

ANNUAL REPORT TEMPLATE: CHAIRS IN DESIGN ENGINEERING¹

Report Due Date: May 2, 2014

Please verify your personal information below and make the necessary corrections.

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Chair in Design Engineering Name: « NSERC- chair in design for aluminum (DFAI) »
File No : 411610 - 08
Contact person, Partner name,
André Dorion, CQRDA
François Racine, Alcoa Canada Itée
Mario Fafard, REGAL Regroupement Aluminium

Top 3 contributions for the year.

1.

An elective course entitled "*Structural lightening for the transportation industry*" is under development and is expected to be taught for the first time in September 2014.

2.

The Chair initiated a multidisciplinary project to design and build an aluminum cauldron for the Sherbrooke 2013 Canada Games. The cauldron was successfully lit at the opening ceremony which led The Prime Minister of Canada, the Right Honorable Stephen Harper, to declare "the Sherbrooke 2013 Canada Games officially open". The cauldron is expected to be used across the nation for the next 10 editions of the Canada Games.

3.

A waterjet cutting machine has been purchased to support student design projects. This is a major acquisition for Université de Sherbrooke. The equipment features a 4' x 4' cutting table and is capable of cutting a vast range of materials and thicknesses. It has been received on April 30th 2014 and is currently being installed.

Best Practices

Please share one best practice that was implemented to be shared with other CDE Chair holders.

1.

The development of a new specialty course can be time consuming. To that end, internships were offered to undergraduate students (Jean-François Dufault, Nicolas Roy and Nicolas Paradis) to prepare pedagogical material in support of the course entitled "*Structural lightening for the transportation industry*". The best practice related to this is to involve students in the development of courses so as to reflect their own expectations of how a design course should

be constructed, how it should be taught and what knowledge depth should be expected. Weekly meetings allow the professors to challenge the students and learn from them all along.

1. Overview

a. Chair Structure

Please provide an overview of the participation in and contributions to the CDE action plan of each member of the Chair's team (Chair holder(s), professional staff, company experts, collaborators, post-doctoral fellows, students, etc.).

Here is an overview of the people involved in the Chair's mandate

- *Senior Chair holder: Prof. Alain Desrochers, P. eng., Université de Sherbrooke, Canada.*

All reported Chair activities have so far been conducted by the senior Chair holder. A team of technicians and professors from the Department of Mechanical Engineering (DME) has played a central role in the supervision and support of undergraduate capstone projects.

- *Chair professional: Sylvain Vachon, P. eng. MBA, Université de Sherbrooke, Canada.*

The Chair professional has been involved in all aspects of the Chair activities. This included technical and administrative support to students, establishing agreements with their industrial partners, meeting with potential industrial partners for new projects, providing free aluminum to capstone projects and assisting students with the fabrication of prototypes.

- *Director of Mechanical engineering department: Prof. Said Elkoun, Université de Sherbrooke, Canada.*

The new director of the Department of Mechanical Engineering has been very supportive of the Chair and has also been instrumental in providing new opportunities such as enabling master degree students to evolve with the Chair in conjunction with industrial partners. Course based master degree students can now be awarded 15 academic credits while working a complete semester (4 months) on R&D projects with industrial partners. Two projects have recently been launched following this new structure; the industrial partners are Remorques Savage and CE Fibre de Verre.

- *Industrial co-Chair : Russel Long, P. eng., Chief Design Engineer, Alcoa Technical Center*

Mr. Russel Long and two colleagues from the Alcoa Technical Center (Donald Spinella and Daniel Bryant) have played an important role in disseminating aluminum knowledge through a series of three webinars. Each webinar was a 1 hour presentation delivered to a class of 40 students with other industrials located around the province of Quebec and attending the presentation remotely.

b. 5 Year Term Objectives Overview

Please provide a brief overview of your Chair, its goals and objectives.

The objectives of the Chair in Design for aluminum are twofold :

1. To evaluate and integrate the strategic use of aluminum in products from a cost/benefit/performance perspective;
2. To develop and disseminate knowledge and expertise on product design, rather than prototypes, where reliability, manufacturing and assembly processes will be assessed.

c. Annual Objectives/Tasks

Please provide a list of the activities that were to be achieved in the past year and your progress toward these objectives.

Chair program : (Achievements, since May 2013 report)

1. Undergraduate training - Applying Knowledge in Aluminum Design (Mech. and Civil Engineering)

- Gathering information & knowledge on aluminum and reliable product design.
More specifically, the Chair is seeking to research and gather information related to aluminum, composite, multi-material assemblies and design criteria applicable to civil infrastructure, aerospace and road vehicle structural components.

- Developing courses on aluminum in engineering.

⇒ *During the summer of 2013, an intern (Jean-François Dufault) has researched and gathered information on aluminium product design. The information was structured and organized on the university Moodle site.*

⇒ *Two new interns (Nicolas Roy and Nicolas Paradis) were recently hired to continue the development of the elective course mentioned earlier during the 2014 summer.*

⇒ *As previously mentioned in this report, three web conferences were organized over the past 12 months. The topics of the presentations were as follow:*

March 27th 2013 – Russel Long from the Alcoa Technical Center on the future of aluminum use in the automobile industry.

November 21st 2013 – Donald Spinella from the Alcoa Technical Center on the joining methods used in aluminum structures.

March 26th 2014 – Daniel Bryant from the Alcoa Technical Center on the manufacturing of aluminum rolled products.

- Supporting aluminum usage in undergraduate capstone design projects.

In 2013, the Chair has been able to honor its commitment to provide aluminum for capstone project teams. This represented an expense of almost 3500\$ in aluminum.

- Industrial project definition and identification

⇒ *Since September 2012, the Chair professional has been working in close collaboration with the SARIC (Service d'appui à la recherche, la création et l'innovation) towards getting capstone projects agreements signed with the industrial partners. These agreements include financial as well as intellectual property issues. As a result, the Chair is not only involved downstream at the manufacturing and final exhibition stages of the capstone projects, but also upstream when the capstone projects and the partnership agreements with the industrials are drafted.*

⇒ *The Chair and its professional remained committed in contacting companies toward finding new capstone projects in a proactive way. Over the past few months, the Chair attended industrial fairs and met with many companies some of which were keen to offer and sponsor new capstone projects:*

- *In September 2013, a Valcourt based company called Verbom successfully proposed an undergraduate capstone project on the design of an aluminum camping trailer to be constructed using blow molded structural aluminum sheets. This is an innovative process that was developed by Verbom.*

- *In 2013 and 2014, Drakkar International offered a capstone project on the design of a new generation of aluminum supermarket shopping carts. Unfortunately, despite*

having been proposed several times over the last year, the project has not yet been selected by undergraduate students.

- *Two course based master degree R&D projects with industrial partners were also identified. The first one is with a local company called CE Fibre de Verre. The main objective of this project is to design a system that enables disabled people to access public pools on their own, without external assistance. A student, Robin Sallet, has started working on this project in May 2014. The second project with Remorques Savage will start in September 2014 and aims at designing a "Deckover tilt trailer" made out of aluminum. The master student is Sylvain Lecornu.*
 - **Capstone projects (fabrication and exhibition)**
 - ⇒ *During the 2013 fall semester, the Chair was pleased to support capstone project prototype fabrication by providing students with appropriate tools and advices. That support has not been limited to the teams that used aluminum. The Chair professional also helped students make sound fabrication choices and identify external suppliers when needed.*
 - ⇒ *At the end of the 2013 fall semester, the yearly Mecageniale public exhibition featured all undergraduate newly created prototypes from the Department of Mechanical Engineering. The Chair provided logistic and organisational support for this exhibition which displayed 12 prototypes that were designed and fabricated by the students themselves. Year after year, the Mecageniale exhibition attracts hundreds of visitors, including kids from primary schools.*
2. Graduate and post-graduate training - Creative Design for Innovative Aluminum Products
- Development of methodologies and advanced design tools;
This point was developed in lengths last year and will not be developed this year.
 - Development of innovative products and materials.
Last year the chair was happy to announce that it had launched an R&D project in collaboration with a company called MC2 Recherche Internationale. An international student was recruited and was granted a BMP Innovation scholarship at the Ph.D. level. Unfortunately, the company went bust in 2013 and the student abandoned her Ph.D. The team is nonetheless working on a methodology paper for the integrated design of a submerged turbine to harness the power of rivers and produce electricity.
3. Chair resources
- ⇒ *In addition to the Chair professional hired in 2011, the Chair has also hired undergraduate interns whose mandate was to support the development of a course related to aluminum product design and multi-material assembly.*
4. Other Chair matter / projects
- ⇒ *During the past year, a team of students from different horizon has worked in close collaboration on a unique multidisciplinary project aiming at designing and fabricating a cauldron for the 2013 Canada Games that were held in Sherbrooke in the month of August. Teaming up in the project with their specific competencies were three local secondary and post-secondary institutions: Bishop's University Department of Fine Arts for the artistic design, Université de Sherbrooke for the engineering and process planning and the Lennoxville Vocational Training Centre (LVTC) for the fabrication and assembly of the artwork. The collaborative aspect of the project was the main driver and the topic of an investigation which led to a paper at the 2013 Canadian Engineering Education Association Conference. The cauldron will be used for the next ten Canada Games, therefore becoming a legacy and insuring the continuity and the visibility of the symbol it is representing. The realisation of this artwork has been made possible, thanks to the support of the Canada Games Council and the Aluminum*

Association of Canada. In addition to the visibility of this project in the media, the Chair was also rewarded publicly by the local community. Indeed, on February 20th 2014, the Chair was awarded a special price from the borough of Lennoxville to highlight the value of this exceptional accomplishment.

d. Objectives/Tasks for Upcoming year

Please provide a list of the activities that you are planning for the upcoming year.

- Scientific exhibition in Sherbrooke (REGAL)
On November 18th 2014, the Chair will host an event called "REGAL student's day". Graduate students from all across Quebec will present the results of their research project on aluminum. The projects are related with REGAL's research axis which are as follow:
 1. Aluminum production (from ore to ingots)
 2. Aluminum transformation (from ingots to sheets and extrusions)
 3. Integration of aluminum in product design and manufacturing (from sheets and extrusions to products)
 Approximately 150 visitors are expected to that event.
- High visibility collaborative project for Canada's 150th anniversary
As a follow up to the Cauldron multidisciplinary project, the Chair is envisioning another collaborative project to highlight the 150th anniversary of the Canada Confederation in 2017. This great event is already being prepared by Canadians from all across the nation (references <http://www.2017startsnow.ca/> and <http://www.i150.ca/> and <http://www.ottawa2017.ca/fr>). Once again, both the French and English communities of Sherbrooke will team up in this unique project. Indeed, students from Université de Sherbrooke Engineering faculty and Bishop's University Department of fine arts are expected to work together toward the design and fabrication of an artwork to celebrate the Canada Confederation. Professor James Benson, our collaborator at Bishop's University, was keen to embark in this new endeavor. The local federal deputy from NDP, the honorable Jean-Rousseau from the NDP, was also informed about the project. The Chair professional registered to receive the newsletter from the imagi Nation 150 committee (<http://www.i150.ca/>) to share ideas and local initiatives.

e. Impact of Semi-Annual meetings

Please describe the influence last year's semi-annual meetings have had on your Design Chair. Note any impact or changes as a result of the meetings.

On January 13th and 14th 2014, the NSERC design chairs gathered nearby Sherbrooke at the hotel Estrimont. This event has been a very good opportunity for visitors to get a tour of the "Centre de Technologie avancée UdeS-BRP". The sharing of tools and best practices supporting capstone projects was truly appreciated by participants. The previous meeting, held in Montreal in June 2013, confirmed the relevance of developing design projects for graduate students.

2. Established Partnerships

Briefly describe the nature and extent of the involvement of the partners. Include details on how the results have been communicated to the partners (e.g. meetings, reports) and how

the industrial partners have transferred knowledge and know-how to the university students, staff, and faculty.

The Design Chair is currently supported by three regular partners: REGAL, Alcoa and CORDA. The extent of their involvement is still in line with their initial commitment.

Alcoa's contribution is in kind, but it is central to the good operation of the Chair. Indeed, it includes the involvement, as industrial co-chair, of Russell Long, Chief Engineer, Ground transportation, at the Alcoa Technical Center (ATC) in Pittsburgh as well as technical resources from Alcoa Innovation in Montreal. The Chair professional and Alcoa Innovation in Montreal have joined efforts to solicit jointly Small to Medium size Enterprises (SME) for R&D projects aimed at graduate and undergraduate students. A few meetings were held with different companies to promote the Chair partnership with Alcoa (Cambli and Rackam projects). From these, an important R&D project is still awaiting to be confirmed by a Canadian manufacturer of armored trucks (Cambli).

The contribution of the Centre Québécois de Recherche et Développement de l'Aluminium CORDA was through grants to Small to Medium size Enterprises (SME) for projects involving students from the Université de Sherbrooke. The newly elected general manager of CORDA, Mr. André Dorion, also visited the Chair on November 6th 2013 and stressed the importance of further developing the relationship between the Chair and the CORDA.

REGAL was instrumental in the creation of the Design Chair as it was part of its strategic plan. REGAL is also the only partner whose contribution is in cash and not contingent upon the completion of specific projects or grant proposals. Being responsible of a research axis on aluminum product design and manufacturing within REGAL, the Chair holder pledged to disseminate to all member institutions, the course material and good practices that are to be generated through the Chair activities.

In addition, two additional partners have contributed directly to the chair, namely the Canadian Aluminum Association and the Canada Games Council in Ottawa. These organizations have decided to support financially a specific project that was managed by the Chair itself. Therefore, a cash contribution of 29 500\$ was received by the finance department of Université de Sherbrooke for the construction of an aluminum cauldron. The Chair professional was deeply involved in this special project in collaboration with bachelor degree students in mechanical engineering, artistic students from Bishop's University and welding students from Lennoxville Vocational Training Center. Canadians from coast to coast to coast have seen the cauldron being lit up at the Opening Ceremony of the Sherbrooke 2013 Canada Games edition on August 2nd 2013 (<http://www.canadagames.tv/>). The Chair gained a lot of exposure and publicity from that event since it has been broadcasted live on TSN television. Local partners from different organization (Université de Sherbrooke, Bishop's University, Lennoxville Vocational Training Center and external suppliers) were also pleased to invest time and energy in the project. Without volunteering support from different people in the community, the total value of the cauldron would have been close to 150 K\$.

3. Sources of Financial Support

Please provide information about the cash and in-kind contributions received during the past year, noting the impact on the Chair activities as well as the estimated values for Chair leverage.

On December 5th 2013, a total of 12 undergraduate capstone projects from the Department of mechanical engineering were presented to the public at the yearly Mecageniale Exhibition. The

total budget of these 12 capstone projects from the 55th promotion that graduated at the end of 2013 was 395 441\$. That financial support is the result of all cash and in-kind contributions from industrial partners and multiple sponsors committed to the different projects. Approximately 80% of that budget were cash contributions whereas the remaining 20% were in-kind contributions. Regarding the 2013 Chair operational budget, excluding NSERC yearly financial support, the Chair received 136 500\$ in contributions from different partners. Approximately 64% of that budget were cash contributions whereas the remaining 36% were in-kind contributions. On top of that, we must mention the fact that the Department of Mechanical Engineering paid 100% of the salary of the Chair professional which amounted to 80 000\$ when calculated with the social benefits. Since the Chair professional is totally dedicated to the chair activities, the total value of the chair budget, excluding the NSERC counterpart, was 216 500\$.

4. *Progress to Date*

Please describe the progress to date made toward the following objectives.

a. Training

Please include all relevant information about courses developed or modified by the Chair focusing on design, the impact of these courses as well as any involvement in competitions etc. Please include the number of students impacted.

I. At the undergraduate level

As previously mentioned, interns have been hired in the 2013 and 2014 summers to develop course material on "*Structural lightening for the transportation industry*". Webinars have also been held by Alcoa Innovation, as described earlier.

II. At the graduate level

A project called dSkibel, that aims at reducing the noise of BRP snowmobiles, was launched with graduate students in the fall of 2013. The project is well under way. Concurrently, a major Automotive Partnership Canada project on the development of an hybrid roadster with BRP is also moving along and is expected to end in march 2015.

b. Design and Development

Describe all relevant information about the design and development of innovative products, processes, systems and technologies.

Design and development of innovative products is central to the Chair on Design for Aluminum and the Université de Sherbrooke Mechanical Engineering program. The undergraduate capstone projects that have been presented publicly at the 2013 yearly Mecageniale Exhibition may be summarized as follow :

Apollon project : The Apollon team designed and built a low cost prototype for a combined heat and power plant to run on commercially available solar panels. The generator harnessed energy from the sun in order to produce heat and electricity.

Ares project : The students from the ARES project developed a solar greenhouse unit that was installed on the roof of the Sherbrooke Hospital. This unit was designed to help reduce energy

costs by pre-heating air channelled through the ducts of the HVAC system.

Arpvec project : The students from the ARPVEC project designed and built a guided drone that was equipped with a vector propulsion system to provide maneuverability without directional rudders and conventional stabilizers.

Daamp project : The main purpose of the Daamp project was to develop an adjustable progressive damping device to be installed on the rear end of a snowmobile or any other recreational vehicle.

E-volve project : The Evolve team designed and built a low power consumption electric vehicle in order to win (which they actually did) the 2014 edition of the Shell Eco-Marathon (SEM) competition in Houston Texas.

Horus project : The main purpose of the Horus project was to design and build a multi-purpose guided aircraft to be used for forest fires surveillance, electric lines inspection and civil rescue operations.

Hype project : The HYPE team has designed and built a mobile platform to help workers install stators in power dam.

ProPulse project : The students from the ProPulse project built a human powered vehicle that will take part to the *Battle Mountain* competition from the *World Human Powered Speed Challenge* (WHPSC) to be held in Nevada in September 2014.

Sparus project: The SPARUS team designed and built industrial equipment to orient and turn over different types of bags with the purpose of increasing the pace of a palletisation line.

Sphyrna project : The students from the SPHYRNA project designed and built a nautical board with an hydrofoil, a seat and a suspension.

Vadhus project : The VADHUS team designed and built a downhill bike suited for reduced mobility people and compatible with ski resort chair lifts.

Venus project : The students from the VENUS project designed and built an equipment for the detection of breast cancer by using *Digital Imagery Elasto-Tomography* technics.

Half of these projects were realized in partnership with industries and another half were sponsored by multiple donators.

c. Collaboration

Describe any collaborations and interaction of the Chair with the department, faculty, university and outside colleagues during the past year in connection with the CDE action plan. Include collaborations with other CDEs, but do not include the Chairs regular workshop meetings.

In February 2014, Alcoa ended its negotiation with the government of Quebec and pledged to keep its aluminum smelters in operation. Therefore, on march 26th 2014, Alcoa representative François Racine came to Sherbrooke for a visit and expressed Alcoa's interest in renewing Alcoa's support to the Chair for its second mandate.

Nonetheless, a few months before, on August 29th 2013, the representatives of Aluminerie

Alouette, namely Mr. Richard Lapierre, strategic vice-president, and Mrs Annie Thabet, senior consultant, came to Sherbrooke for a visit of the engineering faculty and the CTA-UdeS-BRP research center. This meeting was a good occasion to discuss potential partnership with Aluminerie Alouette related with the renewal of the NSERC Chair in design for aluminum. Associated with the completion of the Phase III project, in addition to a pledge of creating 300 direct jobs in its own facilities, Aluminerie Alouette also made a commitment to keep its job creation program so as to generate 1,000 additional jobs in small to medium size enterprises (SME). These jobs will be created by developing partnerships with manufacturing companies that performs aluminum transformation activities, thus supporting the development of new products in addition to raw material in Québec. Hence, a follow up discussion with Aluminerie Alouette representatives will be done in the upcoming weeks as a partnership with the Chair could generate mutual benefits for both Université de Sherbrooke and Aluminerie Alouette.

Moreover, on March 19th 2014, Franco Chiesa and Nicolas Giguère from the NSERC Industrial Research Chair for Colleges in Aluminum Transformation came to Sherbrooke to deliver a technical briefing on molding processes to our undergraduate students. Discussion with this Chair took place to discuss synergies and further collaboration with the Université de Sherbrooke Chair in design for aluminum to support common projects. More specifically, Franco and Nicolas provided important technical support to undergraduate capstone projects, namely Trus+ and Omega, in the field of aluminum molding. This NSERC Chair is located in Trois-Rivières and is specialized in the science of metallurgy.

d. Promotion

Describe any events and activities that were organized to raise the awareness and appreciation in the research and outside communities for all aspects of design engineering.

The 2013 International Aluminium Conference (INALCO) was held in Montreal on October 22nd-23rd. The scope of INALCO is to present and discuss topics relevant to products and constructions in aluminium through the exchange of knowledge and experience from engineers and researchers working in the field. At this conference, the Chair holder was invited to deliver a 3 hour lecture on aluminum in the transportation industry.

The Chair holder gave interviews to Radio Canada Winnipeg in order to discuss the public unveiling of the cauldron that took place on July 5th 2013. Another interview was also recorded with Radio-Canada in Windsor Ontario to discuss the use of aluminum body panels in the new Ford F150 pick-up truck.

5. **Problems Encountered**

Identify the main problems encountered during the past year, their impact and the steps taken to resolve each issue.

The Sherbrooke 2013 Canada Games cauldron project proved to be complex owing to the many resources involved. Indeed, the Chair professional has had to manage the logistic and coordination of the project which involved the following partners:

- Pomperleau Gaz Propane – Supplier of propane cylinders
- Promax Combustion – Designer of the burning system
- Canada Games Council in Ottawa – Final client and financial partner (25 000\$ provided in cash)
- Canada Games Sherbrooke 2013 Committee – Responsible for organising the Games in Sherbrooke.
- Canadian Aluminium Association – Financial sponsor (4500\$ provided in cash)

- Sherbrooke University – Mechanical design of the cauldron aluminum structure, project logistic and management and host of the opening ceremony in the stadium on August 2nd 2013 (<http://www.canadagames.tv/>)
- Bishop's University – Artistic Design of the cauldron and host of the cauldron at the Olympic village during the games for continuous operation.
- Lennoxville Vocational Training Center – Cauldron welding and assembly
- Ville de Sherbrooke – Cauldron operation at the closing ceremony on August 17th 2013.
- Intertek – Inspection of the gas system for CSA approval (Canadian Standard Association)
- The Régie du Bâtiment du Quebec (RBQ) – Issuance of a gas connection permit

Among the hurdles that had to be overcome, it proved a challenge to have the Intertek gas inspection scheduled. The appointment was postponed and delayed a few times. However, the inspector came to Sherbrooke on July 19th 2013 and thankfully, the gas appliance approval was granted in accordance with the CSA B149.3 technical code.

Moreover, a few technical problems were encountered when the cauldron was being operated continuously in the Canada Games Village (Bishop's University). For instance, some spare parts had to be replaced such as the pilot rod used for spark ignition. In fact, this item proved to be the most critical element and had to be replaced many times because of heavy rain.

It was also very challenging to run tests in Lennoxville on the cauldron burning system prior to the games without having pictures disclosed publicly. The reporter Sharon McCully from the Sherbrooke Record newspaper worked hard to get a scoop (pictures of the cauldron in operation prior to the games) which he never got.

¹ In this document references to Chairs in Design Engineering (CDE) also should be interpreted as referring to Chairs in Environmental Design Engineering (CEDE).