappol.ualberta.ca .

1.	**Faculty Dean Signature** Signature: See attached memo (Dr. F. Forbes) — Date:
2.	**Name of the Proposed Centre or Institute** • See attached memo (F. Forbes) • See attached proposal, section *2. Name of the Proposed Centre*
3.	**Academic Justification for Establishment of a Centre or Institute** • Define the vision and purpose of the proposed unit • Demonstrate that the proposed Centre/Institute does not duplicate other efforts at the University • Document the emerging or established excellence of the group of faculty involved, and describe how the proposed Centre or Institute will position the University of Alberta as a national and international leader • See attached proposal, section *3. Academic Justification for Establishment of a Centre or Institute*
4.	**Provide a statement of the priority of the proposed centre or institute within the overall priorities of the Faculty and/or the University of Alberta. Include a statement of benefits the University of Alberta could expect to receive through creation of the proposed centre or institute, including benefits to students.** • See attached memo (F. Forbes) • See attached proposal, section *4. Statement of Priority and Benefits* plus subsections.
5.	**Provide a description of the proposed centre/institute governance structure/reporting lines. Include a diagram of organizational structure.** • See attached proposal section *5. Governance Structure*

6.	**<u>Provide a statement of the role and qualifications of the centre/institute</u> lead of the proposed centre or institute.** • See attached proposal section *6. Role and Qualifications of the Centre Lead*
7.	**<u>Employees</u>** a) Provide a statement of the employment status of employees (i.e., are they University of Alberta employees?) b) Specific source(s) of any "University funding" must be identified c) Personnel expenditures must include adequate provisions for benefit costs, salary settlements, and other escalating factors. • See attached proposal section *7. Employees*
8.	**<u>Financial Plan</u>** a) Include key sources of operating funds, and include revenue sources and expenditures for [ideally] 5 years projected. b) State specific source(s) of any "University funding" c) Provide a plan for the sustainable funding of the operation of the centre or institute (salaries, equipment and maintenance, IT support [data management, web design, etc.) d) Escalation factors must be built into expenditure projections (i.e. escalation due to inflation, future salary settlements, etc.) e) If in-kind support is identified, the specifics of that support must be listed separately. • See attached proposal section *8. Financial Plan*
9.	**<u>Space Requirements.</u>** Space required? Yes☐ No☒ If "No" selected, where is current space? **<u>CME L1-108, CME L1-120, CME L1-118, CME 5-133</u>** If "Yes" selected, complete the following: ☐ On-site at the University of Alberta ☐ Awaiting allocation ☐ Rent/lease required If rent/lease is required, has this been budgeted for? Yes☐ No☐ Is funding required? Yes☐ No☒ Reasons: **<u>See attached proposal, section Budget</u>** Address the following questions: a) If rent/lease or license is required, what is the University of Alberta's commitment? b) If new space or modifications to existing space are required, has Facilities and Operations been contacted and has this been included in the budget? • No new space is required beyond what has already been committed by the Department of Chemical and Materials Engineering. • Details are provided in the attached proposal section *9. Space Requirements and Equipment*

10.	**Potential Risks to the University of Alberta** a) State any reputational, financial, and/or operational risks to the University of Alberta. b) Outline plans to mitigate/manage those risks. c) Risk Management Services may be consulted. • See attached proposal section *10. Potential Risks to the UofA*
11.	**Annual Reporting and Strategic Review: In accordance with UAPPOL Policy** a) State a provision for annual reporting to the Reporting Dean b) State a provision for annual reporting to the Office of the Provost c) State a provision for strategic and operational review by the Reporting Dean (or delegate) at no less frequency than every five years. • See attached proposal section *11. Annual Reporting and Strategic Review*
12.	**Intellectual Property (IP) and Copyright** a) Will any copyright or patentable IP be created, and if so, how will it be handled? b) How will ownership and commercialization of IP be handled? • See attached proposal section *12. Intellectual Property (IP) and Copyright*
13.	**Termination Plan/Provisions** a) Exigency plan for termination: If physical and/or financial resources will remain upon termination, a plan for consultation with donors or agencies associated with the centre or institute must be included in the dissolution plan. • See attached proposal section *13. Termination Plan / Provisions*
14.	**Letters of Support**: Attach letters from relevant on- and off-campus sources • See attached proposal section *14. Letters of Support*
15.	Provide, if applicable, any **agreements and/or memoranda of understanding between the University of Alberta and its partner(s)** to establish, fund and operate the proposed academic centre or institute. • See attached proposal section *15. Agreements and MOUs between the UofA and partners*

UNIVERSITY OF ALBERTA

FACULTY OF ENGINEERING
OFFICE OF THE DEAN

9-201 Donadeo Innovation Centre for Engineering
9211-116 Street NW
Edmonton, Alberta, Canada T6G 1H9
Tel: 780.492.0503
Fax: 780.492.3973
engginfo@ualberta.ca
www.ualberta.ca/engineering

October 11, 2019

Dr. Steven Dew
Provost and Vice-President (Academic)
University of Alberta
2-40 South Academic Building (SAB)
University of Alberta
Edmonton, AB T6G 2G7
Canada

Re: Proposal for Academic Centre "Canadian Centre for Welding and Joining"

Dear Dr. Dew:

In this letter, we propose to create the Canadian Centre for Welding and Joining (CCWJ) as an academic centre at the University of Alberta.

The CCWJ will elevate Canadian welding and joining research to a competitive level equal to any European, American, and Asian facilities. The CCWJ will host interdisciplinary engineering and science research including, metallurgy, heat transfer, fluid mechanics, plasma physics, solid mechanics, computer and mathematical modeling, and human factors, all for welding-related applications. The creation of the CCWJ aims at fostering welding research at UofA in general, and its scope extends far beyond any specific application.

The CCWJ will be hosted at the Faculty of Engineering, Department of Chemical and Materials Engineering. This centre will be instrumental in fulfilling the mandate of the existing Weldco/Industry Chair in Welding and Joining: "the creation and dissemination of knowledge in the areas of materials joining, welding specifications and design, and joining process development" to "ensure that Canada holds a pre-eminent position as a leader in research and development, education and application of welding and joining technologies." The Weldco/Industry Chair in Welding and Joining has an industrial advisory board composed of key companies in Alberta, Canada, and Internationally: Weldco Companies, Acklands Grainger, Canadian Welding Bureau, CESSCO Fabrication and Engineering, Lincoln Electric Company of Canada, Metal Fabricators & Welding Ltd., Miller Electric, Suncor Energy, and Syncrude Canada. The scope of contributions arising within the CCWJ will be Canada-wide, and its goal is global recognition. The current holder of the Weldco/Industry Chair in Welding and Joining is Professor Patricio F. Mendez, and he is the proposed founding director of the CCWJ.

Current welding research operations are collaborative and interdisciplinary in nature, including collaborations within the Department of Chemical and Materials Engineering, extending to the Departments of Mechanical Engineering, the Department of Civil and Environmental Engineering, and the Faculty of Medicine. Currently the CCWJ has 12 ongoing collaborations across the UofA with projects

such as the impact of welding fumes on female welders, process control, advanced automation, specialized statistics, and machine learning/artificial intelligence (see Table 1). In addition, the CCWJ has brought 2 renowned Adjunct Professors to the UofA (John Goldak, Carleton University and Duane Miller, Lincoln Electric Company), and has currently 5 international collaborations with 6 co-supervised graduate students in Germany, Mexico, Japan, Argentina, and China (see Table 2)

Name	Faculty / Department	Research Topic
Leijun Li	Chem. Mat. Eng. (CME)	Metallurgy of welding
Tim Joseph	Mining Engineering	Wear-resistant overlays in mining
Richard Sydora	Physics	Plasma physics of the welding arc
Bernadette Quemerais	Preventive Medicine	Emissions of welding processes
Nicola Cherry	Preventive Medicine	Impact of welding fumes on female welders
Vinay Prasad	CME	Predictive process control for GMAW
Carlos Cervera	Infectious Diseases	Advanced statistical methodologies
Rafiq Ahmad	Mechanical Engineering	Industry 4.0, advanced manufacturing
Eleni Stroulia	Computing Science	Machine learning, artificial intelligence
Horacio Marquez	Electr. Comp. Eng. (ECE)	Complex non-linear systems
Biao Huang	CME	Process control
Sirish Shah	CME	Convolutional neural networks
John Goldak	CME (adjunct) / Carleton	Welding simulation
Duane Miller	CME (adjunct)	Design of welded connections

Table 1: Collaborations with UofA researchers

Name	Institution	Research Topic
Michael Rethmeier	Fraunhofer Germany	Advanced materials
Motomichi Yamamoto	Hiroshima University	Hybrid laser hotwire welding
Marco Ramirez	UNAM Mexico	Plasmas in welding
Mirco Chapetti	CONICET Argentina	Fatigue life of laser additive manufacturing
Shujun Chen	Beijing Univ. of Tech.	Metal transfer and droplet temperature

Table 2: Collaborations with international researchers

The existing physical infrastructure and facilities for the proposed CCWJ is unique in Canada, and superior to most other university welding research operations worldwide. The CCWJ will be hosted in a $5M laboratory facility opened in May 5, 2010 (CME L1-108). Some of the equipment, such as dedicated high speed welding videography, hydrogen testing, dilatometry, and instrumented impact testing are either unique or one of two units existing in Canada. The current facilities have been used for welding research projects sponsored by funding institutions including NSERC, Defense Canada, Auto21, for industrial research involving Syncrude, Hitachi, Wilkinson Steel, and many more, and for service to industry in large and small projects. In addition, the facilities have been used for open labs in the context of AMFI (an outreach program aiming at welding education in SMEs), for teaching undergraduate and graduate students, for lab facilities available to the University of Alberta community, and for demonstrations at

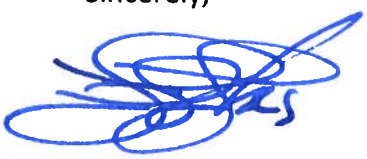
the University of Alberta Open House and Engineering Expo. Both the provincial and federal government have been actively involved in developing the facilities proposed for the CCWJ. Especially notable are two grants from Western Economic Diversification, a $1.5M equipment grant (led by UofA and shared with AITF) and a current $1.1M equipment grant (led by UofA) that will be officially announced shortly.

The unique nature of academic collaborations and infrastructure, as well as its high level of exposure to current and prospective partners across Canada and internationally, create a need for the Canadian Centre for Welding and Joining to be a recognizable entity to partners and institutions inside and outside UofA.

The CCWJ infrastructure is self-sustaining through a consistent track record of research and equipment grants, service to industry, and materials donations from industrial partners. For example, specialty gases are provided free of charge by Praxair, all steel provided free of charge by Supreme Steel and Weldco Companies, and all welding electrodes and other consumables provided by Lincoln Electric. A part-time administrative assistant has been funded consistently since the opening of the lab with the help of the provincial government, Productivity Alberta, and service to industry. There is no other indirect cost involved with the facilities, and no funding from UofA is needed now or in the future.

In summary, the Faculty of Engineering hosts a unique facility and a deep talent pool for welding research that is closely associated with industrial and academic partners in Alberta, Canada, and worldwide. Creating the "Canadian Centre for Welding and Joining" will greatly facilitate the Centre's operation and further the profile of welding and joining at the University of Alberta, and serve to further enhance the reputation of our University as a globe leading institution.

Sincerely,



J. Fraser Forbes, PhD, PEng
Dean of Engineering

October 2019

Proposal to the Academic Planning Committee

Canadian Centre for Welding and Joining

Digital version at http://bit.ly/ccwj_uofa (accessible only for UofA email address)

Submitted from the
Faculty of Engineering,
University of Alberta,
Edmonton, Alberta

Proposal to establish a new Academic Centre: Canadian Centre for Welding and Joining (CCWJ)

1. Name and Faculty of Reporting Dean

Dr. Fraser Forbes, Faculty of Engineering

Signature:	Date:
see attached memo	October 11, 2019

2. Name of the Proposed Centre

The proposed Centre will be called "Canadian Centre for Welding and Joining" (CCWJ).

3. Academic Justification for Establishment of a Centre or Institute

Welding and Joining are central to the development of manufacturing, construction, and natural resources in Alberta and Canada at large. Welding involves not only the act of welding (which is taught at colleges such as NAIT or SAIT), but also the design and selection of alloys, machinery, and processes. The branches of knowledge needed for welding operations involve metallurgy, physics of plasmas, electrical engineering, computer science, health sciences, logistics, and many more. None of these aspects of welding are dealt in appropriate depth at the colleges, which focus on training welders and technologists, but not inventors and thinkers outside of what is immediately available. Alberta has no institution addressing the deeper aspects of welding, despite the pressing need for this knowledge in the province. When the economic situation is favorable, increases in productivity demand this inexistent knowledge. When the economic situation is challenging, lowering costs and finding new applications are essential for survival. The proposed Canadian Centre for Welding and Joining will fulfill this need for multidisciplinary knowledge beyond the trades.

There is no similar initiative at the UofA, in the province, or in Western Canada at large. Only the University of Waterloo in ON has a welding and joining center with academic focus, but with a narrower scope only within engineering.

The Weldco/Industry Chair was created in 2006 to address this need, and envisioned the establishment of an GFC-recognized academic centre called Canadian Centre for Welding and Joining (CCWJ) with a mandate to create and disseminate knowledge in the areas of materials joining, welding specifications and design, metallurgy, and joining process development. The CCWJ will leverage the momentum created by the $5-million Welding Research Lab (established in 2010 through the Weldco/Industry Chair in Welding and Joining), and provide a collaborative structure that consolidates welding related activities by leveraging existing work instead of the potential duplication of efforts.

The CCWJ will elevate the University of Alberta to a pre-eminent position in research and development, education and application of welding and joining technologies. The CCWJ will equal or surpass existing facilities worldwide in terms of the scope of its interdisciplinary research, state-of-the-art infrastructure, collaboration with industry, and education and training of welding engineering and researchers. The CCWJ will function as an entity to bring together interdisciplinary teams of researchers from UofA and industrial partners to obtain research funding and carry out high-quality research. The CCWJ will provide a framework to promote and make accessible the welding expertise at the UofA in many different disciplines beyond the particular expertise of its members, and provide a forum to interact with associations and professional societies. The CCWJ will strengthen the position of researchers by reducing the duplication of efforts and providing credibility to early-career researchers and established researchers who are expanding their focus in an interdisciplinary context.

The vision and mission statement outlined by the donors for the creation of the Weldco/Industry Chair is in *Appendix A: Vision and Mission*.

3a. Proposed Activities

The CCWJ will build on the established track record of the Welding Research Lab. The CCWJ will continue the lab's commitment to teaching and research – combining the deepest, most sophisticated level of fundamental understanding with practical, industry-related and industry-driven applications – and establish a network of excellence in advanced manufacturing around its unique capabilities. Our exceptional connections in the international welding and research community ensure that the industry can benefit from developments that reach far into the future.

The CCWJ will undertake high-quality research on novel welding and joining processes, materials, testing methods, and supporting technologies. The CCWJ will play a key role in introducing advanced and new technologies to industry to drive innovation, increase productivity, and optimize processes and procedures. Research themes are expected to evolve in time depending on the evolution of research and technology, the needs from partners, and the availability of skills at the University of Alberta.

The main application focus of the CCWJ includes manufacturing, equipment manufacturing, metal fabrication, resource-based industries, and oil and gas. The industry expressed a strong desire for such a centre at the UofA and put together the Weldco/Industry endowment in Welding and Joining at the University of Alberta due to its strategic combination of high academic standing, expertise, track record in industrial applications of research, links to the Alberta and federal governments, and geographic location. The CCWJ will fulfill this mandate and function as a liaison among industry, government, equipment manufacturers, consumable manufacturers and the global research community. Through maintaining active international contacts and collaborations, the CCWJ will ensure that Canadian industries have access to the newest developments in technologies and materials. The scope of the CCWJ will include the welding of heavy equipment, petrochemical equipment, energy power plants, and oil and gas pipelines.

Perhaps even greater than industry's need for new technology is its need for highly qualified personnel (HQP) who are trained in the fundamental principles and technologies of advanced welding and joining. The CCWJ will develop outstanding educational programs in Welding and Joining Engineering to help address this critical need. Undergraduate and graduate programs in Materials Engineering will ensure that graduates have the opportunity to develop specialized skills in welding and joining processes, welding metallurgy, design, safety. Courses currently taught are open to all engineering disciplines, advising and co-advising of students occurs across all engineering departments, and the degrees of MSc and MEng in Welding Engineering are currently offered by the Department of Chemical and Materials Engineering. The formation of a Centre will enable the creation of new training and education offerings within an interdisciplinary context that otherwise would be difficult or impractical to coordinate, and cover areas of advanced/additive manufacturing, welding automation, underlying multiphysics of welding, health and safety aspects, and quality control. Establishing the CCWJ will enhance the training of students, facilitate knowledge exchange, and support skill transfer.

The current training activities also include a highly successful internship and outreach program with international partners and local high schools to attract future generations of students and researchers on both an applied and a theoretical level. A high number of returning interns further indicates the success of the program.

TABLE 1: STUDENT STATISTICS OF THE WELDING RESEARCH LAB SINCE 2010

Student types and numbers		
Type	**Number of Research Internships/Apptmts.**	**Individual students**
Research Associates and Post-Docs		10
Graduate Students		39
Undergraduate (Canada)	200	135
Visiting International Students (UG)	17	17
Vis. International Students (Graduate)	25	24
High School	27	16
Junior High School	2	1
Coop Students	2	2
NSERC USRA students	4	4
Research Class	1	1
ISWEP	4	4
WISEST students	4	4
Total:	322	244

The CCWJ will also undertake professional development for practicing engineers. Current activities include graduate and undergraduate welding processing and metallurgy courses and annual seminars aimed at people from industry. Since 2010, the lab has hosted 43 seminars with global leaders of industry and academic research for 899 participants from Alberta industry and 1144 academic participants. It has also regularly represented the University of Alberta in tours

for the Global Academic Leadership Development (GALD) program (213 visitors since 2014), and has hosted high-level dignitaries. Tours hosted for the general public at events such as High School Tours, CWA and AWS Student Chapter tours, UofA Open House and UofA Engineering Expo have brought 3318 visitors since 2012. Photos from these events and quotes from our participants are listed in *Appendix D: Photos from events and quotes from our participants*.

The formation of the CCWJ will introduce new professional development offerings in the area of advanced manufacturing and welding automation. Plans for the CCWJ include applying for provincial funding for such offerings and establish a formalized professional development program within a network of excellence that will be established around the capabilities of the CCWJ.

On the research side, multi-faculty, interdisciplinary collaborations are already an important component of the activities of the Welding Research Lab. The CCWJ will be an umbrella organization that facilitates and coordinates welding-related activities at University of Alberta across researchers, students, departments (e.g. all departments of Engineering), and schools (e.g. collaborations between Engineering and Medicine on human impact of welding). The CCWJ will be established with a research intensive focus and make available unique equipment to collaborators and partners. The CCWJ will provide a framework to promote and make accessible the welding expertise at the UofA in many different disciplines beyond the particular expertise of its members, and provide a forum to interact with associations and professional societies. The CCWJ will strengthen the position of researchers by providing credibility to early-career researchers and established researchers who are expanding their focus in an interdisciplinary context, and reduce the duplication of efforts. This includes leading research initiatives and providing research management support by the experienced team of the Welding Research Lab.

Examples of ongoing internal interdisciplinary collaborations include Prof. L. Li (Materials Eng., welding metallurgy), Prof. T. Joseph (Mining Eng., wear protection of ground engaging equipment), Prof. R. Sydora (Dept. of Physics, welding plasmas), Prof. N. Cherry and Prof. B. Quémerais (Preventive Medicine, welding fumes), Prof. R. Driver (Civil Eng., welding of steel structures), Prof. V. Prasad (Chem. Eng., control of welding processes), Prof. B. Huang (Chem. Eng., process monitoring and sensor filtering/feedback), Prof. H. Marquez (Electr.Eng., non-linear control theory, with emphasis on stability theory), Prof. W. Chen (Materials Eng., fracture and corrosion of welded materials), Prof. R. Ahmad (Mechanical Eng., automation), and Prof. E. Stroulia (Comp. Sci., machine learning in manufacturing). These collaborations have resulted in the co-teaching of classes, developing a new class on welding metallurgy, the publication of papers, and interdisciplinary co-advising of students (e.g. Physics, Medicine) [see Appendix B: Collaborative Publications and Presentations]. Large-scale projects such as an ongoing 5-year, $1.1 million project to “Develop an advanced manufacturing system for automated repairs of heavy machine components” were funded by Western Economic Diversification (WED) only because of the ongoing internal collaboration, and provide an indication of what the CCWJ will enable.

Establishment of the CCWJ will also provide a structure to enable large-scale external scientific collaborations. Current international interdisciplinary collaborations of the Welding Research Lab include a formal MOU with the University of Hiroshima in Japan, and another MOU with the Federal Materials Research Institute of Germany (BAM). The structure of a formal academic centre is expected to have a large impact on the facilitation of formalized research collaboration with other universities and research centres around the world (RWTH Aachen, particularly ISF and WZL; TU Graz; TU Munich) for which MOUs are either in place (RWTH Aachen) or currently being negotiated (TU Graz). These collaborations involve the areas of advanced manufacturing, Artificial Intelligence and Machine Learning in metal manufacturing, and metallurgy of lightweight application and functional alloys.

Individual international collaborations of the Welding Research Lab include Prof. M. Rethmeier (BAM, Germany, advanced materials and welding processes), Dr. N. Jenkins, MD (Harvard, Preventive Medicine, motor skills), Prof. M. Yamamoto (Hiroshima University, advanced welding processes), Prof. S. Chen (Beijing University of Technology; metal transfer), Prof. M. Ramirez (UNAM Mexico; arc plasma), Prof. J. Goldak (Carleton University, welding simulation), and G. Gött (Leibniz Institute for Plasma Science and Technology, INP Greifswald, welding plasma). These activities have resulted in co-supervision of students, several publications and presentations (Appendix B: Collaborative Publications and Presentations), and the development of new research activities involving Alberta companies (Appendix C: Collaborative Projects). They have also resulted in the appointment of Prof. John Goldak (Carleton U., welding simulation) and Dr. Duane Miller (Lincoln Electric, Cleveland, welding design) as adjunct professors in the Faculty of Engineering. The CCWJ will provide a platform to increase such cross-appointments and benefit the broader academic environment at the UofA.

The formation of the CCWJ will also enable new types of collaboration with the provincial and federal governments. In collaboration with the Government of Alberta, the Welding Research Lab has hosted trade missions for a total of 98 industry participants to the 2009, 2013, and 2017 Schweissen&Schneiden Show in Essen/Düsseldorf, Germany (the largest metal manufacturing and fabrication trade show, which takes place every 4 years), and the 2011, 2015, 2016, and 2017 Fabtech Shows (the annual, largest North American manufacturing and fabrication trade show), and the 2016 CanWeld Conference Expo in Edmonton. As a centre, the CCWJ will make it possible to expand our leadership role to the Federal level and become a “one-stop-shop” for everything welding. Anticipated activities include advising on policy in areas of advanced manufacturing and materials selection, including codes and standards. The ongoing project with WED is a first step in this direction, and has already resulted in several meetings with the Assistant Deputy Minister of Western Economic Diversification. The new possibilities opened up by the NSERC Alliance grants to leverage government funds provide a promising avenue to explore. The CCWJ will use our vast network of contacts within the research community and the whole supply chain of manufacturing and the energy sector to lead nationwide initiatives, participate in initiatives such as the NGen Supercluster, and establish direct links between companies and vendors, and educate companies about technologies and implementation options.

These activities align with federal and provincial initiatives, such as the Department of Western Economic Diversification (WED) Western Canada Growth Strategy "Grow West", that includes the following pillars

- Diversification – strengthen the innovation ecosystems, accelerate innovation adoption, embrace technologies that increase productivity, and grow regional economic partnerships
- Skills – develop essential skills that keep pace with change, connect academic skills with practical experience, attract global talent, include and empower western Canadians

These pillars were developed based on findings in the WED "What We Heard" report, which the Welding Research Lab contributed to in several consultations.

Similar goals were a part of the 2018-21 Government of Alberta Business Plan Economic Development and Trade supporting "efforts to make Alberta's economy competitive, diverse and resilient" (Outcome One) and calling for "the development and attraction of the next generation of innovators" in Alberta's academic and research institutions to achieve "globally-competitive research excellence in priority areas":

- Support the growth of globally-competitive enterprises in Alberta through enhanced innovation and technology commercialization programs and partnerships.
- Support the growth of globally-competitive enterprises in Alberta through enhanced innovation and technology
- Promote collaboration that generates economic benefit for Alberta

While the new business plan has not been released, based on the election platform we expect a similar direction of the current government, and the CCWJ will take an active role through participation in consultations, partnerships with the federal and provincial governments and professional societies (Canadian and international) to acquire and disseminate welding knowledge in the complete range from fundamentals to practicing-engineer level, industry support and professional development programs, trade missions, etc.

4. Statement of Priority and Benefits

4a. Importance of Welding

The main challenge of welding as an engineering discipline is that it involves fundamental aspects of many disciplines such as thermodynamics and phase transformations of materials science, heat transfer aspects of mechanical engineering, power electronics of electrical engineering, and materials performance issues of civil and mechanical constructions. Welding is typically "the weakest link" in the chain of structural continuity and it is also the bottleneck in the manufacturing process.

Besides being an essential technology in building construction and metal manufacturing, welding is what holds together the machinery at the core of industries currently essential to the Canadian economy such as oil sands, conventional oil, gas, coal, and mining. Canadian applications are unique in that the harsh environmental conditions often exceed the state of the art of welding

technology. Leading-edge welding expertise is also vital in the automotive and other Canadian manufacturing operations. As the world moves towards a lower carbon future, welding will be essential in renewable energy production. Of note, the Canadian base of expertise in this area is currently thin.

In Alberta, the metal fabrication and machinery manufacturing sectors are integral to the provincial economy. The contributions of these sectors include:

- GDP contribution of more than $4.5 billion (2009)
- GDP contribution of over 2.5% of total Alberta GDP (2002-2009)
- Overall sector wage impact of $4.5 billion (2009)
- Export revenues of greater than $3.5 billion (2008)
- Investments in major oil sands projects for the next 25 years —all of which depend heavily on welding—exceed $200 billion.

Further details can be found in Edmonton Economic Development Corporation's *Value Chain Mapping and Collaboration in the Manufacturing Cluster*, which is included in *Appendix E: Chair Proposal and Report on Value Chain Mapping*.

Going forward, the metal fabrication and machinery manufacturing sectors are starting to encounter stiff global competition as supply chains welcome new global participants. Coupled with this new competition are competitiveness challenges including: ongoing upward cost pressures for Alberta firms relative to their international competition; difficulties achieving scale sufficient to seek larger contracts; existing low innovation and productivity levels; and a skilled labor shortage. This is particularly true as the low-cost international competitors are starting to embrace automation and start to sell products of increasing quality. Low oil prices add to this problem, and several companies have approached the Welding Research Lab for advice on making their facilities more efficient and productive, and on ways to convert their existing setups for diversification of their business plan. This includes areas of advanced manufacturing, welding automation in metal manufacturing, as well as implementing new and optimizing existing processes, consumables, and applications.

4b. Impact of the CCWJ

By tackling the above challenges, the CCWJ will impact manufacturers and operators along the entire supply chain in the energy sector. The development of new technologies will help Alberta companies have an edge in the international market for products and services. Breakthroughs in materials and processes will lead to increased workplace safety and health, products and processes with reduced environmental footprint, and workforce development that can meet Canadian standards while being competitive worldwide. These improvements in technology will involve substantial activity ranging from fundamental research to development and demonstration, requiring a solid partnership among government, university, and industry. From its inception, the Welding Research Lab has been envisaged, set up, and operated with the goal of formalization in mind, and the necessary structure, infrastructure, and collaboration for rapid implementation have already been put in place.

The formal structure of an academic Centre will provide a platform that allows UofA researchers to contribute their welding-related expertise, and leverage new expertise and points of view with the existing network of contacts and funding that otherwise is tied to each specific discipline on an existing structure. The welding-related activities are not limited to engineering, but also include sciences, medical, arts, business, social sciences, and more. Collaborations including sciences, and medicine already exist, and a collaboration with the Faculty of Medicine brought statistical methodologies and expertise not available in engineering. The existence of a center will help expand the scope of research and collaborations by creating a structure to promote welding activities at the UofA beyond specific disciplines. The CCWJ will provide credibility to early-career researchers and help established researchers expanding their focus in an interdisciplinary direction.

The CCWJ will thereby open new funding opportunities and attract new contributions to the endowed chair in Welding and Joining. This will significantly increase the planning window for activities and research programs, and enable sustainable growth. The research at the CCWJ will build the research capacity at the University of Alberta by increasing the number of faculty and students working on new technology for this crucial Alberta industry. The goal is to triple the amount of professors, students, and collaborations from currently 69 to 180 by 2025. The enhanced planning window will also positively impact research support both on the research and the research administration side, which will ensure supervision of students, effective communication with stakeholders, and efficient operations in accordance with Tri-Council and UAPPOL rules.

Development of the type of innovative processes envisaged for the CCWJ will also create new opportunities for manufacturing, technology licensing, and exports. For example, new wear protection overlays that benefit the oil sands industry would not only have valuable applications in other mining applications in Canada and abroad, but also open up new possibilities for transportation (e.g. railroad) and aerospace applications.

These activities will generate new professional development opportunities and disseminate welding knowledge in the complete range from fundamentals to practicing-engineer level, industry support and professional development programs, trade missions, etc.

In conjunction with the opportunities above, the CCWJ will also have an impact on **Equity, Diversity, and Inclusion (EDI)**. The track record of the Welding Research Lab of reaching out to under-represented groups and support of equity and diversity is an important part, and providing a welcoming and encouraging environment, is an important element of the learning experience of its student population and the overall community. Over the past 5 years this has included participation in WISEST (for female High School students), and USchool and TeamUp (for socially vulnerable, Inner City, Aboriginal, and rural youth) on the University level, as well as providing internships to secondary students (incl. Junior High School students) and UG. The leadership of female graduate students in automation, robotics, and welding will provide role models for UG and High School interns. In the summer of 2017 the Welding Research Lab had 50% females, and in the Fall term of 2019, 7 out of 10 UG students in the Welding Research Lab are female (70%!).

In addition, the lab has had as many as 18 different nationalities simultaneously. Combined with the success rate of these students to win scholarships these numbers indicate the success of this approach, which allows students to thrive in an open, creative, and stimulating environment.

The Centre will bring significant benefits to the overall level of sophistication in the welding industry by three mechanisms: 1) direct employment of students, post-doctoral fellows, and research associates, 2) research results and engineering tools from the CCWJ will raise the level of technical expertise, awareness, and competitiveness in Alberta, and 3) a new generation of diverse researchers and engineers who are well-rounded, curious, motivated, and able to interact on all technical, social, and cultural levels.

4c. Benefits for the University of Alberta

The University of Alberta has identified research in materials and utilization of natural resources as high priorities. The development of energy research is a high priority for the Faculty of Engineering. The establishment of the CCWJ as a GFC-recognized Centre will support the University of Alberta's Strategic Plan by advancing existing research strengths in the area of manufacturing and materials for energy applications. The formation of the CCWJ will elevate the level of exposure and visibility of the University of Alberta in these important areas, and leverage on the excellent existing facilities. Welding is one of the most interdisciplinary branches of engineering. The CCWJ will promote further interdisciplinary collaboration by helping to integrate typically unrelated research fields such as heat transfer, fluid mechanics, free surfaces, turbulence, electromagnetism, plasma physics, solid mechanics, elasticity, plasticity, creep, thermodynamics, phase changes, microstructural evolution, electrical circuits, health impact, and more.

The CCWJ will be established as a self-sustaining entity. The endowment funding of $2.1 million from Weldco/Industry Chair for Welding and Joining will support welding research in perpetuity. These funds have served and will continue to serve to attract research and matching funds from agencies such as Western Economic Diversification (WED), Alberta Innovates, and NSERC. The equipment acquired for the CCWJ will bring synergies with many other areas of research and teaching in materials engineering, mechanical, civil, and mining engineering, as well as physics and medicine. The synergies created will make it possible to purchase and maintain unique scientific equipment together with shared access, while ensuring a research intensive focus. This path will ensure a scientific use of equipment without depending on occasional projects for equipment support and maintenance, and channel the unique capabilities and expertise available to a central point of contact for industry and international partner institutions.

The training of HQP will be a major outcome of the proposed Centre; this outcome is well beyond the mandate of industry, and beyond the reach of institutions of training in technologies (colleges). The Welding Research Lab received the American Welding Society's Image of Welding: Educational Facility Award (2013) for "exemplary commitment to furthering the image of welding." The CCWJ will build on the University of Alberta's reputation as a leader in welding education. It will expand opportunities for education of undergraduate and graduate students

and post-doctoral fellows within an interdisciplinary context, facilitate knowledge exchange, and support skill transfer.

The CCWJ will continue the work of the Welding Research Lab in demonstrating the excitement and promise of a career in technology in Canada, and in attracting new students to the University of Alberta. For example, the Welding Research Lab has hosted 56 visiting students, including students from international exchange programs such as University of Alberta Research Experience / China Scholarship Council (UARE-CSC), MitacsGlobalink, Emerging Leaders in the Americas Program (ELAP), and the French Envoleo grant program. To ensure a stream of incoming students and engineers into the future, the Welding Research Lab participates in the WISEST program and has direct collaborations with Archbishop MacDonald High School, D.S. McKenzie High School, St. Joseph High School, Old Scona Academic High School, and Ottewell Junior High School. Since 2012 these efforts have resulted in 33 internships at the Welding Research Lab for students from local junior high and high schools. This year we have further expanded these activities by participating in the University of Alberta USchool program for socially vulnerable, Aboriginal (First Nations, Métis and Inuit) and rural communities.

The CCWJ will build new connections between the University of Alberta and welding-related industries. Welding technology needs to be developed and adapted to the needs of Canada, in particular when there is no “off-the shelf” solution. As a central point of contact for welding-related questions, the CCWJ will add very significant value to industry in Canada, especially companies in Western Canada and Alberta.

The CCWJ will make possible new pan-Alberta collaborations, leveraging the close ties of the Welding Research Lab with relevant Alberta institutions such as InnoTech Alberta and the Industrial Development branch of the Government of Alberta. These two organizations are partners in the Alberta Metal Fabrication Innovation (AMFI) program. AMFI’s mission is to bridge the gap between productivity technologies and their industrial application in Alberta through improved coordination between businesses, technical and networking services, and improved facilitation of knowledge and skill transfer between academia, industry, and government. Beneficiaries of AMFI activities included the Alberta manufacturing companies supplying product to oil sands activities. Through AMFI, the Welding Research Lab has partnered with most other major local manufacturing associations and institutions in Alberta, including Northern Alberta Institute of Technology (NAIT), Southern Alberta Institute of Technology (SAIT), Red Deer College (RDC), as well as Peace River Manufacturers Association (PeRMA) and Central Alberta Rural manufacturers (CARMA). Some of these institutions have expressed an interest in establishing a formal collaboration, for which the recognition as a centre is paramount. Initial steps have been taken with both NAIT and SAIT, and mechanisms are in place to increase this collaboration once a formal structure has been established. By leveraging such collaborations, the CCWJ will bring awareness and raise the profile of the UofA on the federal level. As a Centre, it will be possible to include the area of policy-making, and take an active role through participation in consultations, partnerships with the federal and provincial governments and professional societies (Canadian and international).

The CCWJ will increase the stature of the University of Alberta in the national and international research community, and in key industry sectors. Members of the Welding Research Lab are members of key committees such as IIW: National Delegate for Canada; Expert for C XII and SG 212; Member of IIW TMB; and AWS: A5G Subcommittee on Hard Facing Filler Metals, EC Education Committee, Higher Education – Engineering Subcommittee. They are also involved in the executive committees of the CWB Association (Edmonton chapter), and the American Welding Society (Alberta Chapter, and the Board of Directors).

4d. Benefits for Students

Students will benefit from the CCWJ in numerous ways:

- **Job prospects / Industry Placement:** The welding research lab has a track record of a 100% success rate in industry placement of its graduates, which often includes high-ranking positions at the point of graduation.
- **Scholarships:** The CCWJ will be the role model for student engagement in industry association student chapters, and further increase the high success rate of scholarships for its students
- **Relevant Practical Experience through Industry Internships:** The students will be given the opportunity to participate in industry internships. In the past this has included a 4-month internship at Tesla, which was so successful that Tesla sent a recruiting team to the UofA, and hired another student from the welding research lab for another 4-month internship (ongoing)
- **Industry Networking:** The CCWJ will provide regular networking opportunities with high-ranking industry professionals at the centre, at industry events, and at conferences.
- **Development of Student Leadership**: The current student chapters of leading welding industry associations are considered the most innovative and active in North America, which reflects in attendance of international conferences funded through student fundraising, and nomination of students to leadership functions (in 2019 Mitchell Grams was selected to be a part of the Board of Directors at AWS as one of two inaugural AWS Young Leaders; other students are part of the IIW Young Leaders, and alumni continue to play a leading role on the national level of the CWB Welding Association).
- **Interdisciplinary Research Environment:** Welding research is inherently multidisciplinary, and the interdisciplinary environment established by the CCWJ will support student learning and growth by facilitating access to a broad range of expertise and foster knowledge exchange. This environment will be supported by the unique equipment available, plus specialized instruments available through our collaborators, and access to the broad range of scientific equipment available within the broader UofA ecosystem.
- **Inclusive and Welcoming Environment:** The collaborative environment at the CCWJ will encourage students who may not have considered a career in manufacturing, and by ensuring that these students will find job opportunities in the industry will contribute to making the industry a more inclusive place.

See *Appendix D: Student Success – Scholarships and Industry Placement* for an overview of scholarships and industry placement of graduates.

5. Governance Structure

The CCWJ will be operated by the University of Alberta, under the Dean of Engineering (currently Dean Dr. F. Forbes). The Dean of Engineering is ultimately responsible for the operations of the Centre as an entity within the Faculty of Engineering. The CCWJ Director, guided by an Industrial Advisory Board and a Scientific Advisory Board, recommends actions; the Dean is responsible for executing decisions that affect the operation of the Centre. In addition to hiring, the Dean is responsible for the accounts related to the Centre. Control of all Centre accounts is through the Dean's Office.

The nature of this governance model is described further in the section below, but an important factor is the hierarchy of control embodied in the structure, agreements, and charters related to this. Upper level control of the Centre rests with the University.

The administrative structure of the CCWJ (see Figure 1) is designed to support its research and education mandate and to foster the collaboration with the sponsors of the Weldco/Industry Chair in Welding and Joining, industry partners, and government agencies. In order for the CCWJ to succeed in its goals, it requires the ongoing commitment and collaboration of the University of Alberta and key stakeholders (including contributors to the Weldco/Industry Chair in Welding and Joining, and major contributors such as Lincoln Electric, Miller Electric, and the CWB/ CWB Welding Foundation) as well as a management structure that fosters strong communication and the formation of consensus decisions. The CCWJ will employ a management structure derived from other existing centres in Engineering.

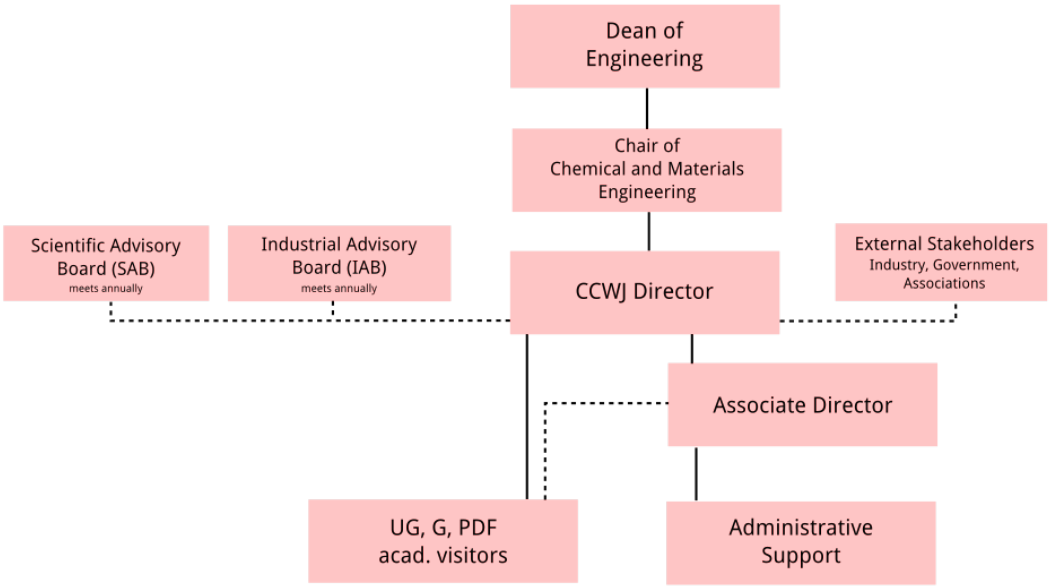


FIGURE 1: PROPOSED STRUCTURE FOR CENTRE. THE DASHED LINES INDICATE ADVISORY ROLES, NOT HIERARCHICAL ROLES

The hierarchy established ensures that the control of the Centre is clearly resting with the UofA.

Director:

The Director will lead the CCWJ activities and coordinate activities with the academic partners and program management. He or she will direct the development of new research projects, and promote the Centre to the University community and provincial, national, and international audiences. The Director will maintain a network of international research contacts with direct benefits to the Centre, the UofA and the industry. All annual operating plans, budgets, and reports will be reviewed and approved by the Director before submission to the UofA, sponsors, or industrial partners.

The Director of the CCWJ is the Weldco/Industry Chair in Welding and Joining, and will be selected by the Dean. The Director shall not receive any salary from the Centre, and shall be a full-time academic staff member of the University of Alberta.

Industrial Advisory Board:

The Industrial Advisory Board (IAB) is expected to meet annually and will provide valuable advice on strategic direction, steward progress, provide feedback on budget, research plans, and intellectual property proposals before submission to the Dean of Engineering and/or the UofA. Although it is expected that the UofA and the CCWJ Director will consider the advice and guidance of the IAB, no term or condition compels the UofA to accept such advice or guidance.

The IAB will be chaired by a representative from industry elected by IAB members. IAB membership consists of:

- One representative of each company that contributes more than $50K to the Weldco/Industry Chair
- Representatives of each company contributing to large multi-year funding structures will be part of the IAB for the duration of the project. Of these members, only representatives of companies that contribute more than $50k annually will have a vote
- Member from the Industry Development Branch of the Government of Alberta (currently Mr. D. Unrau)
- Chair of the Department of Chemical and Materials Engineering (currently Prof. K. Cadien).
- One graduate (within the last 5 years) on a renewable 2-year appointment, who is elected by the IAB members

Participation in the IAB shall be voluntary and not remunerated.

Scientific Advisory Board:

The CCWJ's research mandate is guided by an interdisciplinary Scientific Advisory Board (SAB) that works collaboratively with the Director and has the goal of strengthening the interdisciplinary interaction with collaborators. The SAB is expected to meet annually and will provide scientific advice, steward progress, provide feedback on research plans, research

budgets, and intellectual property proposals before submission to the Dean of Engineering and/or the UofA. Although it is expected that the UofA and the CCWJ Director will consider the advice and guidance of the SAB, no term or condition compels the UofA to accept such advice or guidance.

The SAB works with researchers to align proposals with existing work and strategic direction and areas. The SAB is chaired by the Weldco/Industry Chair. Membership consists of: the Dean of Engineering, CCWJ Director, Chair of the Department of Chemical and Materials Engineering, and two members elected from the pool of internal academic collaborators on a two-year, renewable term. Consideration of EDI will be part of the nomination and selection process. Participation in the SAB shall be voluntary and not remunerated.

Associate Director

The Associate Director (currently Dr. G. Dapp) will manage the laboratories of the CCWJ (currently four), and collaborate on research design, technology implementation, methodology determination, analysis and other activities that facilitate the work of the CCWJ. Duties include all phases of data collection and analysis and the preparation of proposals for new research activities, the presentation of research findings, and the preparation of reports and papers. The Associate Director will make recommendations to the Director regarding long, medium, and short-term research activities, structure of the Centre, and hiring decisions. The Associate Director will consult regularly with the Faculty of Engineering Finance/Human Resource Management team at the University of Alberta, as well as Research Services Office, and other university entities to ensure efficient and compliant management of research grants. The Associate Director will supervise support staff, interact with sponsors and industry, and help promote the Centre to the University community and provincial, national, and international audiences. The Associate Director will supervise procurement and accounting, and report to the Director that all accounts are in order.

The Associate Director will be expected to work independently, overseeing the implementation of decisions made in consultation with the Director, and making some final decisions regarding research projects and their resources. The Associate Director is a full-time trust-funded employee of the University of Alberta and subject to the hiring and employment policies of the University. The recruitment, performance evaluation, and terms of employment will follow the University of Alberta standards for positions of this type.

External Stakeholders

The external stakeholders involve the people and entities outside UofA who will benefit from the knowledge and opportunities generated by the CCWJ. External stakeholders include academic partners, industry, and government, some of whom may be part of the IAB and SAB. These stakeholders may be involved as sponsors or collaborators in ongoing research project, and through their involvement will engage new sponsors and collaborators. These stakeholders do not constitute a formal entity, but are engaged based on the needs of industry, ongoing initiatives of associations, priorities set by the provincial and federal governments, and consideration of

EDI. This involves participation in round-table events, tours, trade missions, etc. and will feed into identifying research priorities, project selection, and outreach activities.

Government partners will connect the CCWJ to federal and provincial funding opportunities and serve as collaborators on policy/advocacy related projects in addition to engaging new industry sponsors and collaborators.

Academic Partners will ensure the operation and growth of the CCWJ in the areas of their expertise, and the supervision and training of Research Associates, PDFs, and students. The Academic Partners promote the Centre to the University community and provincial, national, and international audiences. The Academic Partners will be expected to be involved in technical societies, committees, and editorial boards, engage new sponsors and collaborators, and attract new undergraduate and graduate students to the Centre. Academic Partners shall not receive any salary from the Centre, and shall be full-time academic staff members of the University of Alberta, Adjunct Professors, or collaborators from partner universities.

Support Staff

Support staff will take care of daily accounting, billing, and ordering, manage communications related to industry events or trade missions, maintain contact lists and databases on Centre-related statistics, compile a newsletter, maintain the CCWJ website, make travel arrangements for the Director and faculty, and handle paperwork. These staff (currently T. Runyon and M. Doyle) are trust employees and subject to the hiring and employment policies of the University. Recruitment, performance evaluation, and terms of employment will follow the University of Alberta standards for positions of this type.

6. Role and Qualifications of the Centre Lead

The Director of the CCWJ will be the Weldco/Industry Chair in Welding and Joining. The Director will lead all CCWJ activities and coordinate activities with faculty members and program management. He or she will direct the development of new research projects. The Director will promote the Centre to the University community and provincial, national, and international audiences. He or she will engage new sponsors and collaborators, and lead the recruitment of undergraduate and graduate students. The Director will be expected to be involved in technical societies, committees, and editorial boards on an international level. The director will maintain a network of international research contacts with direct benefits to the Centre, the UofA and the industry.

The founding Director of the CCWJ will be Professor Patricio F. Mendez, inaugural holder of the Weldco/Industry Chair in Welding and Joining. Professor Mendez's teaching and research focus on physics and mathematics of welding and materials processing, including heat transfer, magnetohydrodynamics, arc plasma, thermodynamics, and kinetics. Applications include wear protection for mining, and oil extraction, alloy development, procedure development, new welding processes such as laser cladding, casting, solidification, and direct metal additive manufacturing using semi-solid processing. Before joining the University of Alberta in January 2009, he taught and researched at the Colorado School of Mines. Before that, he was a consulting

engineer at Exponent Inc. In 1995 Dr. Mendez co-founded Semi-Solid Technologies Inc. in Cambridge, MA. Prof. Mendez holds a Ph.D. and a M.S. degree in Materials Engineering MIT, and a Mechanical Engineer degree from the University of Buenos Aires. He is a Fellow of the AWS and the CWA. Selected awards include, UofA Outstanding Mentorship in Undergraduate Research, AWS William Irrgang Award, IIW Kenneth Easterling Award, the ASM Brian Ives Award, the NSF CAREER Award, the MIT Rocca Fellowship, and UBA Research Fellowship, and has 9 patents.

7. Employees

The Welding Research Lab currently funds three employees:

- Full-time Associate Director (currently Dr. G. Dapp), who manages the operating budget of the lab, supports research and outreach activities, and assists the Director in interacting with industry, sponsors, and government contacts
- Part-time secretaries (currently T. Runyon and M. Doyle), who help with event coordination, ordering, and accounting

These staff are University of Alberta employees and are entirely trust funded through the CCWJ. The CCWJ budget will include adequate provisions for benefit costs, salary settlements, and other escalating factors. The same funding and budgetary provisions will apply should additional support staff positions be created in the future.

8. Financial Plan

The CCWJ will be self-sustaining through the endowment of the Weldco/Industry Chair in Welding and Joining, research funds, direct government support for operations, and a limited amount of service provided to industry.

The Weldco/Industry Chair in Welding and Joining is an endowment of funds contributed through 2019 by the nine companies listed in the left column of Table 2. This $2.1 million endowment ($1.7M contributions, $4k accrued earnings) will support long-term research programs in welding, and endowment earnings will be leveraged as cash contributions in NSERC alliance grants. In addition to the endowment, we have received a $1,500,000 equipment grant from Western Economic Diversification (of which $725,000 was shared with AITF [now InnoTech Alberta]), a $1.1 million grant from Western Economic Diversification (100% held at the Welding Research Lab, with an additional in-kind contribution of $1m from Group Six Technologies, KUKA Canada, Octopuz, and others), and a $355,000 grant from the Government of Alberta for the development of the research aspects of the program. The Welding Research Lab has also received a $500,000 grant from the Canada Foundation for Innovation (CFI) through which we added a robotic laser cladding and welding automation research facility. These funds are in addition to the NSERC and industrial funds currently held by Prof. Mendez and other academic partners, which have consistently provided an operating budget to support growth of the Welding Research Lab.

TABLE 2: SPONSORS OF THE WELDCO/INDUSTRY CHAIR IN WELDING, AND CURRENT SUPPORTERS OF THE WELDING RESEARCH LAB

Current sponsors of the Weldco/Industry Chair in Welding and Joining	Current supporters of the Welding Research Lab through projects, equipment, software, consumables, and in-kind.	
Acklands Grainger	AERI	Hobart Brothers
Canadian Welding Bureau	Alicat Scientific	Indalco Alloys
CESSCO Fabrication and Engineering	American Welding Society	JV Drivers
Lincoln Electric Company of Canada	Apollo Laser Clad	Lincoln Electric
Metal Fabricators & Welding Ltd.	Arctec Alloys	Miller Electric
Miller Electric	Bab-Hitachi	MSC Software
Suncor Energy	Canada Foundation for Innovation (CFI)	North American Höganäs
Syncrude Canada	CWB Association	NSERC
Weldco-Beales Mfg.	CWB Welding Foundation	Praxair
	CASTI	Sulzer
	CLAC	Syncrude
	Defence Canada	Thermadyne/Stoody
	Goldaktec / VrWeld	Totem Acoustic
	Flir	Tregaskiss
	Government of Alberta	Walter Surface Technologies
	Group Six Technologies	Western Economic Diversification
	HC Starck	Wilkinson Steel and Metals / Samuel Son & Co.
	Tackpoint Ltd.	
	KUKA	Laserline
	Thermach Inc.	Weldco-Beales Mfg.
	LJ Welding	Octopuz Inc.
	DURUM Verschleisschutz GmbH	

During the initial five-year period of the CCWJ, we plan to seek matching funds from a range of agencies, such as the NSERC Alliance program and federal and provincial initiatives. The funding for the Centre will come from multiple industry partners, and include further leveraging of the Weldco/Industry Endowment spending allocation of currently $68k/year.

Annual expenditures will be set by the funds available from available sources in a given year, and therefore the establishment of the Centre does not pose a financial risk to the University of Alberta. The annual budget is estimated to consist of:

	2019-20	2020-21	2021-22	2022-23
Students & PDF	200,000	330,000	355,000	400,000
Research Associate	90,000	94,000	98,000	102,000
Support Staff	40,000	50,000	50,000	50,000
Lab supplies	20,000	25,000	25,000	30,000
Travel	30,000	30,000	32,000	35,000
Equipment maintenance	5,000	10,000	10,000	15,000
Software maintenance	2,000	5,000	5,000	8,000

As the research program grows, we plan to expand our collaborations to include researchers from other universities. Collaborations are already in place with UNAM (Mexico) and Colorado School of Mines. On a project-specific basis, we also plan to seek collaborations with InnoTech Alberta, CANMET, Natural Resources Canada, and the R&D centres of manufacturing companies in Alberta, Canada, and abroad. The University of Alberta already enjoys extensive collaboration with government organizations and welding-related companies, and we will seek collaboration on CCWJ projects to bring the best minds and facilities to the research program, and to avoid duplication of effort and resources.

8a. Budget Uncertainties and Mitigation

The largest uncertainty regarding the budget stems is the consistent availability of research funding and changes in the Tri-Agency funding structures. Mitigation of these uncertainties include a proactive participation in funding workshops; active outreach and networking activities to industry, industry associations, and government; and close collaboration with University administration and Research Service Office. The endowment earnings (currently approx. $68,000/year) will be leveraged in grant proposals (with expected 200% matching through NSERC) and further reduce uncertainties, and guarantee continuity of the structure of the CCWJ. The 10-year experience of the highly successful Welding Research Lab (see *Figure 2* below) and similar track record for the partners provide a baseline for operation, and have already seen the transition from a funding structure with a strong influence of oil and gas funding to a more diversified and broader industrial basis including advanced manufacturing and industry currently not yet operating in Alberta. In addition, since annual expenditures will be set by the funds available from available sources in a given year, the establishment of the Centre does not pose a financial risk to the University of Alberta.

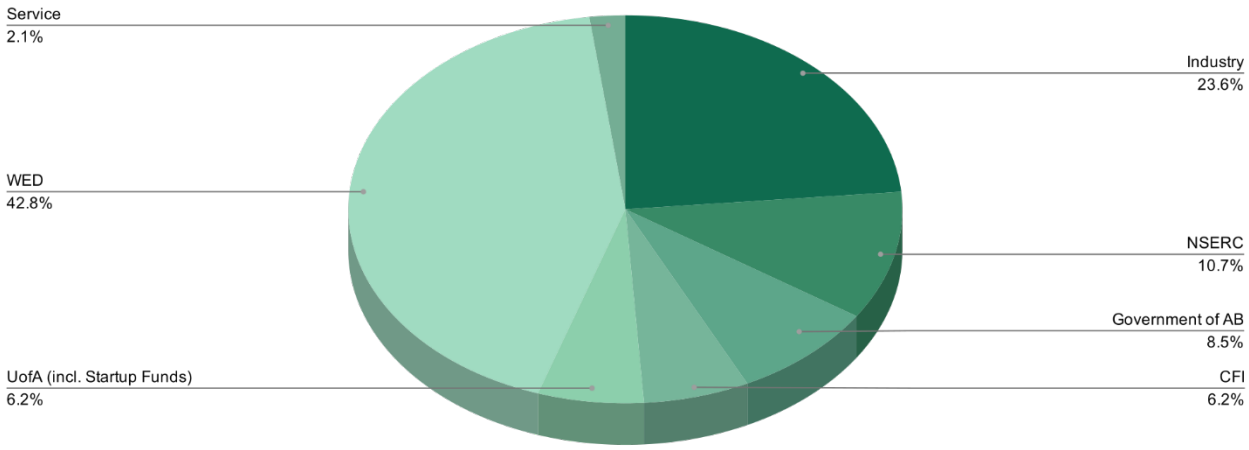


FIGURE 2: 10-YEAR REVENUE DISTRIBUTION OF THE WELDING RESEARCH LAB 2009-2019. TOTAL REVENUE $4.25 MILLION (EXCLUDING EQUIPMENT DONATIONS AND IN-KIND CONTRIBUTIONS)

9. Space Requirements and Equipment

9a. Space Requirements

The CCWJ will be hosted in the existing 275 m^2 Welding Research Lab in CME L1-108, which opened in the Department of Chemical and Materials Engineering on May 5, 2010. The Welding Research Lab also operates a dedicated advanced metallurgical testing laboratory in CME 5-133 (45 m^2). A laser cladding research facility for advanced wear and corrosion protection materials and additive manufacturing (45 m^2) was funded by a $500k grant from the Canada Foundation for Innovation (CFI) John R. Evans Leaders Fund (JELF) and the Alberta Innovation and Advanced Education (IAE), with further support from Western Economic Diversification (WED). It is located in room CME L1-118, with storage space in L1-120.

The spaces were assigned by the Faculty of Engineering as part of the Weldco/Industry Chair, the CFI grant, and the WED grants. There will be no charges for space or equipment usage, and no further space requirements are expected in the short to medium term.

9b. Equipment

The equipment infrastructure of the proposed Centre is currently fully functional as the Welding Research Lab, which hosts state-of-the-art equipment through the donations of welding-related companies and government grants. The equipment includes latest generation, microprocessor-controlled GMAW, GTAW, SAW, PTAW machines, various spot-welding machines, plasma-cutting equipment, two hot-wire GMAW/GTAW units, an ARC Mate 100iC series welding robot and sophisticated equipment for solid-state joining processes like friction stir welding. Pipe welding equipment includes a pipe rotator, various pipe stands, and a Firefly orbital welding system. Further testing equipment consists in several data acquisition systems, various oscilloscopes/analyzer/waveform generators, and the Welding Research Lab's Phantom V210 and Miro eX4 high-speed video cameras, as well as a FLIR A6752sc thermal camera with cooled InSb detector. Software available exclusively to the Welding Research Lab includes a multi-seat license of simulation software Simufact.Welding and Simufact.Forming by MSC Software plus their APEX meshing system, VrWeld welding simulation software, a multi-seat license for JMatPro simulation for calculating properties for multi-component alloys, and custom-made image analysis scripts that are optimized for oil and gas applications. Software that is available through the Faculty of Engineering includes ThermoCalc and COMSOL.

This facility has dedicated transformers and utilities for welding research including a 500 kVA transformer for 600V and a 150kVA for 480V, a 1 ton overhead crane, and an array of dedicated fume extraction, centralized welding gas with computer-controlled, high-precision mass flow controllers, compressed air, and internet lines to allow data logging from each welding power supply online. This facility also features its own dedicated metallography laboratory to evaluate and characterize joints, housing a Nikon SMZ 745T Stereomicroscope, a Nikon Eclipse MA200 Inverted Microscope, a Buehler AutoMet/EcoMet 300 Autopolisher, a Buehler SimpliMet 1000 Hot Mount, Presi Mecatome T180 Microcutter, and a Twin-Jet Electropolisher Fischione Model 110.

The Welding Research Lab also operates a dedicated advanced metallurgical testing laboratory, which contains a Instron CEAST 9350 cryogenic instrumented impact testing with high-energy module capable of testing full-size Charpy samples, a Wilson Rockwell 2000-series hardness tester, a Tukon 2500 Automated Vickers Hardness Tester, a Rita L78 High Speed Dilatometer, and houses the Bruker G8 Galileo Oxygen / Nitrogen / Hydrogen Gas chromatographer. We will add a surface profilometer by late fall of 2019.

The laser cladding research facility provides the CCWJ with a state-of-the-art KUKA KR-16 6-axis robot, a KRC-4 controller, and a 2-axis positioner, together with a 9 kW Laserline LDF 9000-40 laser system with built in two-colour pyrometer. This is complemented by a Creaform Metrascan 750 3D scanning system, Primes BM+ and FM+ laser beam profilers, and a laser power meter. Software available includes a multi-seat version of Octopuz and RoboDK, as well as a single license of Geomagic. The medium-term plan for the robot is to expand the facility with multi-process and machine vision and machine learning capabilities and become a cornerstone of research in welding automation and additive manufacturing.

Cost for equipment purchases, maintenance, and upgrades have been handled by the Welding Research Lab through grants, and will be shared by the members of the CCWJ based on project-specific usage.

10. Potential Risks to the University of Alberta

The main uncertainty associated with the CCWJ is the future budget. Annual expenditures will be set by the funds available from available sources in a given year, and actual expenditures will depend on the success of the Centre in gaining contributions from research partners. If the research income were insufficient, then the activities of the CCWJ would be reduced to the point where they could be sustained on the income from the endowment and matching funding available at that time. The terms for termination of the partnership between Weldco/Industry Chair partners and the University are covered under each endowment agreement (for a sample see *Appendix F: Weldco/Industry Endowment Agreement*).

11. Annual Reporting and Strategic Review

The CCWJ will provide an annual report to the Dean of Engineering. The Dean will annually report on the progress of the Centre to the Provost as required by University of Alberta policy. Further, in consultation with key stakeholders, the Dean will conduct a major operational and strategic review of the CCWJ and its activities within three years of its establishment.

12. Intellectual Property (IP) and Copyright

All IP and copyright will be handled in accordance to the University of Alberta IP and copyright regulations. Beyond existing collaborations and agreements, each new sponsor and industrial partner will sign an agreement that covers the specific details of their involvement in the CCWJ.

13. Termination Plan/Provisions

The CCWJ is funded through several different streams of funds, each of which has its own terms of termination.

The terms for termination of the partnership between each Weldco/Industry Chair partner and the University are covered under individual endowment agreements (sample agreement attached in *Appendix F: Weldco/Industry Endowment Agreement*). The terms for termination of the partnership between IRC partners and the University will be covered under each agreement. The terms for termination for NSERC CRD sponsors or individual research projects or grants are covered under each individual agreement.

According to these agreements, should a Sponsor's involvement in the CCWJ be terminated in accordance to the specific agreement, the parties will take all reasonable steps to wind down the involvement of the terminating Sponsor in the Research Program with a minimum of costs. In these circumstances, the terminating Sponsor will pay for the portion of the Research Program completed and the University's committed and uncancellable costs of the Research Program, the total of which in no event will exceed the terminating Sponsor's Contribution pursuant to the agreement. The Sponsors will pay for the portion of the Research Program completed and the University's committed and uncancellable costs of the Research Program, the total of which in no event will exceed the Contribution pursuant to the agreement.

The remaining budget will determine the scale of operation of the CCWJ, which would be reduced to the point where the Centre could be sustained on the income from the endowment and matching funding available at that time.

14. Letters of Support

[Attached]

15. Agreements and Memoranda of Understanding between the University of Alberta and its Partners

As an academic entity, the Welding Research Lab maintains active collaborations that are formally recognized through Memoranda of Understanding, including an MOU for German-Alberta exchange on welding technologies, signed in Berlin on June 4, 2013, and a MOU for Hiroshima University and University of Alberta exchange on welding technologies, which was last renewed in 2019. Further MOUs are in preparation with the TU Graz and the TU Munich.

These MOUs provide a formalized foundation for the collaborative aspects of the Welding Research Lab but do not affect establishment, funding, or operation of the proposed CCWJ.

UNIVERSITY OF ALBERTA

October 1, 2019

Dr. Steven Dew
Provost and Vice-President (Academic)
University of Alberta
2-40 South Academic Building (SAB)
University of Alberta
Edmonton, AB T6G 2G7

Re: Letter of Support for the Canadian Centre of Welding and Joining (CCWJ), University of Alberta

Dear Dr. Dew,

As a researcher who has collaborated with the Welding Research Lab on fundamental research for several years, I feel privileged to provide this letter of support for the ambitious project of establishing the Canadian Centre of Welding and Joining (CCWJ) at the University of Alberta. I see a very concrete need to establish this centre not only for this university and province, but also in this time of economic pressure, as its role in connecting fundamental and applied research. The ability to address issues from a very deep level up, e.g. studying arc physics and optimizing processes and machines, or using practical problems from the industry to learn more about fundamental principles involved, is exciting for industry and research and will have an incredible impact on the medium to long term prospect of companies. The interdisciplinary aspects of these undertakings also cannot be overstated – as a plasma physicist the microcosm of welding offers new insights into cosmic phenomena, and vice versa.

As part of my collaboration with Prof. Patricio Mendez we have been working closely on arc physics, looking into measuring and analyzing the plasma composition and distribution in the welding arc. Even though this research is very fundamental in nature, welding opens up opportunities to generate and experiment with plasmas that are allow fundamental work while also having direct practical application in the industry. We are currently co-advising 1 graduate student, and have co-advised 4 undergraduate students in this area since 2014.

It is my strong conviction that having the CCWJ at the University of Alberta will have a positive effect not just on our collaboration, but encourage further interdisciplinary collaborations around the inherently interdisciplinary field of welding.

Sincerely,

Richard Sydora

Richard D. Sydora
Professor of Physics,
Director, Theoretical Physics Institute

Department of Physics

Faculty of Science

University of Alberta · Edmonton · Canada · T6G 2E1
Telephone: (780) 492-3624 · Fax: (780) 492-0714
Email: rsydora@ualberta.ca

UNIVERSITY OF ALBERTA

DIVISION OF PREVENTIVE MEDICINE
DEPARTMENT OF MEDICINE
Faculty of Medicine & Dentistry

5-30 University Terrace
8303 – 112 St
Edmonton, Alberta, Canada T6G 2T4
Tel: 780.492.6291
Fax: 780.492.9677
www.medicine.med.ualberta.ca/AboutUs/Divisions/PMED

September 26, 2019

Dr. Steven Dew
Provost and Vice-President (Academic)
University of Alberta
2-40 South Academic Building (SAB)
University of Alberta
Edmonton, AB, T6G 2G7
Canada

Re: Letter of Support for the Canadian Centre of Welding and Joining (CCWJ), University of Alberta

Dear Dr. Dew:

I am sending you this letter to express my unequivocal support for establishing the Canadian Centre of Welding and Joining (CCWJ) at the University of Alberta.

Since 2013, Prof. Patricio Mendez and I have an active and productive interdisciplinary collaboration that combines my research in Occupational Health with the expertise available at the Welding Research lab. Of particular interest to our collaboration are the health effects nanoparticles and ultrafine particles emitted in the welding process, which have become a large issue to the welding industry with the introduction of new Occupational Exposure Limits. We have worked on a comprehensive overview of emissions of environmental strains produced by each welding process, as a part of which Prof. Mendez and I have co-supervised a post-doctoral fellow. The range of equipment and the expertise available in the Welding Research lab has been a tremendous resource and help. A co-authored article on "Fume particles and noise levels produced by common welding processes" was just accepted for publication. We are presently working in collaboration with Dr. Hashisho, from Environmental Engineering, and his MSc student to measure emission factors of common welding processes, for which we have been using Prof. Mendez's facilities to generate representative data.

I strongly commend Prof. Mendez for the efforts in and openness to working interdisciplinary. The spectrum and quality of research carried out at the welding research lab is extremely impressive, covers both applied and fundamental areas, fosters interdisciplinary collaboration, and truly exemplifies the qualities for a GFC-recognized Centre.

I see an immense benefit to the whole research community that will result from establishing the CCWJ at the University of Alberta and support the establishment of the CCWJ as a GFC-recognized Centre at the University of Alberta in the strongest possible terms.

Sincerely,

Bernadette Quémerais
Associate Professor, Division of Preventive Medicine
University of Alberta

UNIVERSITY OF ALBERTA

DIVISION OF PREVENTIVE MEDICINE
DEPARTMENT OF MEDICINE
Faculty of Medicine & Dentistry

5-30 University Terrace
8303 – 112 St
Edmonton, Alberta, Canada T6G 2T4
Tel: 780.492.6291
Fax: 780.492.9677
www.medicine.med.ualberta.ca/AboutUs/Divisions/PMED

September 23, 2019

Dr. Steven Dew
Provost and Vice-President (Academic)
University of Alberta
2-40 South Academic Building (SAB)
University of Alberta
Edmonton, AB T6G 2G7
Canada

Re: Letter of Support for the Canadian Centre of Welding and Joining (CCWJ), University of Alberta

Dear Dr. Dew:

With this letter I would like to express my explicit support for the establishment of the Canadian Centre for Welding and Joining (CCWJ) as a GFC-recognized academic centre at the University of Alberta. Based on my experience in collaborating with the Welding Research Lab on an interdisciplinary level, I strongly believe that the recognition as a Centre will prove to be beneficial for the greater research environment at the UofA, the province, and for Canada.

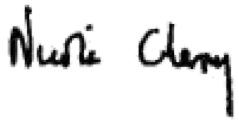
I am currently conducting a CIHR funded study of the impact of occupational conditions on female welders and the unborn child. As part of this research we are validating, in collaboration with Professor Mendez, a job exposure matrix to test assumptions about the influence of welding fume on pregnancy outcome. As part of this collaboration we successfully co-advised a welding apprentice who participated in welding-related research carried out in both our laboratories. The latest round of experiments took place throughout this past summer, and we were able to generate data not available in any publication or database. This data is currently being analyzed, and once published, will provide a significant contribution to the research community. I am looking forward to more of these interdisciplinary projects. The welding research lab with its fundamental knowledge of welding, access to welding equipment, and its specialized characterization equipment is a tremendous resource for occupational health related research. In bringing together equipment makers, manufacturing industry, and interdisciplinary research, it is ideally placed to carry out the research and start making the changes that will have an enormous positive impact a whole industry and, more importantly, the people working in it.

Especially in light of the importance of welding as a manufacturing technology, and the increased awareness of health impact on welders, I have no doubt that the CCWJ will play an central role for

research not only in engineering, but also in bridging gaps between disciplines, connecting industry and research, and training students in various disciplines in this area.

The openness of the laboratory to interdisciplinary endeavours and the collaborative spirit of the team make it a strong candidate for recognition as an official research centre at the UofA, and I am looking forward to further collaboration and to the benefits the CCWJ will bring to our students, colleagues, and the welders and companies in the manufacturing industry.

Sincerely,



Nicola Cherry MD PhD
Tripartite Chair of Occupational Health,
Professor, Division of Preventive Medicine,
University of Alberta

September 24, 2019

Dr. Steven Dew
Provost and Vice-President (Academic)
University of Alberta
2-40 South Academic Building (SAB)
University of Alberta
Edmonton, AB T6G 2G7
Canada

Re: Letter of Support for the Canadian Centre of Welding and Joining (CCWJ), University of Alberta

Dear Dr. Dew:

I am very happy to provide this letter of support for establishing the Canadian Centre of Welding and Joining (CCWJ) at the University of Alberta. The welding research facilities in the Department of Chemical and Materials Engineering not only provide an incredible resource for researchers but based on my interactions with the industry also address a concrete need for the manufacturing industry in Alberta.

My Laboratory of Intelligent Manufacturing, Design and Automation (LIMDA) in the Department of Mechanical Engineering has a focus on Advanced Manufacturing, Industry 4.0 and Robotics, and we have a highly successful ongoing collaboration with the welding research lab and share an NSERC CRD grant on the use of laser cladding for repair welds technology. This project came together because of the network of industrial contacts of Prof. Mendez. As an early career researcher I am very excited about the equipment and expertise of the welding research lab, and the willingness of Prof. Mendez to make available his laboratory and industrial contacts to collaboration and furthering research.

Prof. Mendez and I are currently working on our first invited peer-reviewed publication, and have identified several topics for further collaboration and shared research proposals in the areas of advanced/additive manufacturing, welding automation, 3D vision and controls, and process development. This includes further automation of multi-pass welding and robot-assisted welding in confined spaces. The excellent connections of the welding research lab to the international research community and to the industry will be of great benefit not only for my ongoing and future work, but also to other researchers working at the University of Alberta, and I have no doubt that we all stand to benefit from establishing the Canadian Centre for Welding and Joining.

I wholeheartedly support the establishment of the CCWJ as a GFC-recognized Centre at the University of Alberta and look forward to working with this unique entity.

Sincerely,

Rafiq Ahmad
Assistant Professor,
Laboratory of Intelligent Manufacturing, Design and Automation (LIMDA),
5-287, DICE, Mechanical Engineering Department

UNIVERSITY OF ALBERTA

DEPARTMENT OF CHEMICAL AND MATERIALS ENGINEERING
FACULTY OF ENGINEERING

Donadeo Innovation Centre for Engineering
12th Floor, 9211 – 116 Street NW
Edmonton, Alberta, Canada T6G 1H9
Tel: 780.492.3321
Fax: 780.492.2881
www.cme.engineering.ualberta.ca

October 1, 2019

Dr. Steven Dew
Provost and Vice-President (Academic)
University of Alberta
2-40 South Academic Building (SAB)
University of Alberta
Edmonton, AB T6G 2G7
Canada

Re: Letter of Support for the Canadian Centre of Welding and Joining (CCWJ), University of Alberta

Dear Dr. Dew:

I would like to express my support for establishing the Canadian Centre of Welding and Joining (CCWJ) at the University of Alberta. Since its opening in 2010, the welding research laboratory directed by Prof. Mendez has been an important part of the Department of Chemical and Materials Engineering, seen continuous and steady growth, and has been very popular destination in our outreach activities, including EnggExpos and UofA Open Houses. The fact that the opening of this facility goes back to an industry funded chair, the strong ongoing connection to and interaction with the industry, and the active collaborations with colleagues at the UofA and elsewhere indicates that this facility is a much needed entity for the province and the country.

In my function as the Graduate Chair for the Department of Chemical and Materials Engineering, I have been impressed by the high quality of research and of students that the lab Prof. Mendez's group has been able to attract and retain, including not only top students from the UofA but also top students from Tsinghua University, from the Paton Welding Institute, and the elite institution of the Nuclear Energy Commission of Argentina (Instituto Sabato). In addition, on an undergraduate level, the welding research group has been a very active participant in the Dean's Research Awards program, and has played an active role in the academic experience of many of our students. Overall, the welding research lab has been a fantastic ambassador for graduate studies at the UofA, and has contributed immensely the learning experience students – which reflects in the high success rate of students in obtaining scholarships and obtaining high-level positions upon graduation.

On the research side, I have collaborated with Prof. Patricio Mendez since 2012 in the area of predictive process control in gas-metal arc welding. As a part of this collaboration we have co-advised one undergraduate summer student, one undergraduate co-op student, and published a paper on the findings in IFAC *Advanced Control of Chemical Processes (ADCHEM)*.

I have absolutely no doubt that the recognition as an Academic Centre will help to further enhance and expand the activities, attract new students, encourage new collaborations, and provide an important foundation for growth into the future. I strongly believe that the Centre will help build the reputation of the University of Alberta as a research university, and be a place of invaluable support to Alberta's manufacturing industry.

Sincerely,

Vinay Prasad
Jaffer Professor in Process Systems and Control Engineering
Associate Chair, Graduate Studies

UNIVERSITY OF ALBERTA

FACULTY OF ENGINEERING
OFFICE OF THE DEAN

9-201 Donadeo Innovation Centre for Engineering
9211-116 Street NW
Edmonton, Alberta, Canada T6G 1H9
Tel: 780.492.3320
Fax: 780.492.0500
engginfo@ualberta.ca
www.engineering.ualberta.ca

October 10, 2019

Dr. Steven Dew
Provost and Vice-President (Academic)
University of Alberta
2-40 South Academic Building (SAB)
University of Alberta
Edmonton, AB T6G 2G7
Canada

Re: Letter of Support for the Canadian Centre of Welding and Joining (CCWJ), University of Alberta

Dear Dr. Dew:

It is with great pleasure that I write this letter of support for establishing the Canadian Centre of Welding and Joining (CCWJ) at the University of Alberta.

I have collaborated with Prof. Patricio Mendez since 2014 in the area of wear-resistant overlays in mining. As a part of this collaboration we co-advised one MSc student, with another MSc student carrying out parts of his research in the excellent facilities of the welding research lab. We have also published a paper on "Issues associated with welding and surfacing of large mobile mining equipment for use in oil sands applications" in *Science and Technology of Welding and Joining* in 2015, and a paper on "Welding and Surfacing of Large Mobile Mining Equipment" in the *CWA Journal* in 2016. With the advent of new complex alloys for hard-facing in the mining industry that can address very specific environments and make application-based usage economically feasible, I expect this involvement to grow. The expertise, facilities, and contacts to international researchers and industry that is available at Prof. Mendez lab is an invaluable asset to my research, to this university, and to the province.

In a resource-based economy, such as dominates our province, it is extremely important to stay up-to-date with new developments on a research level. It is also important to further the understanding through collaborations in various disciplines, in order to bring together perspectives, ideas and individual expertise. But what is equally important is to find ways to synthesize and disseminate the knowledge not just to academia, but to industry. The welding research lab has been extremely successful in this regard thus far, and is also a unique resource available to industry to maintain and foster competitive advantage in a global market.

Without any reservation I commend the efforts by Dr. Mendez and his team to establish the Canadian Centre of Welding and Joining at the University of Alberta; and see this as a logical progression for the excellent work that is being done right now, developing practical industrial change for the future, making Alberta a global focus.

Sincerely,

Dr. Tim Joseph. P.Eng., FCIM
Associate Dean & Director, Alberta Equipment – Ground Interactions Syndicate (AEGIS)

UNIVERSITY OF ALBERTA

Department of Electrical and Computer Engineering

Horacio J. Marquez, PhD, Peng, FIET, FEIC, FCAE
Professor
Department of Electrical and Computer Engineering
Electrical and Computer Engineering Research Facility
Edmonton, Alberta, Canada T6G 2V4

Tel: 780.492.3334
www.ece.ualberta.ca/~marquez
hmarquez@ualberta.ca
marquez@eceualberta.ca

Dr. Steven Dew
Provost and Vice-President (Academic)
University of Alberta
2-40 South Academic Building (SAB)
University of Alberta
Edmonton, AB T6G 2G7

October 3, 2019

RE: Letter of Support for the Canadian Centre of Welding and Joining (CCWJ), University of Alberta

Dear Dr. Dew:

I am writing to you to support the initiative to establish the Canadian Centre of Welding and Joining (CCWJ) at the University of Alberta.

Prof. Patricio Mendez and I have been working in the area of robotics control for several years, and are collaborators on the WED-funded project "Automated Repair of Low Volume/High Mix Components in the Alberta Context." My interest in this project is robust control, which is a branch of control theory that takes explicit account of the fact that the mathematical models used in control design are never perfect. This is a very practical problem, as a result of which practical implementations of theoretical models and simulations often fail in industrial contexts. My research background addresses such issues by implementing non-linear control theory, with emphasis on stability theory and robust and optimal control, for example through multirate sampled-data control.

Welding constitutes a complex non-linear system, and when it needs to be controlled and integrated with robotics, the complexity increases even more. The robustness of the system directly impacts the ability of industrial implementation, and we are excited to make a concerted effort in achieving this through an interdisciplinary collaboration to develop the proposed technology. This also indicates why such an automation is still lacking in the industry that does not have the range of resources available to make this possible.

The same argument also applies to the larger endeavor of establishing the CCWJ, which brings together a wide area of expertise and makes it possible to tackle projects of high industrial relevance. This is much-needed, and will create a unique resource for anything related to welding far beyond Western Canada.

I am very excited about this initiative, and look forward to working with colleagues and industrial partners on many projects in the area of welding.

Sincerely,

Horacio J. Marquez,
University of Alberta

Dr. Leijun Li, PEng, FAWS, FCWA, FASM
Professor

Department of Chemical & Materials Engineering
12-217, Donadeo Innovation Centre for Engineering, 9211 116th Street, Edmonton
Alberta T6G 1H9, CANADA

September 24, 2019

Dr. Steven Dew
Provost and Vice-President (Academic)
University of Alberta
2-40 South Academic Building (SAB)
Edmonton, AB T6G 2G7

Dear Dr. Dew:

I am pleased to write this letter of support for establishing the Canadian Centre of Welding and Joining (CCWJ) at the University of Alberta. This is a much needed entity for the province and the country, and it is an ambitious and very promising endeavor for our university. The establishment of the CCWJ as a GFC-recognized Centre will be an important step for welding-interested parties at the UofA in maintaining and increasing the scientific and creative momentum in all aspects of advanced research and teaching related to the joining of metals, from engineering, to physics, to medicine.

I have collaborated with the director of the Welding Research Lab, Prof. Patricio Mendez, the Weldco/Industry Chair in Welding and Joining, since I joined the University of Alberta in 2013. We have worked closely on welding metallurgy, co-created 3 courses (MAT E 466/630 Special Topics in Material Engineering: Fundamentals of Welding, MAT E 466/694: Advanced Manufacturing and Structural Materials, and MAT E 673: Welding Metallurgy), presented 2 shared research papers at the 2014 CanWeld conference, and have been co-PIs on 1 NSERC CRD ($168,000) and 1 CFI grant ($500,000).

The interdisciplinary research and collaboration carried out by the CCWJ will expand a key engineering field in Alberta, and offer more opportunities for education of undergraduate and graduate students and post-doctoral fellows. Moreover, the CCWJ will provide the optimal basis to meet the main challenge of welding as an engineering discipline, the combination of fundamental and applied research in an interdisciplinary context. By bringing together deep aspects of materials science including thermodynamics and phase transformations, as well as the heat transfer aspects of mechanical engineering, the power electronics of electrical engineering, and the materials performance issues of civil and mechanical constructions, the CCWJ will be a hub of activities for students, faculty, and industry.

The establishment of the CCWJ as an Academic Centre will foster future successful collaboration, and encourage further collaborations in typically unrelated research fields such as plasma physics, fluid mechanics, electromagnetism, turbulence, microstructural evolution, health impact, electrical circuits, and more. The recognition the Welding Research Lab has received to date by the international research community is only a small indication of what innovative energies the CCWJ will release.

I strongly support the establishment of the CCWJ as a GFC-recognized Centre at the University of Alberta. I am excited about this unique endeavor, and am looking forward to future collaborations with the CCWJ. Sincerely,

Leijun Li, P.Eng.

UNIVERSITY OF ALBERTA

Department of Medicine - Division of Infectious Diseases
Carlos Cervera, MD

1-124F Clinical Sciences Building
11350-83 Avenue
Edmonton AB T6G 2G3

https://www.ualberta.ca/medicine/departments/medicine/divisions/infectious-diseases

Tel: 780.492.5346
Fax: 780.492.8050

HOSPITALS

UNIVERSITY OF ALBERTA

Karen Doucette, MD
DIRECTOR

Carlos Cervera, MD
Justin Chen, MD
Stanley C. Houston, MD
Dima Kabbani, MD
Dennis Kunimoto, MD
Nelson Lee, MD
Jutta Preiksaitis, MD
Lynora Saxinger, MD
Stephen Shafran, MD
Stephanie Smith, MD
Geoff Taylor, MD

ROYAL ALEXANDRA

Rabia Ahmed, MD
Isabelle Chiu, MD
Ryan Cooper, MD
Mark Joffe, MD
Stuart Rosser, MD
Ameeta Singh, BMBS (UK)

GREY NUNS

Curtiss Boyington, MD
Robyn Harrison, MD
Holly Hoang, MD
Leah Remington, MD

MISERICORDIA

Lesia R. Boychuk, MD
Abraam Isaac, MD
Jamil Kanji, MD
Dennis Marion, MD

ADJUNCT FACULTY

Wendy Sligl, MD
Petra Smyczek, MD
D. Lorne Tyrrell, MD

EMERITUS

Anne Fanning, MD
George Goldsand, MD
Lilly J. Miedzinski, MD

September 30, 2019

Dr. Steven Dew
Provost and Vice-President (Academic)
University of Alberta
2-40 South Academic Building (SAB)
University of Alberta
Edmonton, AB T6G 2G7
Canada

RE: **Letter of Support for the Canadian Centre of Welding and Joining (CCWJ), University of Alberta**

Dear Dr. Dew:

It is my great pleasure to provide this letter of support for establishing the Canadian Centre of Welding and Joining (CCWJ) at the University of Alberta.

I have been collaborating with Prof. Patricio Mendez since 2015 and feel that this collaboration is not only a great example for the benefits of interdisciplinary research, but also a strong indicator why the establishment of the centre is important to the UofA research community.

As part of this collaboration, I was involved in the MSc thesis of a student performing fatigue experiments on large pieces of drilling equipment that were rebuilt to spec from a worn state by using industrial laser cladding technology. We were able to apply statistical analysis methodologies from the field of medicine and demonstrate the feasibility of this technology through a specific and relatively small experimental pool. It is needless to say that the methodology and findings of this work are of great economic interest to the manufacturing industry and for the end user. This research met with great interest from the industry and is the scientific foundation of an applied research project that is currently being prepared with an industrial partner.

The scope of the research carried out at Prof. Mendez's Welding Research Lab becomes clear when reflecting on the fact that the area of my own research on infectious complications of solid organ transplant patients seems far away from

welding. Bridging the disciplines and using our shared interest in the area of statistical analysis of experiments to bring together two different perspectives has been highly productive. I am co-author of a paper which was presented at the 2016 CWA CanWeld conference, and I anticipate much more application of my expertise in medical statistics in the field of welding.

I am convinced that establishing the Canadian Centre for Welding and Joining as a GFC-recognized centre at the university will provide a structure that encourages and support such interdisciplinary collaborations in advanced research and will be the nucleus for innovation and creativity spanning numerous disciplines and applications.

Yours sincerely,

Carlos Cervera, MD, PhD. Assistant Professor
Medical Director, Transplant Infectious Disease
Department of Medicine, Division of Infectious Diseases
University of Alberta

UNIVERSITY OF ALBERTA

September 25, 2019

Dr. Steven Dew
Provost and Vice-President (Academic)
University of Alberta
2-40 South Academic Building (SAB)
University of Alberta
Edmonton, AB T6G 2G7
Canada

Re: Letter of Support for the Canadian Centre of Welding and Joining (CCWJ), University of Alberta

Dear Dr. Dew:

I am very pleased to see the effort undertaken by Prof. Patricio Mendez and the Dean of Engineering to establish the Canadian Centre of Welding and Joining (CCWJ) at the University of Alberta, and am writing this letter to express my support for this endeavour.

I have collaborated with Prof. Patricio Mendez over the years in the area of image recognition and machine learning, in what is now commonly summarized under the umbrella term of artificial intelligence. This effort has significantly increased over the past two years, when we embarked on a project on using convolutional neural network (CNNs) to classify microstructures with deep learning. For this project we hired a young and highly talented Computer Science undergraduate student who had worked with Prof. Mendez's group before, and also involved one of Prof. Mendez's doctoral students who is an expert in metallurgy. This project was extremely successful, and within a short time we were able to put together a program with an astounding success rate.

The findings of this project have been presented at international conferences, such as the 2018 AWS Fabtech Professional Program, and at CanWeld Conference 2018.

Projects like this only happen if one has the right structure that brings together researchers and talented students from a range of academic backgrounds. For this reason I strongly support the establishment of the CCWJ, as this centre will provide not only the ideal platform for such interactions to happen, but the international recognition of the CCWJ has and will continue to attract highly motivated, excellent, and successful students, and contribute to the reputation of the University of Alberta.

I look forward to continuing my collaboration, and am particularly excited about the new possibilities and large-scale projects that a formal recognition as an academic centre will enable.

Sincerely,

Sirish L. Shah

Sirish L. Shah, FCAE
Emeritus Professor

Department of Chemical and Materials Engineering

12th Floor, Donadeo Innovation Centre for Engineering • University of Alberta • Edmonton • Canada • T6G 1H9
Telephone: (780) 965-8717 • Fax: (780) 492-2881
E-mail: sirish.shah@ualberta.ca

Appendices

The information collected here relates mostly to the track record of the current Welding Lab. Publications and grants in collaboration with the proposed partners are included. The existing Welding Lab at the Faculty of Engineering is the natural reference for the past welding activities at UofA.

Appendix A: Vision and Mission

Mandate of Weldco/Industry Chair

Vision:

The Canadian Centre for Welding and Joining will ensure that Canada holds a pre-eminent position as a leader in research and development, education and application of welding and joining technologies.

Mission:

The Canadian Centre for Welding and Joining will be dedicated to the creation and dissemination of knowledge in the areas of materials joining, welding specifications and design, and joining process development. The main application focus of the Centre will be in meeting the needs of Canadian resource-based industries.

Objectives & Activities:

The Centre activities will include high-quality research on novel welding and joining processes, materials, testing methods, and supporting technologies. The other key Centre activity is the training of graduate students and other researchers in the fundamental principles and technologies of advanced welding and joining. Additionally, the Centre should undertake dissemination activities aimed at the practicing engineer to ensure opportunities for on-going professional development.

Appendix B: Collaborative Publications and Presentations

Entries with an asterisk (*) mark UofA collaborations.

Papers in archival journals

Barnes, N., Clark, S., Seetharaman, S. and Mendez, P. F., *Growth mechanism of primary needles during the solidification of chromium carbide overlays*. Acta Mater., 2018. (151): pp. 356–365.

*Barnes, N., Joseph, T., and Mendez, P.F., "Welding and Surfacing of Large Mobile Mining Equipment - Issues and Typical Strategies," CWA J., 2016. (16): pp. 12–21.

*Barnes, N., Joseph, T., and Mendez, P.F., *Issues associated with welding and surfacing of large mobile mining equipment for use in oil sands applications.* Science And Technology Of Welding And Joining, 2015. 20 (6): p. 483-493.

Delgado-Álvarez, A., Mendez, P. F., and Ramírez-Argáez, M. A., *Dimensionless representation of the column characteristics and weld pool interactions for a DC argon arc*. Sci. Technol. Weld. Join., 2019. pp. 1–10.

*Fisher, G., Wolfe, T., Yarmuch, M., Gerlich, A. P. and Mendez, P. F., *The Use of Protective Weld Overlays in Oil Sands Mining*. CWA J., 2011. (Summer): pp. 28–39.

*Gajapathi, S.S., Mitra, S.K., and Mendez, P.F., *Part 2: Application of Kanaya–Okayama heat source in modelling micro electron beam welding.* Science and Technology of Welding and Joining, 2012. 17 (6): p. 435-440.

*Gajapathi, S.S., Mitra, S.K., and Mendez, P.F., *Part 1: Development of new heat source model applicable to micro electron beam welding.* Science And Technology Of Welding And Joining, 2012. 17 (6): p. 429-434.

*Gajapathi, S.S., Mitra, S.K., and Mendez, P.F., *Controlling heat transfer in micro electron beam welding using volumetric heating.* International Journal of Heat and Mass Transfer, 2011. 54 (25-26): p. 5545-5553.

*Gerlich, A. P., Izadi, H., Bundy, J., and Mendez, P.F., *Characterization of high-strength Weld metal containing Mg-bearing inclusions: Microstructural analysis of flux cored welds using a 4% Ni steel consumable exhibits both high strength and toughness*. Weld. J., 2014. 93 (1): pp. 15S-22S.

*Gerlich, A. P. ,Yue, L.. Mendez, P. F. and Zhang, H., *Plastic deformation of nanocrystalline aluminum at high temperatures and strain rate*. Acta Mater, 2010. 58 (6): pp. 2176–2185.

Gibbs, J.W., Schlachter, C., Mayr, P., Kamyabi-Gol, A., and Mendez, P.F., *Cooling Curve Analysis as an Alternative to Dilatometry in Continuous Cooling Transformations.* Materials Transactions A, 2015. 46A (1): p. 148-155.

Gibbs, J.W., Kaufman, M. J., Hackenberg, R. E., and Mendez, P. F., *Cooling curve analysis to determine phase fractions in solid-state precipitation reactions*. Metall. Mater. Trans. A Phys. Metall. Mater. Sci., 2010. 41 (9): pp. 2216–2223.

He, H., Gou, W. , Wang, S., Hou, Y., Ma, C., and Mendez, P. F., *Kinetics of intermetallic compound layers during initial period of reaction between mild steel and molten aluminum.* Int. J. Mater. Res., 2019. (Jan), pp. 146.111735.

Kamyabi-Gol, A. , Clark, S., Gibbs, J. W., Seetharaman, S., and Mendez, P. F., *Quantification of evolution of multiple simultaneous phase transformations using dilation curve analysis (DCA)*. Acta Mater., 2016. (102): pp. 231–240.

Mendez, P.F., Goett, G., and Guest, S.D., *High-Speed Video of Metal Transfer in Submerged Arc Welding.* Welding Journal, 2015. 94 (10): p. 325s-332s.

Mendez, P.F., Tello, K. E., and Lienert, T. J., *Scaling of coupled heat transfer and plastic deformation around the pin in friction stir welding*. Acta Mater., 2010. 58 (18): pp. 6012–6026.

Marcano, D., Mendez, P.F., Gibbs, J.W., and Kannengiesser, T., *Martensite fraction determination using cooling curve analysis.* Solid State Phenomena, 2011. 172-174: p. 221-226.

Papers in refereed conference proceedings

Mendez, P. F., Tello, K. E., and Gajapathi, S. S. *Generalization and Communication of Welding Simulations and Experiments Using Scaling Analysis.* Trends in Welding Research. June 4-8, 2012. Chicago, IL. p. 249-258.

Papers in conference proceedings

*Bell, K., Cervera, C., and Mendez, P.F., *Full-Scale Testing of the Fatigue Life of Laser Clad Components.* In: CWA 2016 CanWeld Conference. September 4, 2016. Edmonton, AB.

Delgado, J. A. , Argáez, M. A. R., and Mendez, P. F., *Efecto de la Corriente y Longitud de Arco en Soldaduras con Arco Eléctrico Asistido por Modelado Matemático*. In: *Sixth Engineering, Science and Technology Conference ESTEC*, 2017. 3 (1): pp. 373–382.

*Gajapathi, S.S., Mitra, S.K., and Mendez, P.F., *Modeling of micro electron beam welding by incorporating melting and evaporation*. In: *ASME 2012 International Mechanical Engineering Congress & Exposition, IMECE2012*. 2012: Houston, TX.

*Gajapathi, S.S., Mendez, P.F., and Mitra, S.K. *Analytical method to study the temperature distribution in case of a moving heat source in electron beam micro-welding.* In: *HEFAT2010, 7th International Conference on Heat Transfer, Fluid Mechanics and Thermodynamics*. 19-21 July 2010, 2010. Antalya, Turkey. p. HEFAT2010-1286.

*Gajapathi, S.S., Mitra, S.K., and Mendez, P.F. *Modeling Of Micro Welding Process Using Electron Beam Under High Peclet Number.* In: *ASME 2010 International Mechanical Engineering Congress & Exposition. IMECE2010*. November 12-18, 2010. Vancouver, BC. p. IMECE2010-39248.

Kamyabi-Gol, A., Gibbs, J.W., and Mendez, P.F. *Advanced mathematical treatment of dilatometry and calorimetry to discriminate and quantify multiple phase transformations.* In: *International Conference on Solid-Solid Phase Transformations in Inorganic Materials*. June 28 - July 3, 2015. Whistler, BC. p. 1199-1206.

Kiattisaksri, P., Gibbs, P.J., Koenig, K., Pfeif, E.A., Lasseigne, A.N., Mendez, P.F., Mishra, B., and Olson, D.L., *Assessment of the State of Precipitation in Aluminum Casting A356.2 Alloy Using Nondestructive Microstructure Electronic Property Measurements*. In: *Review of Progress in Quantitative Nondestructive Evaluation, Vols 29a and 29b*, D.O. Thompson and D.E. Chimenti, Editors. 2010. p. 1285-1292.

Mendez, P. F., Ponomarov, V., and Tokar, A., *Mechanism of Formation of Sub-Surface Channels in Metal Bodies by Pulsed GTAW Arc Action*. In: *IIW Annual Assembly*, 2015.

Mendez, P. F., Goett, G., and Guest, S. D., *High Speed Video of Metal Transfer in Submerged Arc Welding*. In: *IIW Annual Assembly*, 2014, p. Doc. 212-1345-14.

Mendez, P.F. and Stier, N., *OMS: A Computer Algorithm to Develop Closed-Form Solutions to Multicoupled, Multiphysics Problems*. In: 10th International Seminar Numerical Analysis of Weldability, 2012, pp. 219–254.

Ponomarov, V., Tokar, A., and Mendez, P.F. *Use of Pulsed TIG Arc for Manufacturing of Subsurface Channels in Metal Bodies*. In: *IIW Annual Assembly 2015*. Helsinki, Finland. Doc. 212-1389-15.

*Ranjan, R., Talati, A., Ho, M., Bharmal, H., Bavdekar, V.A., Prasad, V., and Mendez, P.F. *Multivariate Data Analysis of Gas-Metal Arc Welding Process*. In: IFAC *Advanced Control of Chemical Processes (ADCHEM)*. June 7-10, 2015. Whistler, BC. p. 463-468.

Tello, K.E., Gerlich, A.P., and Mendez, P.F., *Use of scaling laws to estimate grain size and coarsening in the stir zone of friction stir welding*, in *Mathematical Modelling of Weld Phenomena 9*, H. Cerjak, Editor. 2010, TU Graz: Graz-Seggau, Austria. p. 357-367.

Conference Abstracts

Bell, K., Molina, C., Chapetti, M. and Mendez, P. F., *Fatigue life of laser additive manufacturing repaired steel component.* In: *19° Congreso Internacional de Metalurgia y Materiales CONAMET-SAM,* 2019. Valdivia, Chile.

Delgado, J. A. , Argáez, M. A. R., and Mendez, P. F. , *Mathematical Modeling of Argon and Nitrogen Plasma Arcs at Atmospheric Pressure*. In: *72nd Annual Congress of ABM*, 2017.

Delgado, J. A., Betancourt, B. M., Argáez, M. A. R., and Mendez, P. F., *Modelado Matemático de Soldadura con Arco TIG Expuesta en Diferentes Atmósferas*. In: *Memorias del XXIII congreso internacional annual de la SOMIM*, 2017.

Duman, U. and Mendez, P.F. *Weld penetration in high productivity GTAW.* In: *Fabtech/AWS Annual Meeting* 2010. Atlanta, GA. p. 207-212.

*Gajapathi, S., Mitra, S.K., and Mendez, P.F. *A novel approach to Microwelding using Electron Beam.* In: *IIW Annual Assembly*. Sep. 15-18, 2013. Essen, Germany.

*Gajapathi, S.S., Mitra, S.K., and Mendez, P.F. *Modeling of Micro Electron Beam Welding with melting and evaporation.* In: *International Mechanical Engineering Congress & Exposition (IMECE2012)* 2012. p. IMECE2012-88427.

Hiscocks, J. et al., "Friction Stir Welding of Magnesium Alloy Wheels," AUTO 21 Annual Meeting. Niagara Falls, ON, 2015.

*Li, L., Mendez, P.F., Wang, Y.J., and Yin, Z. *Metallurgy of welding and heat-treating of P91 steel.* In: *CanWeld/CWA Annual meeting*. Sep. 28 - Oct. 1, 2014. Vancouver, BC.

Mendez, P. F., Goett, G., and Guest, S. D., *New Experiments on High-Speed Video of Metal Transfer in SAW*. In: *CanWeld/CWA Annual Meeting*, 2015.

*Mendez, P.F., Li, L., Bell, M.A., Kamyabi-Gol, A., Wood, G., Islam, S., and Guest, S.D. *Virtual procedure development for pipeline steel.* In: *Canweld/CWA Annual Meeting*. Sep. 28 - Oct. 1, 2014. Vancouver, BC.

*Mendez, P.F., Gajapathi, S.S., and Mitra, S.K., *Thermal profile of high voltage EBW in the submillimeter scale*, in *IIW Annual Assembly*. 2012: Denver, CO.

Co-Advised Students

Undergraduate Students

*Amanda Dubrule. Co-advised with Prof. N. Cherry (UofA, Preventive Medicine)
*Anurag Talati. Co-advised with Prof. V. Prasad (UofA, control of welding processes)
Megan Ho. Co-advised with Prof. V. Prasad (UofA, control of welding processes)
*Kyle Foster. Co-advised with Prof. R. Sydora (UofA, Physics)
*Ruzhen Xu. Co-advised with Prof. R. Sydora (UofA, Physics)
*Choong Heng Jie. Co-advised with Prof. R. Sydora (UofA, Physics)
*Paul D. Gelinas. Co-advised with Prof. R. Sydora (UofA, Physics)
Benjamin Vergara Mesina. Advisor of BSc thesis (UChile, Mechanical Engineering)
David Apaoblaza Chaer. Advisor of BSc thesis (UChile, Mechanical Engineering)
Ivan Ignacio Gonzalez Perez. Co-advisor of BSc thesis (UChile, Mechanical Engineering)
Eriel Perez Zapico. Co-advisor of BSc thesis (UChile, Mechanical Engineering)
Joaquin Vara Vargas. Co-advisor of BSc thesis (UChile, Mechanical Engineering)
Stefano Sacco Hawas. Co-advisor of BSc thesis (UChile, Mechanical Engineering)
Francisco Ignacio Cubillos Baldessari. Co-advisor of BSc thesis (UChile, Mechanical Engineering)
*Kevin Wang. Co-advised with Prof. S. Shah (UofA, artificial intelligence)

Graduate Students

Anna Tokas. PhD. Co-advised with V. Ponomarov (UFU Brazil, MecE)

Hossein Izadi, PhD. Co-advised with Prof. A. Gerlich (UofA, now University of Waterloo)
*Jordan Tsui. MSc. Co-advised with Prof. A. Gerlich (UofA, now University of Waterloo)
*Kyle Foster. MSc. (ongoing). Co-advised with Prof. R. Sydora (UofA, Physics)
*Matthew Dewar. MSc. Co-advised with Prof. A. Gerlich (UofA, now University of Waterloo)
*Satya Gajapathi. MSc. Co-advised with Prof. S. Mitra (UofA, Mechanical Engineering)
*Steven Duncan. MSc. Co-advised with Prof. T. Joseph (UofA, Mining)
Alfredo Delgado Alvarez. PhD. Co-advised with Prof. M. Ramirez (UNAM, Mexico)
*Habiba Imam. MSc. Co-advised with Prof. R. Ahmad (UofA, MecE)
Arturo Morales Antonio. MSc. Co-advised with Prof. M. Ramirez (UNAM, Mexico)
Alberto Velazques Sanchez. MSc. Co-advised with Prof. M. Ramirez (UNAM, Mexico)
Kevin Scott. PhD. (Colorado School of Mines, USA)
Jose Alberto Bejarano. MSc. (UNAL, Colombia)

Postdoctoral Fellows

*Hossein Izadi, PhD. Co-advised with Prof. B. Quemerais (UofA, Preventive Medicine)

Co-Developed Courses

MAT E 454: Welding Metallurgy (with A. Gerlich)
MAT E 466/630 Special Topics in Material Engineering: Fundamentals of Welding (with L. Li)
MAT E 466/694: Advanced Manufacturing and Structural Materials (with L. Li)

Appendix C: Collaborative Projects

NSERC CRD CWB Welding Foundation, LJ Welding, Weldco-Beales Mfg. (pending approval), Structure-Processing Relationships for Welding New Steels with Small Alloying Additions. PI P. Mendez and J. Goldak (Carleton/UofA). Collaborators: J. Brewster (SAIT) and M. Farrokhzad (SAIT). 2019 (approval pending)

NSERC CRD Enbridge, *Mechanical and Metallurgical Implications of Non-Ideal Geometry in Circumferential Pipeline Welds*. PI P. Mendez. Collaborators: J. Goldak (Carleton), L. Ludwig (Enbridge). 2016.

NSERC CRD Group Six Technologies, *Automation and modeling of a novel laser cladding process to repair and rebuild worn components for extreme applications.* PI R. Ahmad (UofA) and P. Mendez. 2019

NSERC CRD Apollo Laser Cladding, *Heat and mass transfer aspects of laser deposition of Ni-WC wear resistant metal matrix composites.* PI P. Mendez and L. Li (UofA). 2014.

NSERC CRD Babcock Hitachi, *Deposition of abrasion-resistant Ni-WC overlays using Hot Wire TIG Welding.* PI P. Mendez and A. Gerlich (UofA). 2012.

NSERC CRD Syncrude, *Heat and mass transfer phenomena in the application of wire-based Ni-WC overlays,* PI P. Mendez and A. Gerlich (UofA). 2011.

NSERC CRD Syncrude, *Improving Application of an Observation Platform to Study the Behaviour of WC-cored Nickel Electrodes.* PI P. Mendez and A. Gerlich (UofA). 2010.

NSERC CRD with Wilkinson Steel and Metals / Samuel Son & Co., *Processing and microstructural development of wear protection coatings based in the Fe-Cr-C system.* PI P. Mendez and A. Gerlich. 2014.

NSERC RTI, *A high accuracy analyzer for materials containing hydrogen, nitrogen, and oxygen.* PI P. Mendez, H. Henein, A. Gerlich, W. Chen (UofA). 2009.

NSERC RTI, *SEM/EDX for materials analysis*. PI D. Ivey, H. Henein, W. Chen, J. Luo, H. Chung, J. Nychka, D. Li, P. Mendez. 2016 (in process).

NSERC Engage, *Real-time monitoring of weld quality in flash-butt welding*. PI V. Prasad, in collaboration with P. Mendez, 2013.

GCCIR/ZIM, Germany/Alberta 2+2, *ProLas*. Group Six Technologies (Canada), DURUM Verschleiss - Schutz GmbH (Germany), Fraunhofer IPK (Germany), UofA. 2016.

CFI / IAE, *Development of Laser Processing Facility for Wear and Corrosion Protection Materials.* PI P. Mendez and L. Li (UofA), 2015.

Defence Canada, *Development of Friction Stir Processing for the Fabrication of Metal Matrix Composites*. PI P. Mendez and A. Gerlich (UofA). 2010.

Alberta Enterprise and Advanced Education, *Partnership between the University of Alberta and BAM (Germany)*, PI. P. Mendez and M. Rethmeier (Fraunhofer IPK/BAM, Germany). 2013.

Auto21, *Tailor-Welded Blank Manufacturing of Mg Alloy Parts*. PI P. Mendez and A. Gerlich, 2015.

Appendix D: Student Success – Scholarships and Industry Placement

Awards and Scholarships

Year	Name	Award Name
2019	Alejandro Hintze	CWB WF UofA Student Award
		Tenaris Rocca Fellowship
	Alysen Townsley	AWS Alberta Section Scholarship
	Dmytro Havrylov	CWB WF UofA Student Award
	Yingxin (Julie) Song	CWA Edmonton Chapter
	Kyle Foster	CWA Edmonton Chapter
	Mehera Salah	Loran Scholar
	Mitchell Grams	AWS District Scholarship
		Future Leader Program, Board of Directors AWS
	Yi Lu	AWS District Scholarship
		China Institute Student Travel Scholarship
	Ying Wang	AWS District Scholarship
		AWS Leadership Symposium 2019
		China Institute Student Travel Scholarship
2018	Alejandro Hintze	Captain Thomas Farrell Greenhalgh Memorial Graduate Scholarship
	Kevin Wang	CWA Edmonton
	Mitchell Grams	CWA Edmonton Scholarship
		Environmental Engineering
	Syed Alam	AWS Alberta Section Prize in Welding Engineering
	Yi Lu	CWA National Scholarship
		Neil McEwen Scholarship
	Ying Wang	CWA National Scholarship
		IIW Travel Bursary Bali
		TW Fraser and Shirley Russell Teaching Fellowship
2017	Dmytro Havrylov	Captain Thomas Farrell Greenhalgh Memorial Graduate Scholarship
	Yi Lu	CWA Edmonton Chapter Scholarship
	Ying Wang	DB Robinson Graduate Scholarship
2016	Cory McIntosh	CWA Post-Secondary
		Queen Elizabeth II Graduate Scholarship-Master's level
		Shell Enhanced Learning Fund (SELF)
	Dmytro Havrylov	University of Alberta Doctoral Recruitment Scholarship
	Gentry Wood	APEGA Ivan Finlay Leadership Award
		Canadian Commission of IIW Bursary
		Profiling Alberta's Graduate Students Award (FGSR Travel Award)
	Goetz Dapp	University of Alberta Excellence in Leadership Award
	Matthew Bell	Graduate Scholarship Advanced Education
	Mitchell Grams	AWS Jerry Hope Endowment Scholarship
		Chevron Graduate Scholarship in Natural Gas Engineering
		FGSR Profiling Alberta's Graduate Students Award
		Green & Gold Student Leadership and Professional Development Grant
		GSA Academic Travel Award
		Queen Elizabeth II Graduate Scholarship-Master's level
	Nairn Barnes	AWS Fellowship (renewal)
		FGSR Travel Bursary
		Queen Elizabeth II Graduate Scholarship-Doctoral
	Patricio Mendez	CWA CanWeld Conference Gold Medal Award
		Michael N. Vuchnich Award

	Rebekah Bannister	CWA Edmonton Chapter Award
	Vivek Sengupta	CWA Foundation Post-Secondary Award
		CWA welding Engineering award for excellence in welding engineering and research
		FGSR Graduate Travel Award
		GSA Academic Travel Award
		Shell Enhanced Learning Fund (SELF)
2015	Aliya Lakhani	CEMF Engineering Ambassador Scholarship
		Education Abroad
		Green & Gold Student Leadership and Professional Development Grant
		Student Union Social Justice and Activism Award
		URI Undergraduate Researcher Stipend
	Ata Kamyabi	CWA Edmonton Graduate Annual Award for Excellence in Welding Engineering
	Eddie Alvarez Rocha	CWA Edmonton Graduate Annual Award for Excellence in Welding Engineering
	Gentry Wood	Neil McEwen Memorial Graduate Scholarship in Welding (Materials) Engineering
	Genty Wood	Petro-Canada Graduate Scholarship in Petroleum Engineering
	Goetz Dapp	2015 Information Technology Unsung Hero Award
		Finalist: University of Alberta Award for Outstanding Mentorship in Undergraduate Research and Creative Activities (Early Career Faculty)
	Matthew Bell	Queen Elizabeth II Graduate Scholarship
	Max der Boghossain	AWS Poster Competition, First Prize
	Mitchell Grams	Alexander Graham Bell Canada Graduate Scholarship NSERC
		Captain Thomas Farrell Greenhalgh Memorial Graduate Scholarship
		Walter H. Johns Graduate Fellowship
	Nairn Barnes	AWS Graduate Fellowship
		Petro-Canada Graduate Scholarship in Petroleum Engineering
	Patricio Mendez	AWS Savage Award
		University of Alberta Award for Outstanding Mentorship in Undergraduate Research and Creative Activities (Established Faculty Category)
	Yi Lu	Captain Thomas Farrell Greenhalgh Memorial Graduate Scholarship
2014	Ata Kamyabi	Profiling Alberta's Graduate Students Award
		Queen Elizabeth II Graduate Scholarship
	Gentry Wood	AWS District Scholarship
		AWS Leadership Symposium Scholarship
		AWS Student Chapter Member Award
		CWA University of Alberta Welding Engineering Scholarship
		Graduate Student Association Teaching Assistant Award
	Leijun Li	ASM Fellow
		WH Hobart Memorial Award
	Patricio Mendez	ASM M. Brian Ives Lectureship Award - an individual who has made distinguished and significant contributions to the Canadian Materials community
		AWS Adams Memorial Membership Award
		AWS Fellow - Career of significant achievements in the technical and research arenas
2013	Welding Research Lab	AWS Image of Welding: Educational Facility Award
	Eddie Alvarez Rocha	1st Place in the MecE design competition and "Shop Award"
	John Andreiuk	TMS Extraction and Processing Division Scholarship
	Jordan Tsui	AUTO21 Conference, Best in Theme award (Matrials and Processing)
	Mitchell Grams	NSERC Student Research Award
	Nairn Barnes	ASM Senior Design Competition
		AWS, District Award
	Patricio Mendez	AWS William Irrgang Memorial Award
		CWA Fellowship Award
	Satya Gajapathi	IIW Henry Granjon Prize

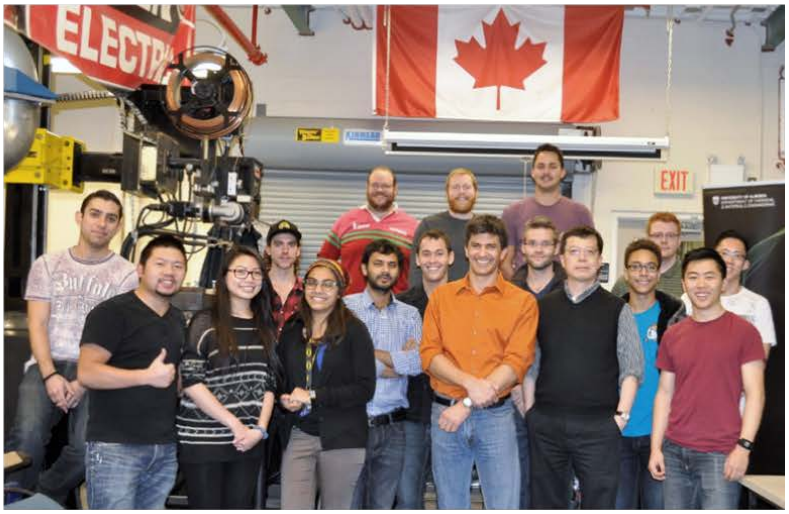
	Steven Borle	CWA, University of Alberta Welding Engineering Program Scholarship
	Stuart Guest	AWS, Student Leadership sumposium Representative
		CWA, University of Alberta Welding Engineering Program Scholarship
2012	Julien Chapuis	University of Alberta Welding Engineering Program Scholarship
	Nairn Barnes	NSERC Student Research Award
	Patricio Mendez	IIW Kenneth Esterling Best Paper Award
	Stuart Guest	University of Alberta Welding Engineering Program Scholarship
		Welding Hero, Miller Electric
2011	John Gibbs	DOE NNSA Stewardship Science Graduate Fellowship
	Karem Trello	TMS, Henry DeWitt Smith Scholarship
	Patricio Mendez	AWS William Spraragen Award
2010	Greg Lehnhoff	NSF and DOE Graduate Fellowships
	Kevin Scott	Captain Thomas Farrell Greenhalgh Memorial Graduate Scholarship
	Satya Gajapathi	Kaplan Graduate Student Award, UofA

Select Industry Placement of Students

Year	Name	Position Title	Company	Degree	Graduation Year
2019	Ata Kamyabi Gol	Welding R&D Engineer	Apollo Clad	PhD	2015
	Kévin Mussard	Responsable de production at NAVAL GROUP	Amaris Group (Cherbourg)	MSc (Visiting)	2016
	Unmesh Padalkar	Data Scientist	Wayfair	BSc (Visiting)	2014
2018	Cory McIntosh	Junior Integrity Specialist	Stantec (Calgary)	MSc	2017
	Dakota Jones	Research and Development Engineer in Training	Apollo Laser Clad (Edmonton)	MEng	2018
	J. Eduardo Alvarez Rocha	QA Coordinator, Mechanical EIT, Syncrude	Syncrude	BSc	2015
	Julien Chapuis	Welding Methods Expert	CNIM	Post-doc	2012
	Kévin Mussard	Chef Monteur (RTE de sous traitant) pour Naval Group	Amaris Group (Cherbourg, France)	MSc (Visiting)	2016
	Matthew Bell	Materials Engineer	Iris NDT (Edmonton)	MEng	2018
	Niko Wolf	Consultant for Siemens Management Consulting	Siemens (Munich)	BSc (Visiting)	2016
	Shahrukh Al Islam	Management Consultant	Senior Consultant - AI Strategy, Omnia AI, Monitor Deloitte (Toronto)	BSc	2015
	Simon Pohardy	Welding Operation Engineer	Saipem	MSc (Visiting)	2017
	Vivek Sengupta	Consumable Research and Development Manager	Lincoln Electric Canada (Toronto)	MSc	2017
2017	Gentry Wood	Research and Development Engineer	Apollo Laser Clad (Edmonton)	PhD	2017
	Kévin Mussard	Responsable Technique d'Execution pour Naval Group	Amaris Group (Cherbourg)	MSc (Visiting)	2016
	Kurtis Bell	Asset Integrity Specialist	Iris NDT (Edmonton)	MSc	2018
	Nairn Barnes	Junior Welding Engineer	Supreme Steel (Edmonton)	PhD	2017
	Satya Gajapathi	Innovation Lead, Advanced Manufacturing and Welding	CCNB-INNOV (Bathurst)	MSc	2011
	Simon Pohardy	Welding Engineer in Training	GRTgaz	MSc (Visiting)	2017

2016	Jordan Tsui	Welding Engineer	Evraz (Saskatchewan)	MSc	2016
	Kévin Mussard	Alternant ingénieur soudeur	GRTgaz	MSc (Visiting)	2016
	Unmesh Padalkar	Analyst	Axis Bank	BSc (Visiting)	2014
2015	Ata Kamyabi Gol	Assistant Professor	Fedorsi University of Mashad (Iran)	PhD	2015
	Hossein Izadi	Head of Materials Department Sun Air Research Institute	Fedorsi University of Mashad (Iran)	PhD	2014
	Matthew Dewar	Process Engineer	Group Six Technologies (Edmonton)	MSc	2012
2014	Kevin Scott	New Product Introduction Engineer	Emerson	MSc	2011
	Steven Borle	Materials Engineer	Group Six Technologies (Edmonton)	MSc	2014
	Stuart Guest	Assistant Team Lead Materials	Stantec (Calgary)	PhD	2014
2013	J. Eduardo Alvarez Rocha	ABSA IPV, ABSA Welding Examiner, API 510 and CSA W178.2 Level 2 Inspector; QA Lead	Polo Inspections Ltd. (Owner, Edmonton)	BSc	2015
	Julien Chapuis	Manager of Welding Processes Unit at AREVA NP	Areva	Post-doc	2012
2012	Julien Chapuis	Welding Vision Engineer — Technical Center	Areva	Post-doc	2012
	Satya Gajapathi	Innovation Project Manager	Ulterra	MSc	2011
2011	Kevin Scott	Arc Research Scientist	Miller Electric	MSc	2011
	Satya Gajapathi	Process Development Engineer	Apollo Clad	MSc	2011

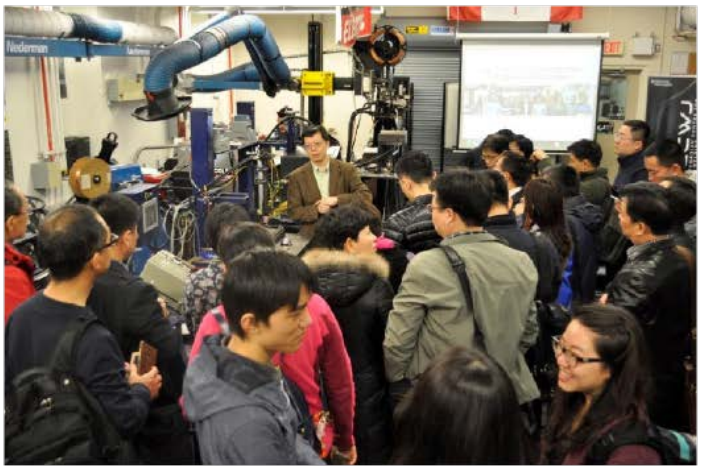
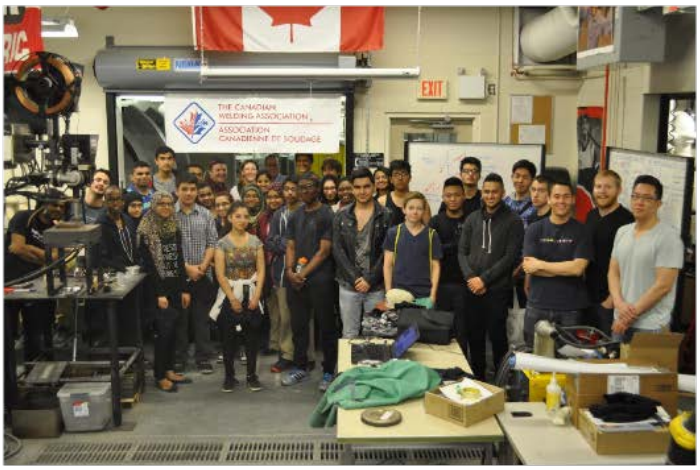
Appendix E: Photos from events and quotes from our participants



Top: Welding Research Lab Team and Collaborator Leijun Li (Left), Arrival of new Welding Gear (Right)

Middle: Virtual Welder in ETLC, January 2015 (Left), Lab Tour for St. Joseph's High School 2015 (Right)

Bottom: Seminar by Prof. John Goldak (Carleton, now Adjunct Professor UofA) and Lab Tour, May 2015




Top: Visit by GALD delegation, China, 2015 (Left), Visit J.Percy Page High School 2015 (Right)

Middle: Seminar on Duplex / Superduplex Stainless Steels 2014 (Left), CWA Lab Tour 2014 (Right)

Bottom: Seminar on Design of Welded Connections 2019 (Left), AMFI Lab Tour 2014 (Right)

AMFI:

"Great educational material and well presented. Excellent knowledge of materials, great presenters, great discussions throughout [the] workshop […]." Ian Cotnam, Metal Alloy

"[…] vast knowledge of presenters with industry experience. […] Eye opening what is taking place behind the scenes." Tim MacIntyre, Suncor

"Large amount of knowledge in short amount of time – very efficient." Will Morlidge, Exchanger Industries

"[Most valuable of the lab tour was] seeing progress being made in bring[ing] welding understanding into [the] 21st century in Alberta. Good on you all! Proud of what Alberta is doing." Mel Meunier, Aero Trailer

Outreach:

"The clips that you have on YouTube are fantastic and obviously more up to date than the footage that I currently use." Darren Jefferies, Senior Welding Inspection lecturer, TWI Ltd

"Thanks again for providing these clips. It will make my job easier." Mark Stathers, Okanagan Welding Dept. Okanagan College.

"Thanks for the openness to share findings, video, etc.!" Mark Robinson, Alberta Pipe Trades College

Lab Tours:

"Thank you so much for sharing your lab and your team's research with the UAlberta Ambassadors. Several of them came to me after and told me that it was one of the coolest things they'd seen on campus. You knowledge and passion for welding research was a joy to see!" Jenna, UofA Ambassadors

CWA/CWB:

"Events hosted by the [Welding Research Lab] or AMFI provide opportunity to network with Industry partners with the same passion to invest and improve our welding industry. It is great exposure to showcase updates and initiatives of our company." Ken McKen, CWB

Seminars:

"Wonderful lecture and discussion!" Ken Bird, Supreme Steel

Classes:

"This is the best university level course that I have ever taken. […]I've never had another class with a lab component that was actually extremely useful and applicable." (MAT E630/466, 2016)

"Excellent course. Learned tonnes of valuable and relevant information related to welding. Prof was excellent and the course was well organized." (MAT E630/466, 2012)

"General course quality is really good and helps me in my work as well, really an awesome class." (MAT E630/466, 2012)

"I will definitely recommend this course to everyone I know. It is a good welding background course. Now I can have a decent conversation about welding during the ASM dinners!" (MAT E630/466, 2012)

"Prof. Mendez is so dedicated to teach student with the highest quality and integrity. He did everything to help each student understand the topics very well." (MAT E630/466, 2013)

"[…] the quality of information provided was very high. This was the most practical and useful university course I have taken." (MAT E630/466, 2011)

"I REALLY enjoyed the combination of lecture, demonstrations, and hands-on experience. I liked the small class size and the open discussions." (MAT E630/466, 2011)

Appendix E: Chair Proposal and Report on Value Chain Mapping

DRAFT Proposal to:

The Welding and Joining Industry

Project Title

University of Alberta Industry Chair in Welding and Joining

Faculty of Engineering, University of Alberta

Synopsis

This proposal presents an opportunity for industry users of welding and joining technology to support an initiative to significantly enhance welding and joining research and technology development in Alberta and Canada. In association with the Faculty of Engineering and the University of Alberta's Century Campaign, our key partners will play a crucial role in this vital and evolving field.

Rationale

Not since the 1960's has the University of Alberta had such a dramatic opportunity to shape its future. We invite our stakeholders to join us in ensuring the University continues to meet the needs of our students, our communities, and our business partners for decades to come. **Together, we have an extraordinary opportunity to shape the University of Alberta as we chart our course for the 21st century.**

Strategic alliances are critical to achieving our goal of becoming indisputably recognized, nationally and internationally, as one of Canada's finest universities. The U of A is committed to the pursuit of "win-win" partnerships that will fully meet the needs of our corporate partners and individual supporters while fulfilling the priorities of the University of Alberta.

Faculty Growth

In 1972 the Faculty of Engineering undergraduate enrolment was 1,180. In 2004, **this enrolment has almost tripled to over 3,200 students, and the University of Alberta is now in the top 5% of over 400 engineering schools in North America.**

The recent rapid growth in the Faculty of Engineering, supported by strong demand from employers and high-quality students, is part of a government-approved expansion. This on-going expansion will result in the total undergraduate engineering enrolment reaching a level of approximately 3,500 students by September 2004**.**

Graduate enrolments in the Faculty of Engineering have also expanded tremendously. From 191 students in 1972 to over 1000 students in 2004 graduate student enrolment has grown by almost 500%. Further increases to 1,200 graduate students are expected by 2005–2006. At this enrolment level for graduate students, the Faculty of Engineering at the University of Alberta will be **one of the largest engineering schools in North America.**

Faculty Recruitment & Retention

Supporting the undergraduate and graduate program expansions has required a substantial increase in the number of faculty members. Since 1972, our 88-member faculty has almost doubled in size to 165. **A faculty complement of 185–190 professors is needed by 2004–2005 to support the enrolment increases.** The growth in staff numbers (and student enrolment) has placed tremendous strain on the current physical facilities.

One-third of today's University of Alberta teachers and researchers—scholars who have been at the forefront of their fields for generations — will retire over the next five years. These talented individuals have built the University of Alberta, and we are committed to maintaining their impressive legacies. The quality of the educators and researchers we hire over the next five years will be crucial in maintaining and enhancing our reputation as one of the top universities in Canada and in the world.

The Faculty of Engineering has been extremely successful in attracting faculty members of the highest quality. More than 110 new professors have been appointed since 1996 and we must retain these outstanding new faculty members. We need to recruit 35 additional professors in the period 2003–2005. This recruitment will depend on our ability to provide appropriate new infrastructure and facilities for the support of the educational and research activities in the Faculty of Engineering.

Department of Chemical & Materials Engineering

The Department of Chemical & Materials Engineering currently has 37 faculty members, 420 undergraduate students, and 130 graduate students. In recent years, the department has seen significant growth due, in part, to the following changes:

- establishment of five NSERC Industrial Research Chair programs and two Canada Research Chairs since 1996;
- creation of the Oilsands Engineering program;
- creation of the Industry Advisory Committee in Materials Engineering in 1995
- continued growth of our undergraduate Co-op education program (30% increase since 1998); and
- a share of the 40% increase in the graduate program enrolments in the Faculty of Engineering since 1998.
- Enrolment in the Materials Engineering graduate program has grown from 15 students in 1995 to 45 in 2003.

Welding Engineering Program

The University of Alberta Welding Engineering Program is a graduate program within the Faculty of Engineering, supported by the Departments of Civil, Mechanical and its home department of Chemical & Materials Engineering. It is the only graduate program in welding application, design, engineering, and research in Canada and the only welding program focused on pressure vessel and pipeline industry requirements. This program is particularly relevant to the needs of the western Canadian industry base. In addition to the graduate program, the welding process and metallurgy courses are available to senior undergraduates as technical electives. Many graduates who have taken these courses hold significant positions in industries important to the Alberta economy and in consulting engineering positions that support the economy.

The program provides an understanding of welding processes, metallurgy and design, and includes courses on quality assurance and testing. Welding instruction is supported by a Welding Laboratory in Chemical and Materials Engineering. The processes in this laboratory include most of the standard arc welding processes and also a resistance spot welder and a plasma transferred arc welder for cladding.

Graduates from the program are suited for careers in such diverse areas as pressure vessel or structural engineering, petroleum and gas processing industries and chemical plant fabrication. The program has been in place formally since 1979. Over this period some 27 degrees in welding engineering have been conferred and there are currently seven graduate students in the program. Our graduates have been placed in key welding engineering positions throughout Canada and in the rest of North America.

Chair Description

The Chair in Welding and Joining will initially consider research which is important and relevant to the Alberta industry base and mayinclude areas such as:

- Aging and embrittlement mechanisms and associated repair techniques
- Improved welding processes/techniques for the application of wear resisting overlays
- Welding techniques for ultra-high strength pipeline materials
- Improved NDT and other inspection techniques
- Education of the existing welding engineering practitioners
- Explosion bonding for high temperature applications

Many research projects have been conducted in the Welding Engineering Laboratory since the program started. A comprehensive array of welding processes is available, along with diagnostic instrumentation and non-destructive testing capability. Much of the work is in welding pipeline steels, for both welding process and welding metallurgy interests. Other projects have studied hydrogen disbanding of stainless steel cladding in pressure vessels, which is of interest to oil and gas processing industries, and the narrow gap welding of large pressure vessels, which is of importance for large scale processing of heavy oils and coal. Present projects include the analysis of alternating current parameters in the GTAW and SMAW processes, the behaviour of short-circuiting parameters using computer-controlled power sources, SMAW weld metal properties in high strength structural steels, residual stresses in narrow-gap welds and the effects of oil contamination and humidity on SWAW electrodes.

Opportunity

A gift of $140,000 from seven key welding industry partners per year over a ten-year period will enable the Faculty of Engineering to develop the **Industry Chair in Welding and Joining** to focus on welding engineering, research and education.

In partnership with the CRC/CFI, NSERC, and the Faculty of Engineering, a 5.5:1 match will be provided for the duration of the funding agreement of the Chair to ensure its immediate establishment and full operation. At the end of the ten-year period, the endowment will be fully established and will fund the **Industry Chair in Welding and Joining** in perpetuity. With industry participation, the Faculty of Engineering at the University of Alberta will put this crucial initiative in place, significantly adding to growing efforts in an area in which the University of Alberta is already internationally recognized for its excellence.

The investment by users of welding and joining technology of $140,000 per year over ten years is leveraged through matching funds, partner contributions and endowment yield to become an

overall investment of over $9,000,000. A fully funded chair will be endowed in perpetuity in the process.

The seven select industry members are requested to commit to $20,000 per year for ten years. This payment plan is only a suggestion and the Faculty of Engineering would be pleased to discuss an alternate schedule that meets the needs of all partners.

Recognition

In addition to making each of the participating company's names prominent within the Faculty of Engineering, the University of Alberta will continue to recognize all participants in appropriate U of A publications: "The U of A Engineer" (Engineering alumni magazine); "New Trail" (U of A alumni magazine), "U of A Report to the Community"; and so on. As well, a major recognition event will be organized to publicly acknowledge the significant support from industry partners for research and education in this vital area of engineering.

The Department of Chemical and Materials Engineering, the School of Mining Engineering, and the Faculty of Engineering Co-op Education office will offer their assistance. There is a growing need for engineers whose academic training is directly applicable to the welding engineering field. Focused and knowledgeable students will be available for co-op work placements with the potential for permanent placement on the Industry Chair members' teams.

This opportunity for branding, name recognition, and reputation management on the U of A campus, specifically within the Faculty of Engineering, will position all members as industry leaders and employers of choice for graduating engineering students.

Finally, the Faculty of Engineering, in partnership with select industry companies, will prepare a fitting media campaign to promote the gift to appropriate constituencies across Alberta and Canada.

Summary

The cost of welding to Canadian industry is estimated at $3.6bn in 2002 or 0.365% of GDP. This is both a cost to Canadian industry and an opportunity for significant cost savings with improved technology and application techniques. However, these savings cannot be realised without enhancement in skills at all levels. The retention and expansion of the program would be an important contribution to that enhancement. The establishment of the University of Alberta **Industry Chair in Welding and Joining** as part of Canada's only welding degree program will greatly enhance the welding engineering research and education that is currently being conducted at the University of Alberta. The Faculty of Engineering earnestly seeks your commitment to this very worthy initiative.

Contact Information Thank you for your consideration of this proposal. If you have any comments or would like further information, please contact:

Katherine Irwin
Acting Manager, External Relations
Faculty of Engineering
University of Alberta
E6-050 ETLC
Edmonton AB T6G 2V4
PHONE: (780) 492-1317
FAX: (780) 492-0500
katherine.irwin@ualberta.ca

David M. Petis
Assistant Dean, External Relations
Faculty of Engineering
University of Alberta
E6-050 ETLC
Edmonton AB T6G 2V4
PHONE: (780) 492-5080
FAX: (780) 492-0500
david.petis@ualberta.ca

David T. Lynch, PhD, P.Eng.
Dean, Faculty of Engineering
University of Alberta
E6-050 ETLC
Edmonton AB T6G 2V4
PHONE: (780) 492-3596
FAX: (780) 492-0500
david.lynch@ualberta.ca

Edmonton Economic Development Corporation

Value Chain Mapping and Collaboration in the Manufacturing Cluster

Final Report

December 16, 2004

Suite 701, 9707 – 110 Street
Edmonton, Alberta T5K 2L9

1-866-246-6287 (toll free)
1-780-447-2111 (office)
1-780-451-8710 (fax)

www.qgiconsulting.com

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Executive Summary

As part of the Greater Edmonton Competitiveness Strategy, Edmonton Economic Development Corporation (EEDC) engaged private consultants and mobilized a wide range of stakeholders in the analysis of the economic structure, strengths and participants in the region's economy. EEDC asked QGI Consulting to assist with the extension of the cluster strategy using an application of the theory of value chains. Layering the value chain model onto the existing cluster framework provides for a deeper understanding of the structure and behaviour of firms in the Edmonton manufacturing cluster, particularly with respect to the degree of effective collaboration between firms within the cluster.

The study included both quantitative analysis of publicly available information about the structure of the cluster and a series of interviews and focus group with firms within the cluster. Analysis of the structure of the cluster revealed that Edmonton's manufacturing sector is the fastest growing manufacturing cluster in Canada and that it is much more important to the regional economy than may be commonly thought. Companies in the Metal Products manufacturing sub-clusters alone generate an estimated $3.7 to $4.0 billion per year in revenue and have operating profits estimated at $210 to $240 million. The employment generated by this group of companies is three times as large as that provided by all: elementary, secondary, technical schools and universities in the region, combined. The Metal Products manufacturing sub-cluster was found to have a logical value chain structure within the local economy and it was selected as the focus of examination for this study.

When broken out into sub-clusters, the largest were found to be the Oil and Gas Field Machinery firms and Machine Shops. When examined in terms of their growth from 2000-2003 the fastest growing sub-clusters were the two largest mentioned above, with the addition of the Valves, Compressors and Pumps manufacturers. These three groups had employment growth rates of from 15-27% over the period.

With input from the project sponsors, 13 representative firms were selected to participate in interviews of 1-2 hours each. The interviews covered the following areas:

- What are the firm's primary products and markets and in which areas do they believe lie their greatest opportunities for growth?
- How does the firm currently collaborate with suppliers, customers, and peers or competitors?
- What does the firm believe are the primary barriers to increasing the level of value added manufacturing being done in the Edmonton region?
- What role might EEDC or other agencies play in improving the effectiveness of collaboration amongst Edmonton region manufacturers?

Following the interview process, four individuals from the Alberta government and University of Alberta were also interviewed to review the results of the survey and validate the findings.

Many of the companies interviewed are currently or were previously family-owned businesses and this type of business may be more likely to be risk averse compared to larger or more financially diversified firms. The interviews also revealed that many of the companies engaged in contract manufacturing had only short-term contracts with their clients and that most of their business was generated by long-term personal relationships between the business owners or executives and their key clients. Given the short term nature of these contracts, the management of the majority of these firms are very reluctant to invest capital in the facilities, materials and human resources that are required for a firm to move from custom fabrication to product design, manufacturing and marketing.

The firms are also handicapped by the fact that they have little experience with professional strategic business development activities and indeed often have little interaction with their customers beyond responding to technical requests for short-term fabrication contracts. Their lack of market knowledge and insight inhibits their capability to understand the types of product or service innovations that might have commercial value to their customers, their markets and themselves.

There are some very important exceptions to this characterization of Edmonton's metal products manufacturers. These few exceptional firms are in the small but vital minority. A key distinction that can be made with respect to firms in this sector is between those firms who develop and market proprietary products or components, and those who only provide fabrication or manufacturing services for original equipment manufacturers (OEM's).

The primary markets for the products and services provided by Edmonton's metal products manufacturers are the Western Canadian resource extraction industries. For the most part, the firms interviewed identified these sectors as being the source of their greatest potential growth as well. However, a number of the firms expressed a desire to diversify out of the Western Canada resource industries. ***If a firm produced its own proprietary products it was much more likely to identify either a preference or an active strategy to diversify its markets.*** Based upon the interviews, QGI Consulting believes that ***w***ealth generation for the Edmonton region, and diversification of the Edmonton metal manufacturing cluster away from the Western Canadian oil and gas extraction industry can best be achieved by strategies that encourage the attraction and growth of firms engaged in proprietary products manufacturing.

The key barriers to growth identified in the interviews were, in order of increasing importance (i.e. listed from least to most important:

- Transportation costs
- Lack of specific skills and experience
- Lack of skilled machinists
- General macroeconomic issues
- Lack of a market driven culture

Measuring the collaborative behaviour of firms with their suppliers and customers within the value chain framework is useful because it shows the degree to which firms have adopted a strategic and market driven business model. The interviews revealed that even firms who recognized the importance of collaboration within their cluster or with their suppliers and customers indicated that many of their peers, customers and suppliers were reluctant to engage in meaningful collaborative activities. However, some excellent examples of effective collaboration were identified in the course of the study. For example, some firms have begun to restrict their suppliers to pre-qualified vendors who provide mutually negotiated fixed price and service contracts for their services. For other firms, the recent hiring of full-time professional sales personnel is a step towards deepening the relationships between the machine shops and their clients. A few firms have embarked on formal company wide customer service and change management training with the goal of creating customer focused organizations.

Local best practices in collaboration that were identified include the EEDC and Canadian Manufacturers and Exporters support for the LEAN manufacturing consortium and the EEDC sponsored and facilitated Manufacturers' Steering Committee. In addition, one of the interview participants identified the effective functioning of the joint University of Alberta Department of Civil Engineering and Natural Sciences and Engineering Research Council (NSERC) program for research and development in construction as an example of best practice in collaboration amongst competing companies, and the operation of this program received special examination in the study.

With respect to the role of EEDC and other agencies in on-going support for the cluster firms, the following areas were identified:

- Networking and Facilitation
- Providing a one-stop-shop for Edmonton manufacturers
- Support for International Marketing
- Raise the profile of Trades training
- Industry Attraction
- Advocacy on Macroeconomic/Tax issues

Based upon the quantitative analysis and interview results, QGI Consulting recommends that EEDC continue and even enhance its support for the activities of this vital economic cluster

For the majority of firms in this sector, the continued pursuit of activities intended to foster collaboration in areas of business process improvement, general management skills and capabilities and public policy advocacy are appropriate and necessary. Therefore, EEDC involvement with partner institutions and organizations in initiatives like LEAN manufacturing, and the facilitation of the Manufacturers Steering Committee should continue.

However, QGI recommends that EEDC elevate its level of support for firms in the Metal Products Manufacturing sector that have invested in the development and marketing of proprietary products as these companies represent the greatest opportunities for growth of the region's economy. EEDC should consider partnering with other agencies and departments in the provincial and federal governments, and with the University of Alberta to develop a new forum for innovation and collaboration in the Metal Products Manufacturing sector. Such a model could be based in part upon the existing NSERC/Alberta Construction Industry Research Chair but QGI recommends that government and industry stakeholders be brought together in facilitated discussions to examine what would work best for Alberta and specifically for Edmonton manufacturers. One of the options that should receive serious consideration is the creation of a new Centre for Manufacturing Innovation and Growth, within the business school of the University of Alberta. As Edmonton region manufacturers and other stakeholders have identified a lack of strategic management and marketing capability as a key barrier to future development, such a centre could coordinate multiple initiatives in this area and serve as the nexus of collaboration for Alberta and particularly for Edmonton region manufacturers.

In addition, EEDC should continue to take an active role in creating a favourable policy environment amongst government decision makers in the city, provincial and federal governments with respect to the importance and potential future value of the Metal Products manufacturing sector. The information available from this study on the value and growth of the Metal Products Manufacturing sector can assist EEDC in their communication with political and bureaucratic leadership in the civic and provincial governments to obtain support and funding for initiatives designed to support the growth of this vital engine of economic prosperity.

That EEDC has commissioned this study and that Edmonton manufacturing companies have participated so enthusiastically in the interviews and focus group suggests that the local climate exists to capitalize on this energy and enthusiasm to engage a broader group of regional manufacturers in new initiatives to continue the growth and expansion that has brought such prosperity to our region.

QGI Consulting hopes that the methodology developed for the examination of the Manufacturing Cluster will be of use to EEDC and other agencies in improving their understanding of the structure, behaviour and development of other cluster groups.

1.0 Purpose of the Project

As part of the Greater Edmonton Competitiveness Strategy, Edmonton Economic Development Corporation (EEDC) engaged private consultants and mobilized a wide range of stakeholders in the analysis and diagnosis of the economic structure, strengths and participants in the region's economy.

This project resulted in the identification of ten principal economic clusters of firms and their associated suppliers, intermediaries and foundation institutions. The definition of these clusters and the mobilization of the business community and associated stakeholders around the development of strategic initiatives in support of these clusters has been a major accomplishment.

EEDC has asked QGI Consulting to assist with the extension of the cluster strategy using an application of the theory of value chains to enhance the current understanding of the Edmonton region economy and to assist in the continuing mobilization of the region's leading companies and support institutions in the development and implementation of economic strategies.

A deeper understanding of Edmonton's economic clusters is worthwhile because clusters have been acknowledged by economic development professionals as key sources of competitive advantage for a regional economy. Clusters provide a critical mass of individuals and firms with specialized expertise and interests in a confined geographic area. This grouping of interests and abilities encourages both collaboration and competition, which results in acceleration of the innovative behaviors that keep firms competitive.

In analyzing the structure and competitiveness of Edmonton's manufacturing cluster, QGI and EEDC have chosen to use the value chain model of economic systems to group specific types of firms according to their relationships to each other and to their customers. The value chain model defines the relationships between firms in terms of the transformation of their inputs and products from primary manufacturing through to final production and sale of end products. The value chain model is an effective way to structure an analysis of an economic system because it is descriptive of the relationships between firms and it emphasizes the importance of collaboration amongst the participants in the chain.

Layering the value chain model onto the existing cluster framework should provide a deeper understanding of not only the structure, but equally importantly of the behaviour of firms in the Edmonton manufacturing cluster. Of particular interest is the degree to which participants in the Edmonton manufacturing cluster engage in effective collaboration with other participants in the cluster. Collaboration drives learning and innovation, which are critical to maintaining competitive advantage. Using the value chain model to structure an analysis of collaborative behavior amongst Edmonton manufacturing firms should ensure a structured and efficient dialogue resulting in a focused set of priorities.

2.0 Quantitative Analysis

In order to confirm and enhance EEDC's understanding of the structure of the Manufacturing cluster, QGI completed an analysis of business establishment and employment data. EEDC provided QGI with data from the Statistics Canada, "Canadian Business Patterns" (CBP) data product. The CBP data provide counts of firms by North American Industrial Classification System (NAICS) codes at varying levels of detail. QGI used the highly detailed six-digit level of codes in their initial analysis.[1]

QGI extracted data on business establishments in the major Canadian census metropolitan areas, to provide analysis of Edmonton's manufacturing cluster in comparison to manufacturing in other areas of the country. The data provided by EEDC included a coding of industry groups according to the cluster definitions that were provided in the original analysis performed by ICF Consulting for EEDC. QGI

[1] In addition to the use of Statistics Canada data, QGI has compiled a list of the firms engaged in manufacturing in the Edmonton Region. This list can be used as a starting point for future activities of EEDC with respect to this cluster. This list is attached to this report as Appendix 2.

reviewed the existing 72 separate NAICS classifications and added an additional 81 NAICS codes to the Manufacturing cluster definition. The data were then sorted according to total employment generated by each code within the Manufacturing cluster group, to identify the top 80% employment generating types of enterprises. This reduced the list from 153 down to 57 specific types of enterprises that remained in the cluster group.

Based upon observation, these 57 NAICS classifications were then grouped into the following sub-clusters:

- Building and Construction Components & Products
- Building Materials
- Electronics Manufacturing
- **Machine Shops and Support**
- **Machinery / Metal Products Manufacturing**
- **Metal Boilers/Containers/Tanks/ and Vessels**
- **Other Metal Components or Parts**
- Other Miscellaneous Manufacturing
- Mineral Products Refining
- Motor Vehicle/Trailer/Motorhome Manufacturing
- Plastics

Upon further analysis and inspection, QGI selected the four sub-clusters that are highlighted above, for more detailed examination. These groupings of firms appear to have a direct value chain relationship and QGI, with the approval of EEDC and IRAP chose to focus the next stage of the project upon understanding the structure and behavior of firms within these industry groups. The following graphs and figures provide a demographic breakdown on the firms in this grouping of sub-clusters that will be called the ***Metal Products Manufacturing*** sector, for the purposes of this study.

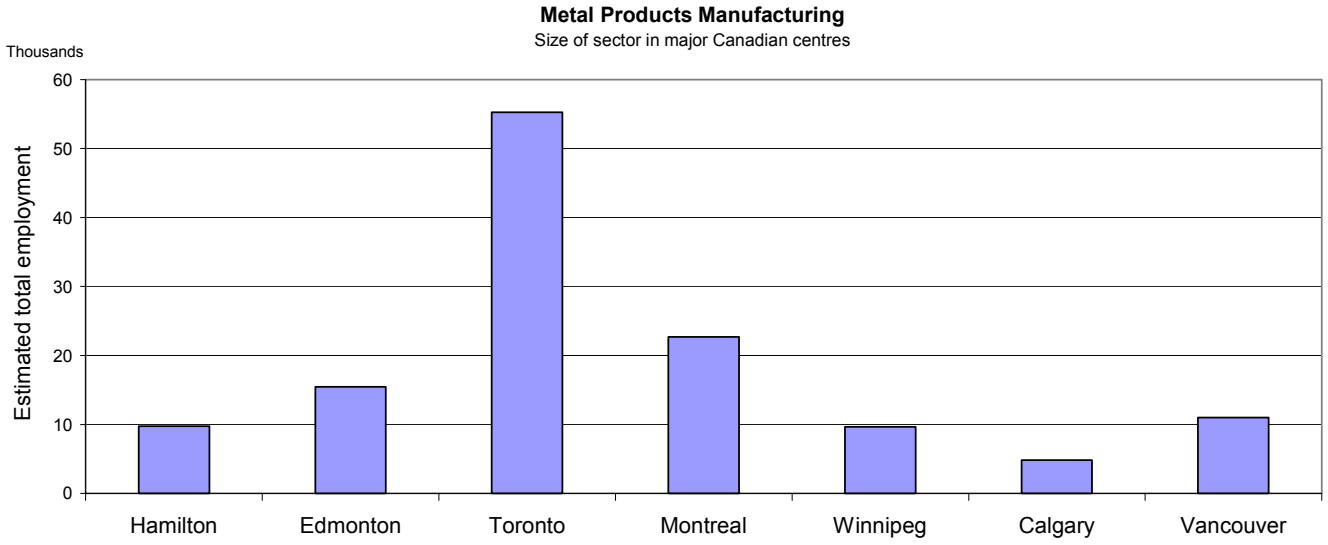
Figure 1. Composition and Employment of Edmonton Metal Products Manufacturing

Sub-Cluster	NAICS Classification	Number Firms with >20 employees	Total Employment
Machine Shops and Support	332113 - Forging	4	295
	332118 - Stamping	1	70
	332710 - Machine Shops	49	3,238
	332720 - Turned Product and Screw, Nut and Bolt Manufacturing	1	45
	332810 - Coating, Engraving, Heat Treating and Allied Activities	13	1,113
Machinery/ Metal Products Manufacturing	333110 - Agricultural Implement Manufacturing	0	33
	333120 - Construction Machinery Manufacturing	3	328
	333130 - Mining and Oil and Gas Field Machinery Manufacturing	49	4,348
	333310 - Commercial and Service Industry Machinery Manufacturing	5	408
	333413 - Industrial and Commercial Fan and Blower and Air Purification	1	35
	333416 - Heating Equipment and Commercial Refrigeration Equipment	5	335
	333920 - Material Handling Equipment Manufacturing	9	680
	333990 - All Other General-Purpose Machinery Manufacturing	2	173
Metal Boilers/Containers/Tanks/Vessels	332410 - Power Boiler and Heat Exchanger Manufacturing	4	480
	332420 - Metal Tank (Heavy Gauge) Manufacturing	7	798
	332439 - Other Metal Container Manufacturing	2	128
Other Metal Components or Parts	332910 - Metal Valve Manufacturing	13	878
	332999 - All Other Miscellaneous Fabricated Metal Product Manufacturing	7	603
	333511 - Industrial Mould Manufacturing	1	90
	333519 - Other Metalworking Machinery Manufacturing	6	388
	333910 - Pump and Compressor Manufacturing	11	990
Total Metal Products Manufacturing		193	15,458

Firms in the manufacturing sector make up over 5% of the total labour force in the Edmonton region with the Metal Products Manufacturing sub-sector contributing just over half of the total manufacturing employment. While this number may seem low, it represents a significant source of wealth creation and employment in our region. The total number of people working in manufacturing in the Edmonton region is equivalent to:

- 2 times the size of the legal and accounting services industry
- 3 times the employment of all workers and staff at all elementary and secondary schools, colleges universities and technical schools combined
- Equivalent to the employment generated by the entire health care industry in the region.

Figure 2. Size of Metal Products Manufacturing Sectors in Canada



When compared to other regions of the country, we discover that Edmonton's Metal Products Manufacturing sector is the third largest in the country, and is of relatively greater importance to the Edmonton economy than are the corresponding industry sectors in the other large Canadian metropolitan regions. This measure of relative importance is clearly displayed in the graph below.

Figure 3. Relative Concentration of Manufacturing in Major Canadian Metropolitan Regions

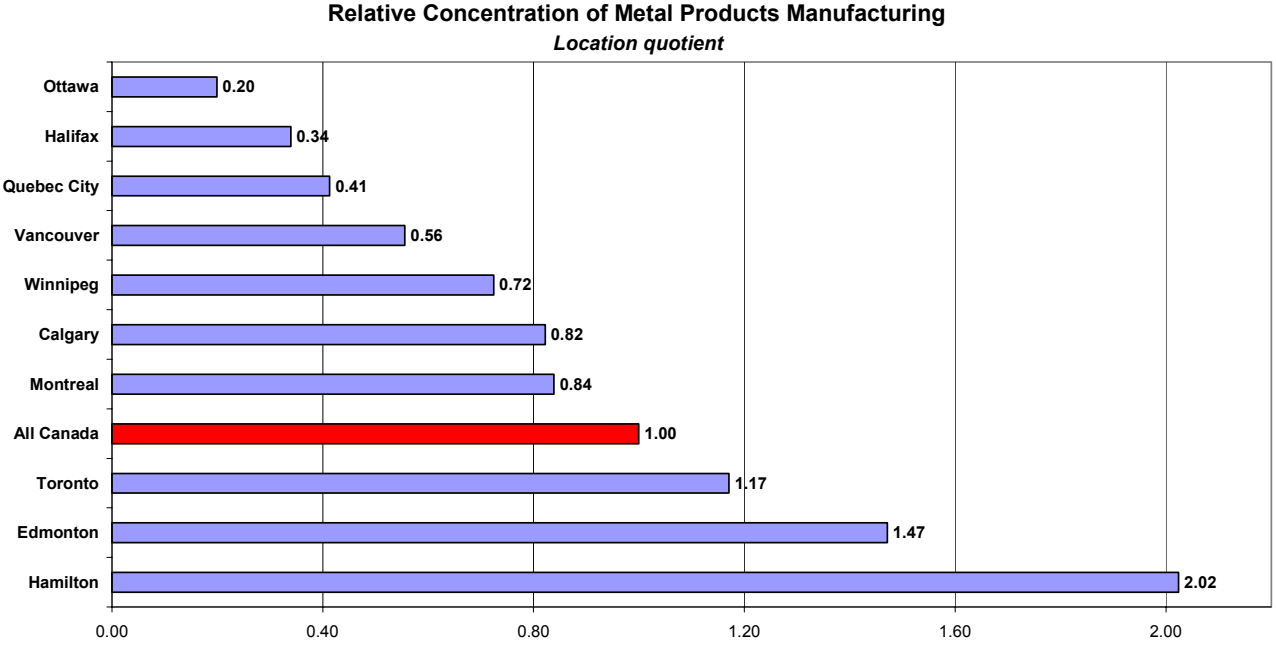
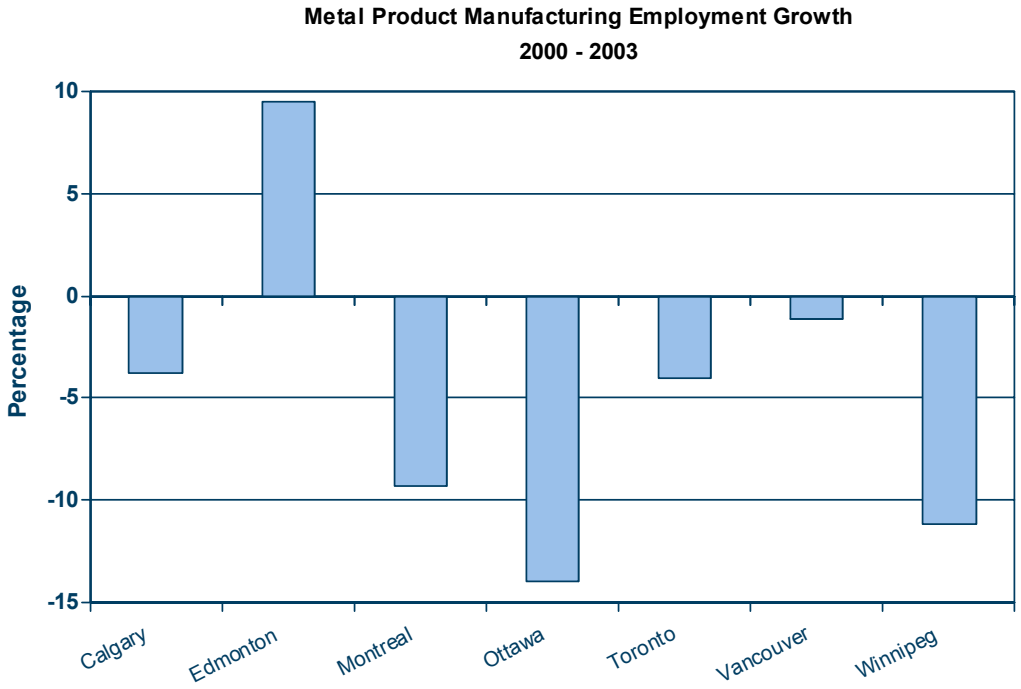


Figure 3 above shows the ratio of the relative concentration of employment in the four target sub-clusters that make up the Metal Products Manufacturing sector within the Edmonton region economy divided by the same relative concentration in Canada as a whole. A location quotient of 1.0 represents average concentration; a quotient greater than 1.0 represents a higher concentration and less than 1.0 represents a smaller concentration.

In addition to being an anchor of the Edmonton region economy, the employment growth data displayed below clearly shows that this sector has grown rapidly as a source of high quality full-time employment in the region.

Figure 4. Employment Growth of Metal Products Manufacturing



Clearly, Edmonton's metal products manufacturing sector is a vital source of employment for the regional economy. In order to estimate the financial value to the Edmonton region of this vital economic cluster, QGI Consulting obtained a custom extract of data from Statistics Canada's Industrial Organization and Finance Division. This data provided corporate revenue, expense and income data for manufacturing enterprises at the national and provincial levels.[2] Using a combination of the Statistics Canada Canadian Business Patterns data and the custom extract data QGI has estimated the total annual revenue of all Metal Products Manufacturing firms in the Edmonton region at between $3.7 and $4.0 billion.[3] Using the same methodology the corresponding estimate of operating profit for such companies is between $210 and $240 million.

[2] Data could not be obtained at the census metropolitan region level, as it would not be sufficiently accurate due to the exclusion of data that would be required to protect Statistics Canada's confidentiality policies. The most recent available data was for calendar year 2002.

[3]The range of $3.7 to $4.0 billion is based on two calculations used to estimate total revenue. The first was obtained by taking the ratio of employment generated in Edmonton's metal products manufacturing versus national statistics for the sector multiplied by the total revenue estimate for the sector nationally, as provided by the Statistics Canada Industrial Organization and Finance division. This yielded a value of (0.7 x $59 billion) = $4 billion

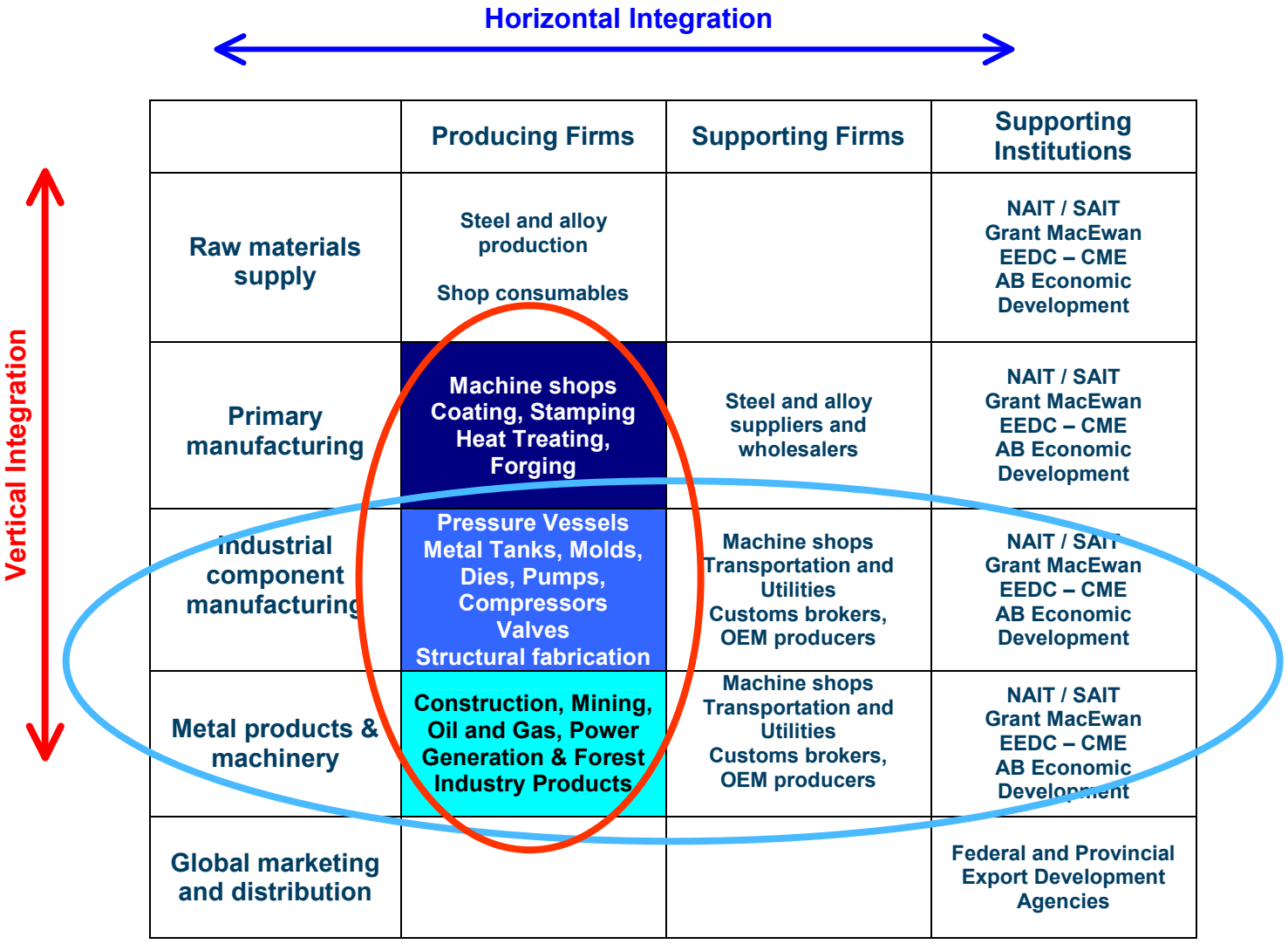
The second estimate used the ratio of the number of enterprises in Edmonton's Metal Products Manufacturing sector as reported in the Canadian Business patterns data versus the total number of Alberta enterprises in the sector as reported in the Industrial Organization and Finance division data multiplied by the total revenue estimate for the sector in Alberta. This yielded a value of (.64 x $5.8 billion) = $3.7 billion

The data above forcefully illustrate the importance of this economic cluster and the desirability of EEDC's continuing to support initiatives designed to grow this critical sector of Edmonton's economy.

2.1 Edmonton's Metal Products Manufacturing Value Chain

In order to provide a value chain framework for the next stage of analysis, QGI created a value chain map of the Edmonton Metal Products Manufacturing sector. This value chain map shows the relationship of the various types of enterprises that make up the sector and provides a framework for the continuing analysis of the degree of vertical and horizontal collaboration and integration that may exist.

Figure 5. Metal Products Manufacturing Value Chain



To provide another view of the Metal Products Manufacturing sub-clusters, QGI has prepared bubble charts to illustrate the relative size and growth of the sub-clusters within this sector. In Figure 6 below, the total estimated employment in each sub-cluster of the Metal Products Manufacturing sector is displayed by the width of the bubbles. The number of firms in each sub-cluster is shown on the horizontal axis and the sub-clusters are displayed according to their level on the value chain on the vertical axis. This graph demonstrates that when judged in terms of sub-cluster size, the intermediate levels of the value chain are relatively smaller than either the primary or tertiary levels, in this cluster grouping.

Figure 6 – Metal Products Manufacturing sub-cluster size.

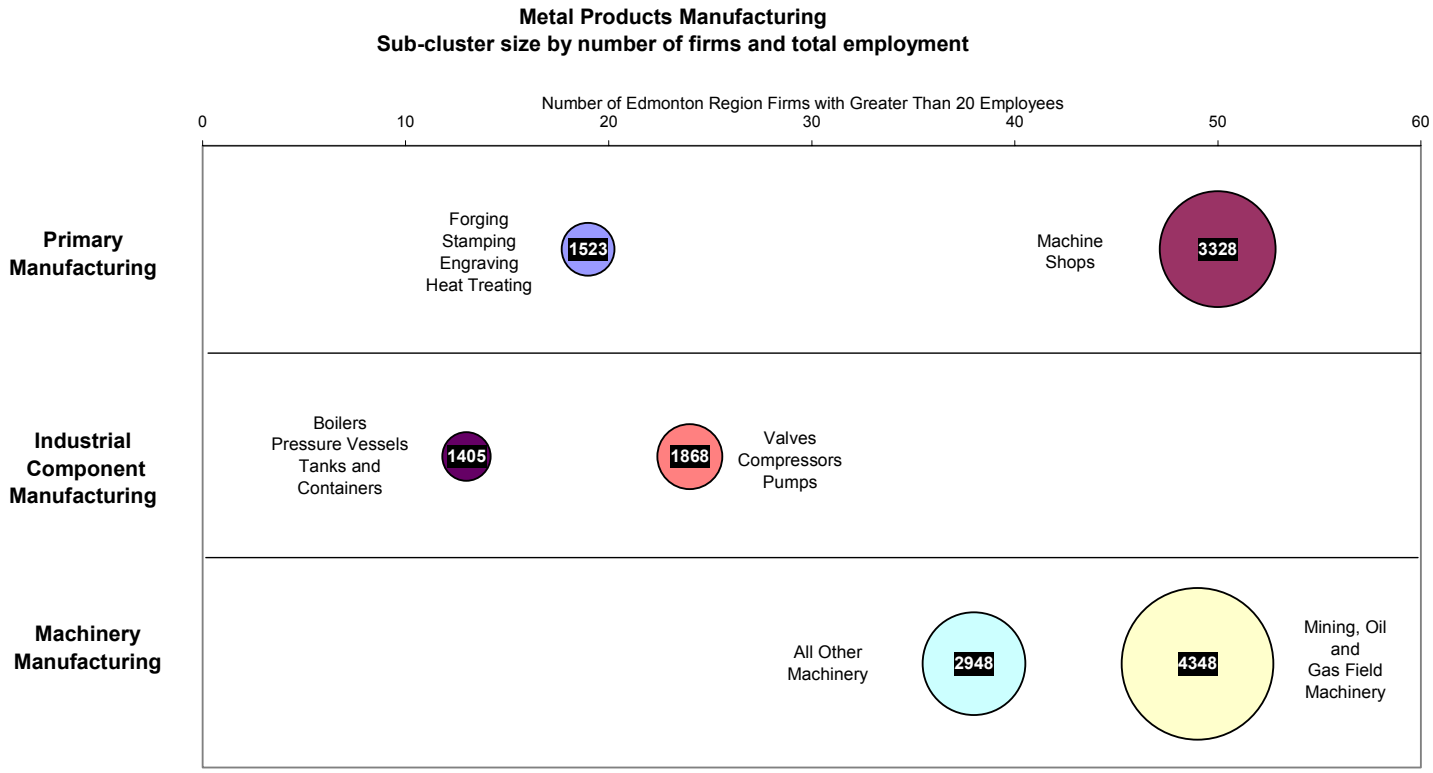
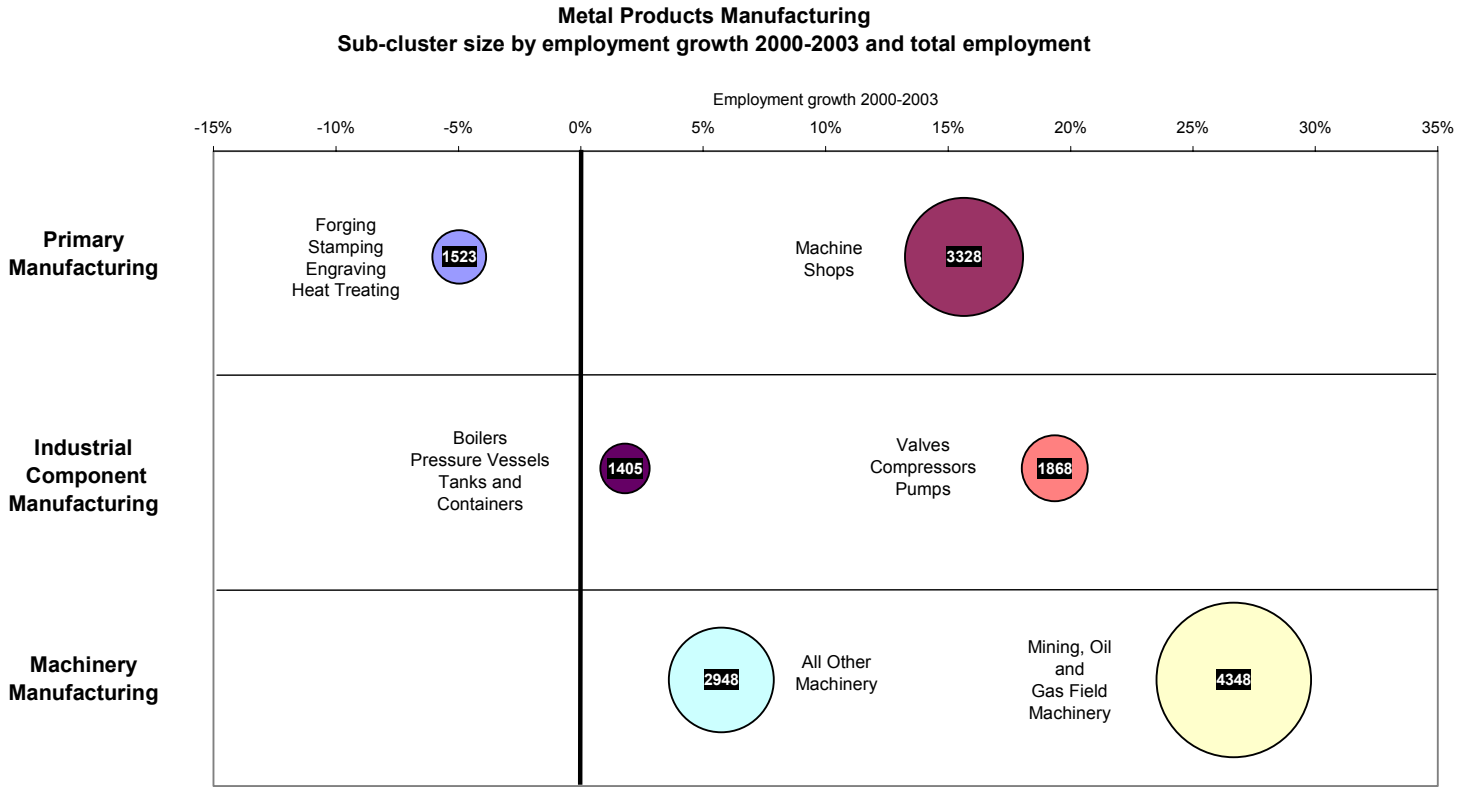


Figure 7 – Metal Products Manufacturing sub-cluster growth.



In Figure 7 above, the bubble chart illustrates the relative growth of the sub-clusters on the horizontal axis with bubble width again showing the total estimated employment in the groupings. This chart shows that the Mining, Oil and Gas Field Machinery; Machine Shop; and Valves, Compressors and Pumps sub-clusters have grown extremely rapidly from 2000 to 2003. These three groups can legitimately be seen as a tightly related and integrated grouping for which policy development and cluster support may need to be custom-tailored. Based upon our interviews and research, QGI believes it possible that one reason for the loss of employment in the smaller Forging, Stamping, Heat Treating and Engraving group is that these functions are more and more being taken on by the larger Machine Shop group, however this hypothesis would need further study to be validated.

3.0 Manufacturing Sector Interviews and Focus Group

Following the initial quantitative analysis of the Statistics Canada data, and discussion with the project stakeholders on the preliminary findings from this analysis, the next stage of the EEDC Value Chain Mapping project required QGI Consulting to conduct interviews with leading firms in the target industry sector – Metal Products Manufacturing. The findings from these interviews were subsequently reviewed by a focus group of manufacturers to confirm and refine the findings.

3.1 Purpose

The purpose of these interviews was to validate the preliminary findings with respect to the size and composition of the sector and to obtain specific information from leading firms in the sector with respect to growth opportunities and constraints for Edmonton manufacturers.

3.2 Interview Process

The goal of the interview process was to obtain insight into the key issues that leading firms in the manufacturing sector in Edmonton believe will have the greatest effect on the sectors' future success. Specifically the interview process was designed to obtain the following information:

- What are the firm's primary products and markets and in which areas do they believe lie their greatest opportunities for growth?
- How does the firm currently collaborate with suppliers, customers, and peers or competitors?
- What does the firm believe are the primary barriers to increasing the level of value added manufacturing being done in the Edmonton region?
- What role might EEDC or other agencies play in improving the effectiveness of collaboration amongst Edmonton region manufacturers?

QGI Consulting worked with EEDC and IRAP stakeholders to develop a list of interview participants that would cover the broad range of firms currently active in the manufacturing sector in terms of size, sophistication and market presence. Together, QGI and the project stakeholders were able to coordinate interviews with the following companies:

Firm	***Respondent***	***Business***
Cessco Fabrication and Engineering	Don McFarlane,	Pressure vessel manufacturer and custom heavy equipment fabricator.
Flexxaire	Daryll Friesen	Industrial variable speed fan manufacturer
Metal Fabricators and Welding Ltd.	Gary Keen	Custom metal fabrication shop
Kellogg, Brown and Root	Tony Rawa	Large industrial plant fabrication and construction
Stamco	Mike Allison	Mold and die design and manufacturing, stamping and other metal fabrication.
IMAC	Brian Wilson	Custom industrial heavy metal design and fabrication
Domino Machine	Werner Harder, Gary Loblick	Custom metal fabrication and manufacturing
Marathon Marine	David Unsworth	Commercial and recreational aluminum marine products manufacturer
Argus Machine Ltd.	Brett Padget	Manufacturer of specialty valves used in oil and gas industry
JEM Precision	Robert Korthuis	Tool and equipment calibration specialist.
Precimax	David and Maurits Kool	Custom precision machine shop
Universe Machine Corporation	Andreas Schmidt	Metal products manufacturing, modification, fabrication and service
Cooper Cameron	Michael Powley	Manufacturer of wellhead equipment for oil and gas industry and specialty fabrication and servicing shop.

In addition to the private sector firms listed above, QGI Consulting interviewed the following four representatives from support institutions in the public sector.

Organization	***Respondent***	***Responsibility***
Alberta Economic Development	David Giroux	Sr. Director Sector Development
Alberta Economic Development	Brad Trefan	Sr. Director Strategic Manufacturing
Alberta Economic Development	Paul Godfrey	Director, Industrial Machinery and Equipment
University of Alberta	Simaan AbouRizk	NSERC/Alberta Construction Industry Research Professor in Construction Engineering and Management

Both Brian Dumsday and Robert Moore of QGI Consulting conducted all the interviews - with the exception of the interviews with Messrs. Trefan and Godfrey of Alberta Economic Development – which were conducted by Robert Moore. Interview length ranged from 80 minutes to over 2 hours, depending on the

availability and interest of the respondents. Interview participants received a written request from EEDC to provide their support to the project prior to being contacted by QGI representatives. All interviews were conducted in the offices or on the premises of the respondents and in most cases the interviews included a tour of the firms premises and operations. A formal interview guide was used to structure the discussions and to collect interview information.[4]

3.3 Interview and Focus Group Findings

3.31 Industry Demographics

Validation of preliminary value chain map

Most companies interviewed accepted the structure of the value chain map as presented in the interview. In a few cases, changes were made to the initial map in recognition of the absence of a specific definition that matched the way the firm wished to be described. This change in emphasis was required because of the NAICS definition structure that does not seem to provide effective descriptive categories for businesses in the pressure vessel and heavy metal fabrication businesses.

Size and Ownership

Most of the firms interviewed in this study are representative of the manufacturing sector generally in Edmonton in that they are small to medium size enterprises with between 30 and 150 employees. While a few of the firms represent the local operations of large national or multinational companies (KBR and Cooper Cameron for example) these are exceptions. In addition to most being relatively small companies, 8 of the firms are privately owned and in many cases are either family owned and run businesses or are only recently being run by professional paid management after having been founded as family enterprises.

Current Markets and Customer Relationships

Most of the firms indicated that their business is currently primarily directed to supporting activities in oil and gas exploration, extraction or production. However, a number of firms also provide services or products to heavy construction, mining, power generation and forest products industries. Virtually none of the activities of the firms interviewed are related directly to consumer products industries. In addition, while a number of the firms are either considering or actively pursuing markets outside of Western Canada, a very high proportion of sales revenues are currently being received from customers in Western Canada, particularly from customers involved in the oil and gas business in the Western Canada Sedimentary Basin[5].

While some of the firms were involved in longer-term relationships with clients, much of their business was generated by low volume specialized production runs. Contract provisions with clients tended to be very short term and often highly price competitive. While some of the firms produced their own proprietary products, even these firms generally relied on low volume custom fabrication work to support or supplement their revenue base.

In particular for the “job shop” business of custom fabrication, respondents indicated that personal relationships were crucial to attract and retain business. In fact, few of the firms interviewed had professional sales management with most business development being done through long-standing personal relationships between owner/proprietors and their clients.

[4] A copy of the Interview Guide is attached as Appendix 1.
[5] The Western Canada Sedimentary Basin is the term commonly used to describe the area in Manitoba, Saskatchewan, Alberta, BC and the Northwest Territory where the majority of Canada’s oil and gas exploration takes place. For further information on this region, a good source is the Alberta Geological Survey website at http://www.ags.gov.ab.ca/

Critical Material Inputs

The most important material inputs to these firms is steel plate and steel alloys. Most of this material is purchased through intermediaries (wholesalers) however two of the firms interviewed purchase directly from steel mills. Very little steel consumed by these firms originates from steel mills in Canada. Most of the product is produced in Europe or the Far East. Eastern Canadian steel mills were said to be uncompetitive on price, quality and particularly on delivery times. A number of firms commented that eastern steel producers had integrated their business with the automotive industry and were unresponsive to the needs of Edmonton manufacturers.

Implications of Industry Demographics

The size and ownership structure and history of these businesses has important implications for their growth potential. Innovation and experimentation are necessary for businesses to grow and remain competitive. Many of the companies in this sector in the Edmonton region are currently or were previously family-owned businesses. While many may be on solid financial footing with excellent current cash flow, these sorts of business are more likely to be risk averse compared to larger or more financially diversified firms when it comes to investing in business or product development. Also, given the short term nature of the contracts most firms have with their customers, the management of the majority of these firms will be very reluctant to invest capital in the facilities, materials and human resources that are required for a firm to move from custom fabrication to product design, manufacturing and marketing.

In addition, many of these businesses are active in supplying or supporting the upstream oil and gas industry and there is a strong collective memory of past collapses of activity in this industry, particularly following the introduction of the National Energy Program in the 1980's. This shared history makes many of the managers and owners of these businesses reluctant to invest their current good fortune in uncertain future growth opportunities outside the sector.

The firms are also handicapped by the fact that they have little experience with professional strategic business development activities and indeed often have little interaction with their customers beyond responding to technical requests for short-term fabrication contracts. Their lack of market knowledge and insight inhibits their capability to understand the types of product or service innovations that might have commercial value to their customers, their markets and themselves.

There are some very important exceptions to this characterization of Edmonton's metal products manufacturers. These few exceptional firms are in the small but vital minority. A key distinction that can be made with respect to firms in this sector is between those firms who develop and market proprietary products or components, and those who only provide fabrication or manufacturing services for original equipment manufacturers (OEM's).

Wealth generation for the Edmonton region, and diversification of the Edmonton metal manufacturing cluster away from the Western Canadian oil and gas extraction industry can best be achieved by strategies that encourage the attraction and growth of firms engaged in proprietary products manufacturing. This issue will be discussed further in subsequent sections of this report.

3.32 Growth Opportunities Identified

As mentioned above, the primary markets for the products and services provided by Edmonton's metal products manufacturers are the Western Canadian resource extraction industries. For the most part, the firms interviewed identified these sectors as being the source of their greatest potential growth as well. However, a number of the firms expressed a desire to diversify out of the Western Canada resource industries. ***If a firm produced its own proprietary products it was much more likely to identify either a preference or an active strategy to diversify its markets.***

In a number of cases, this diversification was by geographic market, rather than by product or industry sector. For example, a number of firms who are currently providing metal fabrication and manufacturing

services in the mining and gas compression business indicated that they hope to expand their markets for these services outside of Canada. Multiple respondents mentioned a desire to expand into markets in the United States, Middle East, Asia, South America and Africa. In addition, one company expressed an interest in expanding their sales into specialized niche markets in NW Ontario and the Great Lakes states.

The respondents identified six specific growth opportunities in foreign markets, amounting to approximately $30 million per year in total additional sales. Where respondents were targeting foreign markets, their growth expectations were generally much higher than the expectations of those companies targeting growth opportunities domestically. In particular, where companies identified a need or desire to grow their businesses within the conventional oil and gas extraction industry in the Western Canada Sedimentary Basin, the firms generally recognized that growth here would likely be incremental and may have to come at the expense of incumbent competitors in those markets as overall economic activity in this market is not expected to grow substantially in the short term, and will likely shrink in the medium term.

In general, firms obtaining a high proportion of their business from custom machining in a “job shop” environment were more likely to identify current local Western Canadian markets as their target growth markets and firms producing proprietary products or customized heavy fabrication components were more likely to be willing to explore opportunities beyond the local markets.

It is important to note that exports of proprietary products and services outside the region are much more effective at generating wealth and spin off job creation within the region than growth that is targeted at market share within the local market. While some firms may improve their overall competitiveness and profitability by growing within the Western Canadian market, and may be more viable and stable firms in the longer term, in the short term their effect on overall employment and wealth generation will be at best limited from a regional economic development perspective.

Exporting producers grow the economic pie for all stakeholders in the local economy. More efficient “job shops” may grab a tastier piece for themselves but they are unlikely to satisfy the economic appetites of future citizens and stakeholders.

Producers of proprietary products exported from the region can also contribute to the economic viability of local machine shops and custom fabricators who can provide contract manufacturing and specialized services to such manufacturers as their business expands. In fact, a well-trained and sophisticated machine shop industry is vital to the future expansion of metal products manufacturing.

As manufacturing grows, the proprietary product manufacturers will require the services of top-notch machine shops and these firms can in turn contribute to the management and production processes and sophistication of their contract shops. Examples of this type of collaborative contracting and development already exist in the region between certain leading upstream petroleum industry service and component providers and local Edmonton custom fabrication and manufacturing companies.

3.33 Barriers to Growth

The respondents identified the following barriers to growth, which are listed in the reverse order of perceived importance as determined in the interviews (i.e. listed from least to most important).

5. Transportation costs

While Edmonton’s obvious distance from markets outside of Western Canada was occasionally cited as a barrier to growth, most companies more realistically just accept that certain mass produced low value manufactured goods cannot be cost effectively produced in Edmonton and they redirect their energies towards high value specialized manufacturing that builds on their incumbent experience and expertise.

Some companies that do produce and market more generic products were not aware of the degree to which logistics costs might limit their market reach as they sell their products FOB Edmonton and do not have expertise or experience with logistics.

4. Lack of specific skills and experience

A number of firms who had some interest in expanding sales to foreign markets expressed frustration at the lack of experience with international trade processes such as customs, duties and export declarations and documentation.

A lack of experience in general management, marketing and customer service hinders and frustrates many companies who've had a more operationally focused past experience. These companies often lack the basic human resource management and planning skills necessary to create an innovative and customer focused organization.

3. Lack of skilled machinists

While some respondents indicated that this was a problem of absolute numerical shortage due to the limited number of qualified candidates being graduated from NAIT and SAIT, others suggested that it was also a problem of quality, as well as quantity of candidates.

Multiple respondents complained that more highly skilled students are actively streamed away from trades towards academic training at the expense of manufacturing industry. The firms argued that skilled machinists must have good math and problem solving skills and that not enough suitable candidates are entering these trades.

This was seen as a cultural problem due to the perceived low prestige awarded to these jobs in our society. It was recommended that this issue be addressed through a comprehensive education campaign involving industry and all levels of educational institutions to increase the desirability and prestige of skilled manufacturing trades.

2. General Macroeconomic issues

As would be expected, a number of significant macroeconomic and competitive issues were identified as barriers to or limits upon the future growth of the sector.

- Steel industry issues
  - Particularly the impact of Chinese demand upon supply and prices for steel
  - Stainless steel surcharges, duties and supply limitations
  - The inability or unwillingness of Eastern Canadian steel producers to be competitive in price, quality and delivery time.

- Canadian dollar appreciation and fluctuation
  - As most export sales are priced in US dollars the recent 25% increase in the value of the Canadian dollar has squeezed potential profit margins. At least one of the firms interviewed who are active in the US market engages in periodic hedging of US funds transactions to provide certainty with respect to future exchange rates. However, most firms either had insufficient foreign transaction volumes or they lacked the knowledge required to engage in foreign currency hedging strategies.

- The presence of incumbent competitors and foreign resistance to accept new standards for processes and procedures were also cited as barriers to growth.

- Limited growth available in target markets
  - As mentioned earlier, where companies were targeting market share growth within the upstream oil and gas industry in the Western Canada Sedimentary Basin, the lack of expected growth in this overall market, and the likelihood of price competition from existing competitors in that market were cited as barriers to growth.

1. Lack of a Market Driven Culture

As described earlier, the experience of many firms with the past volatility of the oil and gas industry has made firms reluctant to invest in product development, with most firms relying instead on their expertise as custom machinists, or 'job shops'. Currently business levels are good and firms' current business supporting the conventional oil and gas industry plus growing work associated with oilsands capital project development creates complacency about the need to look for new opportunities and new markets. Ironically, it is this robust economy that could fund innovation and diversification that is in part responsible for dulling most firms' incentive to pursue innovative and entrepreneurial ventures.

Furthermore, the nature of their business relationships as described earlier, leads to lack of involvement with customers and markets due to short-term contracts and leads to the creation and persistence of operations-oriented business cultures. Also, the structure of many smaller privately and family-owned businesses leads to a high level of risk aversion and fear of innovation and change.

Without a motivating force to drive cultural change, growth opportunities will be limited for many of the smaller local manufacturers. Even in organizations where ownership and management recognize the need to create a more market and customer driven organization, middle management will be resistant if the benefits of change aren't tangible and relatively short term.

This study can assist in providing a clear understanding of the systemic and historical reasons why these manufacturers have such operationally oriented focus rather than market oriented or strategic business focus. EEDC must ensure that the insights gained through this study of Edmonton's Metal Products Manufacturing sector do not lead to short term and optimistic but misguided strategies to attempt broad cultural change by attempting to create strategic marketers within every machine shop in the region.

We will propose a more targeted approach to what is clearly a significant issue and important limit on the growth of this industry in our region

3.34 Experience with Collaboration

As has been emphasized throughout this report, collaboration between peers within an economic cluster is essential to stimulate the innovative behaviours that keep firms competitive. In addition, measuring the collaborative behaviour of firms with their suppliers and customers within the value chain framework is useful because it shows the degree to which firms have adopted a strategic and market driven business model. QGI spent considerable time during our interviews with Edmonton manufacturing firms exploring the firms' experience with collaboration.

As mentioned above, even firms who recognized the importance of collaboration within their cluster or with their suppliers and customers indicated that many of their peers, and even their customers and suppliers were reluctant to engage in meaningful collaborative activities. This was particularly true for firms where the companies had tactical, short-term contract-oriented business relationships with their customers. Firms performing custom machining for customers in the oil and gas sector indicated that many of their customers were reluctant to enter into longer-term business relationships.

However, a reluctance or inability to effectively collaborate with peers, suppliers and customers was not universal and some excellent examples of effective collaboration were identified in the course of the study.

Examples of Early Stage Collaboration

Examples of active collaboration with customers and suppliers were quite rare. However, while most firms indicated that the practice is still uncommon in their industry, some firms have begun to restrict their suppliers to pre-qualified vendors who provide mutually negotiated fixed price and service contracts for their services. The development of these longer-term commercial relationships with suppliers encourages a more cooperative and committed relationship to develop between the firms.

For other firms, the recent hiring of full-time professional sales personnel is a step towards deepening the relationships between the machine shops and their clients. A few firms have embarked on formal company wide customer service and change management training with the goal of creating customer focused organizations.

However, firms engaging in genuine multi-level marketing and supported by strategic marketing management are extremely unusual within the Edmonton Metal Products Manufacturing sector.

Successful Collaboration and Local Best Practices

A number of examples of ***non-competitive*** collaboration between peer organizations do exist in the cluster in Edmonton. For example the Alberta pressure vessel manufacturers work cooperatively on both advocacy and policy issues as well as on cooperative processes in areas such as employee benefits administration.

Another frequently cited example of effective collaboration is the EEDC and Canadian Manufacturers and Exporters support for the LEAN manufacturing consortium, which has been formed in the Edmonton region. This program provides opportunities for Edmonton area companies to learn the principles of LEAN manufacturing both from each other, and from professional consultants who are experienced in the principles of LEAN manufacturing. LEAN manufacturing is an approach to designing and managing production processes that emphasizes minimal inventory and just-in-time delivery to improve efficiency. The LEAN philosophy also emphasizes the importance of customer pull instead of a production push planning systems and thereby reinforces the importance of customer and supplier collaboration in production planning. In this sense, the LEAN consortium can be seen as an important contributor to strategies that emphasize the importance of value chain collaboration, though this is not the primary goal of most LEAN initiatives.

In addition, the EEDC sponsored and facilitated Manufacturers' Steering Committee was given high marks by the companies who are active in this group. The Manufacturers' Steering Committee is a group of senior executives from manufacturing companies in the Edmonton region who meet approximately quarterly to examine issues of joint interest to the committee. The group was formed with the active support and continuing facilitation of EEDC and has established for itself a mandate of working to explore potential growth opportunities for the cluster and where appropriate pursuing specific cluster initiatives. The group has successfully developed networking relationships within the cluster, as well as beginning dialogue with support organizations and stakeholders in government, research and educational agencies.

Participants in this group attribute its success to a number factors including:

- Steering committee membership is deliberately not composed of direct competitors, but is instead made up of leading individuals from firms in complementary, or unrelated businesses.
- The informal nature of the organization and the avoidance of minutes, action items and advocacy responsibilities and expectations.
- The steering committee is viewed by its members as a place where senior executives in small to medium size organizations can talk candidly with peers in other companies about issues for which they have no internal "sounding boards" in their organizations. It is a support organization on critical business issues for executives who would other wise feel quite isolated in dealing with policy and strategy issues.
- The continuing and effective facilitation of the group by EEDC staff.

There are also examples of effective relationships between larger firms who are engaged in the manufacture of proprietary products, and firms who are providing contracted manufacturing services in the local area. One well established manufacturer and custom machine shop described how an Edmonton based international manufacturer of oilfield wellhead equipment had worked with the smaller company to improve their production, quality control and management processes to allow them to provide manufacturing capacity over the long-term of components of the larger firm's products.

In addition, a well-known local Edmonton manufacturer of products used in the transportation and agricultural heavy equipment industry has worked over an extended period with individuals in the gas compression industry to modify their products to be used in this new market segment. This collaboration has required significant investment of risk capital by the Edmonton company and dedication of correspondingly significant management time and effort on behalf of the gas industry partner. This joint initiative is likely to result in strong business growth for the Edmonton firm if the joint product development activities result in commercialization of the new product.

NSERC/Alberta Construction Industry Research Chair

One particular example of best practices in collaboration that was identified by one of the interview participants is the Chairmanship by Professor Simaan AbouRizk of the University of Alberta Department of Civil Engineering, of the Natural Sciences and Engineering Research Council (NSERC) Construction Industry Research Chair. This position, which is held by Prof. AbouRizk, was established through a partnership between NSERC, a consortium of construction companies and supporting institutions, and the University of Alberta. The goals of this program include establishing research programs of relevance to the construction industry, enhancing the overall quality of construction engineering education at the University of Alberta, and the transfer of research and technology to industry.[6]

Of interest to this study of the Edmonton manufacturing sector is that Prof. AbouRizk's industry partners include a number of firms who are direct competitors and yet this collaborative effort continues to engage its industry members who remain dedicated to the on-going initiative. That the initiative is viewed as an example of best practices in industry collaboration amongst competing firms makes it an obvious candidate for study to determine if it can provide a model for the development of a new vehicle to improve collaboration within Edmonton's Metal Products Manufacturing sector.

Robert Moore and Brian Dumsday interviewed Prof. AbouRizk to learn more about this program, and to gain insights as to why this collaborative effort has been so successful.

In addition to the Chair of the program, a research team including programmers, industry liaison, and graduate students in Engineering assist the Chair holder. The program maintains strong ties with the construction industry and is guided by a management committee and a technical committee formed from these industrial collaborators. The research program is conducted in accordance with a research agreement that was developed, reviewed, and ratified by the Chair Advisory Board and the Industry Liaison Office at the University of Alberta.

All intellectual property developed through the program is owned by the University of Alberta. Generally, actively involved companies are entitled to royalty-free use of all inventions and developments with which they were involved. Other members are entitled to use these inventions for reduced royalties. In addition, the agreement provides non-disclosure clauses to protect the companies involved.

The program, under Prof. AbouRizk's leadership, has resulted in a number of specific products of benefit to the construction industry including: technology transfer programs of immediate benefit to the collaborating companies.

For example, the program selected for research and development the process of project estimation in construction. The result of this research and collaboration was the development and release of project estimation software, known as 'Simphony'. In addition to this software the program has resulted in the development of maintenance management software, project life-cycle cost analysis systems, various templates for project estimation and simulation, and the research has spawned over 30 research publications in refereed academic journals. The direct commercial value of the available software and business analysis tools would be conservatively estimated in the many millions of dollars.

[6] Further information about the program is available on the program website at http://irc.construction.ualberta.ca/html/index.html

In discussion with Prof. AbouRizk, he identified the following factors that he believed were crucial to the success of the initiative:

- Prof. AbouRizk met with over 40 potential participating industry partners and chose only those who were natural collaborators to participate in the initial launch of the program. These firms were not necessarily the largest or most technologically sophisticated – they were companies with organizational cultures and leadership that were open to collaboration.
- Individual representatives from Industry must have the authority, influence and technological literacy (expertise) to be effective and active collaborators.
- The nature of the research program is intentionally directed towards areas that while not directly targeting any firms most strategic and sensitive areas of proprietary capability, are of direct commercial value to the participants and create a relationship of mutual value between the academic research group and the industry partners.
- The research does not replace work that can be or is being done within any of the individual companies.
- All active collaborators have access to all intellectual property.

Prof. AbouRizk has great latitude to direct the activities of this program and he has the leadership abilities to use this latitude judiciously and effectively. The role of Prof. AbouRizk in the success of the program should not be understated. However, the structure of the program may serve as a useful model for the creation of a similar program directed to the needs and benefits of Edmonton's Metal Products Manufacturing sector.

3.35 Role of EEDC and other agencies

The interview and focus group participants had a wide variety of views on the appropriate role for agencies like EEDC. While a few participants thought it appropriate that EEDC limit its role to promotion of the region and advocacy support for the region to senior governments on macroeconomic issues, this was not the majority view. In addition, the greater the individuals experience with EEDC initiatives such as the Manufacturers' Steering Committee or the EEDC and CME supported LEAN consortium, the more likely they were to see an expanded role for EEDC.

Networking and Facilitation

As mentioned above, the role of EEDC in supporting the LEAN manufacturing consortium and in its facilitation of the Edmonton Manufacturing Steering Committee obtained high marks from numerous interview participants. Most firms heartily recommended that this sort of cooperative approach with the CME and with other agencies such as Alberta Economic Development be continued.

Beyond these two initiatives there was general support for the idea that EEDC continue to support both formal and informal mechanisms to encourage productive collaboration and create educational opportunities for Edmonton manufacturers.

Be a one stop shop for Edmonton Manufacturers

Interview participants frequently mentioned a desire for EEDC to serve as a one-stop shop for other agencies and governments programs in support of educational and business development opportunities for manufacturers. Many recipients expressed frustration with their difficulty just learning what specific programs might be available to support their training and marketing objectives.

Support for International Marketing

Some firms specifically identified a desire for EEDC to support the international marketing objectives and desires of their firms both through direct support for their firms trade efforts (trade show funding and support, joint trade missions) and through continuing the current EEDC initiatives to promote the Edmonton region in domestic and foreign markets.

Raise profile of Trades Training

As mentioned earlier in the report, many firms identified the need for EEDC to work with industry and all levels of educational institutions to increase the desirability and prestige of skilled manufacturing trades. This initiative would hopefully raise the profile of manufacturing amongst potential entrants to the industry and increase the skill levels of new machinists.

Industry Attraction

The role of EEDC in industry attraction efforts was controversial amongst the interview participants. Some firms were leery of EEDC's activism in this area, as they feared that EEDC might simply attract large international competitors to the region who would drive their companies out of business.

However, some firms recognized that it might be useful to explore whether licensing arrangements could be developed with foreign producers of process machinery such as that used in the forest and pulp and paper industries. This would allow local shops to service and repair machinery and components manufactured in Europe and may lead to sub-contracting of manufacturing of components of systems in the future.

Macroeconomic/Tax issues

Finally, EEDC and more senior agencies and levels of government were seen as playing a strong role in ensuring that the macroeconomic environment was made more conducive to growth of manufacturing. In general, participants identified the need for EEDC and others to continually benchmark our region against others to ensure that our policy and regulatory environments remain supportive of innovation and risk investment through the adjustment of tax and fiscal policies that keep Alberta manufacturers competitive with those in other jurisdictions. Specifically, multiple participants mentioned the need for accelerated write-offs of capital investments.

4.0 Recommendations

4.1 Support for Cluster Growth

The very concept of government support for economic cluster initiatives is still questioned by some who believe that success or failure of a region's firms is best left entirely to private sector competitive forces. However, over the last decade or so a growing body of evidence has arisen suggesting that, economic clusters which are supported by well funded and effectively facilitated cluster organizations that promote collaboration and innovation, contribute greatly to regional economic growth and enhance the competitiveness of the regional cluster.[7]

As recommended by the interview and focus group participants, QGI agrees that EEDC should continue its support for existing cluster initiatives and should consider how the priorities identified by the study participants might receive enhanced support.

This study suggests that the greatest opportunities for growth of the Metal Products Manufacturing sector reside with those companies that have invested in the development and marketing of proprietary products. Most of these companies are currently directly involved in serving the oil and gas industry in North America however some already have significant presence in international markets and others have plans or aspirations to expand outside the country. However, many of the participants in the Metal Products Manufacturing sector have neither the capability nor aspirations to be directly involved in export markets.

QGI Consulting recommends that EEDC and its economic development partners pursue two different strategies to support the different types of firms within this sector.

[7] A landmark study in global experience with economic cluster initiatives (CI's) is *The Cluster Initiative Greenbook*, by Solvell, Lindqvist, and Ketels, 2003. This study involved a wide ranging survey of over 250 CI's worldwide and resulted in the creation of the Cluster Initiative Performance Model which provides a framework for assessing CI's to evaluate how and why they may succeed or fail.

4.11 Efficiency Oriented Strategies

For the majority of firms in this sector, the continued pursuit of activities intended to foster collaboration in areas of business process improvement, general management skills and capabilities and public policy advocacy are appropriate and necessary. Therefore, EEDC involvement with partner institutions and organizations in initiatives like LEAN manufacturing, and the facilitation of the Manufacturers Steering Committee should continue.

These initiatives will help to increase the culture of collaboration and innovation amongst the participating firms and will support the ongoing development of management capability and effectiveness of the participating small and medium sized enterprises.

In addition, EEDC should, as requested by a number of the firms interviewed, continue to work with industry partners and educational institutions to raise the profile and status of manufacturing trades in order to recruit more qualified individuals into the industry.

However, while necessary, strategies to increase collaboration and innovation in the areas of business process improvement and business efficiency do not by themselves create an improved willingness or capability for firms to expand their capabilities in the areas of product development and commercialization. A different approach will be required to support growth in these vital areas.

4.12 Business Innovation and Growth – a new mechanism for collaboration

As stated at the beginning of this report, focusing on strategies to encourage collaboration within key economic clusters is important because it encourages the innovative and competitive behaviours that improve the sector's competitiveness. This competitiveness is particularly important for firms who sell products or provide services to markets outside the regional economy as these firms increase the overall wealth of the region.

Within the Metal Products Manufacturing sector, QGI recommends that EEDC develop new mechanisms and new partnerships focused particularly on its exporting producers of proprietary products and services. These collaboration and innovation mechanisms would be distinct from those currently being pursued, which we have broadly termed 'efficiency oriented strategies.'

QGI recommends that EEDC partner with other agencies and departments in the provincial and federal governments, and with the University of Alberta to develop a new forum for innovation and collaboration in the Metal Products Manufacturing sector. Such a model could be based in part upon the existing NSERC/Alberta Construction Industry Research Chair but QGI recommends that government and industry stakeholders be brought together in facilitated discussions to examine what would work best for Alberta and specifically for Edmonton manufacturers. It is our view that one of the options that should receive serious consideration is the creation of a new Centre for Manufacturing Innovation and Growth, within the business school of the University of Alberta. As Edmonton region manufacturers and other stakeholders have identified a lack of strategic management and marketing capability as a key barrier to future development, such a centre could coordinate multiple initiatives in this area and serve as the nexus of collaboration for Alberta and particularly for Edmonton region manufacturers. In order to be successful, such a centre would need to be established with a strong continuing involvement from industry as well as be consistent with and supportive of initiatives and strategies of other key educational and government institutions.

4.2 Cluster Advocacy: Engage Civic and Senior Governments

As part of this initiative, QGI believes that EEDC needs to take an active role in creating a favourable policy environment amongst government decision makers in the city, provincial and federal governments. Most individuals involved in the sector do not believe that our senior political leaders appreciate the current or potential value of the manufacturing sector in Alberta, as has been demonstrated in this study. However, QGI Consulting met with representatives from Alberta Economic Development (AED) as part of this study

and our discussions suggest that at the policy development level within the provincial government, the overall strengths, weaknesses and opportunities inherent in the Metal Products Manufacturing sector are well appreciated by AED at the Director and Senior Director levels. If EEDC could create momentum for support of this sector at the Minister and Deputy Minister levels, initiatives to create new collaborative mechanisms in the manufacturing sector would resonate strongly at the program development levels of AED.

Recently, the Alberta Government published "Securing Tomorrow's Prosperity" a strategic policy framework, which was co-signed by the Premier and the Minister of Economic Development. The document identifies four strategic directions for the Alberta economy for the next 20 years:

- Enhance Alberta's Current Competitive Advantages
- Build Alberta's Innovation System
- Grow and Strengthen Small and Medium Enterprises (SME's)
- Focus on Priority Value-Added Sectors

Within this strategy document are a number of the same observations and conclusions regarding the strengths and weaknesses of Alberta manufacturing that have been identified in this study. In particular the document recognizes the need to increase management/leadership capacity within SME's. It also explicitly identifies the need to create a new culture of innovation that "enhances cooperation, collaboration and convergence."[8] This policy framework represents an excellent opportunity for EEDC to align its strategy for supporting this sector with a strategic provincial government policy initiative.

Following the election of a new Mayor in Edmonton and with the recent conclusion of the provincial election in Alberta and the subsequent appointment of a new Cabinet with many changes at the deputy minister level, timing is especially ripe for EEDC to undertake new initiatives to increase political awareness of the value of the Metal Products Manufacturing sector. Time is of the essence however as the new City and provincial governments will be planning their political programs under a new electoral mandate no later than the beginning of the New Year.

The information available from this study on the value and growth of the Metal Products Manufacturing sector can assist EEDC in their communication with political and bureaucratic leadership in the civic and provincial governments to obtain support and funding for initiatives designed to support the growth of this vital engine of economic prosperity.

5.0 Conclusion

Edmonton's manufacturing sector and particularly its Metal Products Manufacturing cluster are critical to Edmonton's current economic prosperity. The findings and strategies examined in this report suggest that the future growth of this cluster will require new strategies that enhance collaboration and increase the strategic planning vision and capabilities of local firms. That EEDC has commissioned this study and that Edmonton manufacturing companies have participated so enthusiastically in the interviews and focus group suggests that the local climate exists to capitalize on this energy and enthusiasm to engage a broader group of regional manufacturers in new initiatives to continue the growth and expansion that has brought such prosperity to our region.

Finally, QGI Consulting hopes that the methodology developed for the examination of the Manufacturing Cluster will be of use to EEDC and other agencies in improving their understanding of the structure, behaviour and development of other cluster groups.

[8] *Securing Tomorrow's Prosperity,* Alberta Economic Development, Spring 2004. Page 10 ISBN# 0-7785-3358-1

Appendix 1. Interview Guide

Provide an introduction and overview of the findings from the study so far.

Confirm respondent's time availability (60 minutes preferred)
Explain purpose of the project
Briefly review demographic data
Value chain map and concentration

A. Does the respondent agree with the basic value chain structure provided?

Yes __
No __

If 'No', what changes or errors are identified?

_____
_____
_____
_____
_____

B. Where does the respondent believe that they fit on the value chain map?

Primary manufacturing
Component manufacturing
Machinery manufacturing
Supporting industry

Other: (specify) _____

Comments:

_____
_____
_____
_____
_____
_____
_____
_____

C. Critical Inputs

What does the respondent think are the critical non-labour or financial inputs to his/her business.

Material/Component Inputs	Source	Is Source local?	Does local source exist Y/N	Why local source not used

Sample probing questions:

- Does the location of your firm depend upon the location of your input sources and if so why? (Logistics concerns, history, integration?)
- If local suppliers exist, but aren't used, what might they do in order to become your suppliers?

D. Primary Products and Markets

Product	% Sales Alberta		% Sales other Canada		% Sales USA		% Sales other International	
	Current	Growth Potential ?	Current	Growth Potential ?	Current	Growth Potential ?	Current	Growth Potential ?

Sample probing questions:

- What are your primary products and markets?
- In which of those markets do you see the greatest potential for growth over the next several years?

E. In what ways, if any, does the respondent collaborate with their suppliers, peers/competitors, customers in areas such as:

	Product Development	Business Planning	Marketing Market Development Sales	Advocacy / Government Relations
Suppliers local				
Suppliers other				
Peers / Competitors local				
Peers / Competitors other				
Customers Alberta				
Customers other				

Sample probing questions:

- Tell us about the ways in which you work cooperatively with your suppliers, customers and competitors or peers, on issues of common interest?
- Are your relationships formal or informal? Are they project or "deal" oriented or are they on-going?
- In which areas of collaboration have you enjoyed great success, with suppliers, customers and peers, and why?
- In which areas has collaborative effort not been tried, or has not worked out and why?

F. Thinking about the growth opportunities that we discussed in question D above what do you think should be done to increase the amount of value-added manufacturing being done in the Edmonton region?

Note which of the following are mentioned by the respondent and if not mentioned probe to determine if they are considered important.

- Improving local sources of supply
- Attracting new local sources of supply

- Improving access to intermediate (local) or final markets (how?)
- Collaborative marketing or business development

G. What are the most important barriers to increasing the level of value-added manufacturing being done in the Edmonton region?

H. What role might EEDC, or other agencies or organizations play in improving the effectiveness of collaboration amongst local Edmonton region manufacturers and their suppliers?

- Provide formal facilitation for business development
- Provide staff, meeting locations
- Lead development/dissemination
- Improve infrastructure (specifically?)
- Industrial attraction efforts to strengthen local value chains
- Stay out of the way

Appendix 2. **List of Companies**

Cluster Group Description	Company Name
Steel and Metal Product Supply	AltaSteel Ltd
	Alberta Custom Pipe Bending & Mfg. Ltd.
	Grant Prideco Canada
	American Brass & Aluminum Foundry Ltd.
	Childers Products Company Limited
	Metal Supermarkets
	Quality Steel Foundries Ltd
Forging, Stamping, Coating, Engraving, Heat Treating	Hunt Manufacturing Ltd
	Ironco Iron Works Ltd.
	Metal Fabricators And Welding Ltd.
	Cours Metal Profiles
	Alberta Plastic Bumper Ltd.
	All Brite Metal Finishing Ltd.
	Alpine Chrome Industries Ltd.
	Brimstone Furnace Works Ltd
	Canadian Custom Engravers Ltd
	Canadian Galvanizing
	Edmonton Electroplating Ltd.
	Fairmont Electoplating
	Flo's Engraving
	Industrial Plating (1981) Ltd.
	Inotec Coating and Hydraulics Inc
	Micro Industries (Alberta) Ltd.
	Shaw Pipe Protection Limited
	Supreme Plating (1983) Ltd.
	Thermex Metal Treating Ltd.
	Western Hardchrome Plating Co. Ltd.
	Western Mobile Equipment Refinishing
	Metal-Span Rollforming Corp
Prefabricated Metal Components and Plate Work	Almac Metal Industries Ltd.
	Alta Fab Structure Ltd.
	Brytex Building Systems Inc
	Dell Erectors Ltd.
	Robertson Building Systems
	Camsteel Fabricators (Alberta) Ltd.
	Collins Industries
	Fabco Metal Products Ltd
	G T Metal Products Ltd.
	Gem Steel Edmonton Ltd.
	Imperial Steel Fabricating Ltd.
	Norfab Mfg Inc.
	Northern Weldarc Ltd.
	Nor-West Metal Craft Ltd
	Premier Steel (1990) Inc.
	Quality Fabricating & Supply

	Rampart Steel Ltd.
	Scott Steel Ltd.
	Supreme Steel Ltd
	Supreme Steel Ltd - Bridge Division
	Waiward Steel Fabricators Ltd
Boiler, Pressure Vessels Tanks and Containers	A B B Combustion Services
	Altex Heat Exchanger Ltd
	Edmonton Exchanger & Manufacturing Ltd
	Noralta Metal Fabricators Inc
	Factotum Steel Industries Inc.
	ZCL Composites Inc.
	Penfabco Oilfield Equipment Sales & Service Ltd
	Crown Cork & Seal Canada Inc.
Machine Shops	Affordable Industries
	Alberta Rewind & Pump Services Ltd
	Allfab-Metals Ltd.
	Antrim Industries Inc.
	Apex Machine & Manufacturing Ltd.
	Apollo Machine & Welding
	Armor Machine & Manufacturing Ltd.
	Atomic Machine Shop Inc.
	Boreal Machine Inc
	BSL Machine Ltd
	C N C Industries Ltd.
	C R C Wellhead Supply Ltd
	C S M Compressor Supplies & Machine Works Ltd
	Canak Industries Inc
	Domino Machine Co. Ltd.
	Fieldco Manufacturing Inc.
	Gambit Products Ltd.
	Grubisa Millwright Services Ltd.
	Headhunters Diesel Ltd
	I M Industries
	Industrial Machine Shop Ltd.
	Inspira Manufacturing Inc
	J & H Machine Tools Ltd.
	L P M Machines Ltd
	McKinney Machine Company Ltd.
	Norsearch Industries (1986) Ltd.
	Oxford Machine & Welding Ltd.
	Pat's Driveline
	Precimax Mfg Ltd
	Production Die-Makers & Machine
	Reinhold Industries Ltd.
	Texflo Machining Limited
	UMW Valve
	Universe Machine Corporation
	Uniwest Machining Ltd.
	Weldangrind Ltd.

Pumps, Compressor and Valve Manufacturing	Driesser Value, Halliburton Group Canada Inc.
	Alberta Compressor Valve Co. Ltd.
	Dover Corporation (Canada) Ltd
	Eagle Pump & Compressors Ltd
	Flexxaire Manufacturing Inc.
	Sulzer Bingham Pumps Inc.
	Weatherford Canada Limited
	Gledhill Steel Products Ltd
	Hi Kalibre Equipment Ltd.
	Invicta Valve Mfg Inc.
	Roda Deaco Valve Ltd
Miscellaneous Fabricated Metal Product Manufacturing	Halbar Stainless Products Ltd.
	Stinger Fabrication & Welding Ltd
	The Great Canadian Mint
	Fero Corporation
	Stamco Specialty Tool & Mfg Co (1979) Ltd
	Strathcona Manufacturing Inc.
	Raylin Manufacturers & Distributors Ltd.
All Other Industrial Machinery Manufacturing	Jenric Millwork
	Finning Limited
	Peacock Inc.
	Spartan Controls
	Hoisting Ltd.
	Imac Design Group Limited
	Cessco Fabrication and Engineering
	Complete Package Technology Ltd.
	Diversified Steel Products Manufacturing Ltd
	Unisorb Canada Ltd
	Bloemhof Inc.
	Stanfos Inc.
	Alberta Precision Tool Mfg Ltd.
	L J Welding & Machine Services Ltd.
	Mpb Lasertech
	T C G Pipe Services Ltd.
	Black Cat Blades Ltd
	Valley Blades Limited
Mining and Oil and Gas Field Machinery Manufacturing	Almac Machine Works Ltd.
	Weldco-Beales MFG. Alberta Ltd.
	ABB Vetco Gray
	Stream-Flo Industries Ltd
	Hyduke Energy Svc. Inc.
	Argus Machine Co. Ltd.
	Canturn Machine Co. Ltd.
	Cooper Cameron Canada Ltd.
	Larsen & D'Amico Mfg Ltd
	Master Flo Valve Inc
	Top-Co Industries Limited
	Tri-Service Oilfield Manufacturing Ltd
	Vector Oil Tool Ltd.
	Walters Oil Tool Machine Ltd.

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Appendix F: Weldco/Industry Endowment Agreement

UNIVERSITY OF ALBERTA

RECEIVED
DEC 19 2006

STATEMENT OF TRUST

Donor Information

Weldco-Beales Manufacturing Inc.
Doug Schindel
12155 – 154 Street
Edmonton, AB T5V 1J3
Phone: 780-453-5306
E-mail: schindel@weldco-beales.com

1

I/we hereby donate to the Governors of the University of Alberta (the "University") as trustees, as an endowment in perpetuity, the sum of **$750,000** ("the Endowment").

2

Unless otherwise specified in paragraph 3, the income from the Endowment shall be used, at the discretion of the University, for priority projects and programs.

3

The Endowment is designated to the:

Weldco-Beales/Industry Endowment in support of Welding and Joining Initiatives

Earnings may be used at the discretion of the Dean of Engineering in support of initiatives undertaken in the Alberta Centre for Welding and Joining.

In the event that future circumstances render the continuation of the aforementioned activity impractical or undesirable, the University may use the principal or income for such other purposes as will, in its opinion, honour, as nearly as practical, the original intent of the donor.

4

The Endowment will be administered by the University in accordance with the *Post-Secondary Learning Act*, the *Endowment Management Policy*, the *Statement of Operating Principles and Spending Policy* and the *Endowment Investment Policy*.

Copies of these policies and guidelines are available upon request or they can be viewed at http://www.finance.ualberta.ca/endowments.

Signature of the donor(s) or agent(s) of the:

Weldco-Beales/Industry Endowment in support of Welding and Joining Initiatives

Dated this 15 day of DEC, 2006

Signature

DOUG SCHINDEL
Printed Name

Receipt of fund and acceptance of conditions acknowledged by the University as Trustee

Dated this 3rd day of January, 2007

Per: _____
Signature - Vice President (External Relations)

SANDRA CONN
Printed Name

Per: _____
for Signature - Director, Financial Services

D. BARSZCZEWSKI
Printed Name

Developed in consultation with the University's legal counsel

REV 09/2006

GIFT AGREEMENT BETWEEN

WELDCO-BEALES MANUFACTURING INC.
("the Donor")

AND

THE UNIVERSITY OF ALBERTA
("the University")

I. THE GIFT

Weldco-Beales Manufacturing Inc. has generously pledged a gift of $750,000 to the Department of Chemical and Materials Engineering in the Faculty of Engineering at the University of Alberta. This pledge will be fulfilled over a period of 10 years, beginning in 2006.

Annual gifts of $75,000 will be made by Weldco-Beales Manufacturing Inc. to the University of Alberta every December 15 from 2006 through to December 15, 2015.

Pledge reminders will be provided by the University one month in advance of the payment due date.

II. PURPOSE

The purpose of the gift is to establish the **Weldco-Beales/Industry Endowment in Support of Welding and Joining** at the University of Alberta. This investment by Weldco-Beales Manufacturing Inc. of $75,000 per year over ten years will be leveraged through matching funds, additional industry contributions, and endowment yield to establish the Alberta Centre for Welding and Joining at the University of Alberta.

III. RECOGNITION

The Faculty of Engineering will establish the **Weldco-Beales/Industry Chair in Welding and Joining** as the cornerstone of the Alberta Centre for Welding and Joining. This endowed chair will exist in perpetuity and will carry the Weldco-Beales name for generations into the future. In addition to making the Weldco-Beales name prominent within the name of the Centre, the University will continue to recognize Weldco-Beales Manufacturing in its donor publications as appropriate ("The UofA Engineer"- Engineering alumni magazine, "New Trail" - UofA alumni magazine, etc.).

A major recognition event will publicly acknowledge Weldco-Beales support for the Alberta Centre for Welding and Joining and the appointment of the **Weldco-Beales/Industry Chair in Welding and Joining**.

A representative of Weldco-Beales will be invited to sit on the selection committee as an industry representative when the initial **Weldco-Beales/Industry Chair in Welding and Joining** is to be selected.

III. ACCOUNTABILITY

The University will report annually to the Donor on the status of the gift and the centre's activities.

V. OTHER

Both Weldco-Beales Manufacturing Inc. and the University affirm that this gift does not and shall not, in any way, compromise the University Mission and Vision Statement, constrain academic freedom on campus, contravene any policy of the University, or reflect negatively on the University's public image.

The focus of the academic priorities at University of Alberta may shift over time, and it may become impossible, inadvisable or impracticable to apply the gift for the purpose set out above. If the University is of the opinion that a revised purpose is appropriate, the University shall exercise its discretion, in consultation with Weldco-Beales Manufacturing, and use the gift to the best advantage of the University for other purposes consonant with the spirit and intent of the Donor's gift.

Doug Schindel
President, Weldco-Beales Manufacturing Inc.

DEC 15/06
Date

Dr. David T. Lynch, P.Eng.
Dean, Faculty of Engineering
University of Alberta

DEC. 15/06
Date