Design for Extreme Environments

A NSERC Design Engineering Chair

Renewal Proposal
November 19, 2007

McGill University, Montreal, Canada

The DEE Team

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- CE: Dept. of Chemical Engineering
- CEAM: Dept. of Civil Engineering and Applied Mechanics
- ECE: Dept. of Electrical and Computer Engineering
- FoE: Faculty of Engineering
- ME: Dept. of Mechanical Engineering
- MMME: Dept. of Mining, Metals and Materials Engineering
- SoA: School of Architecture

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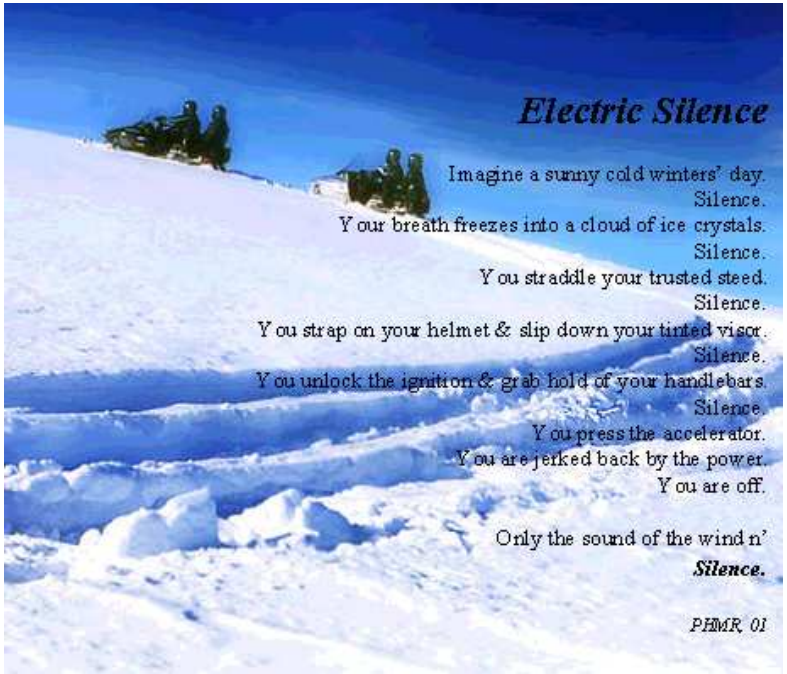
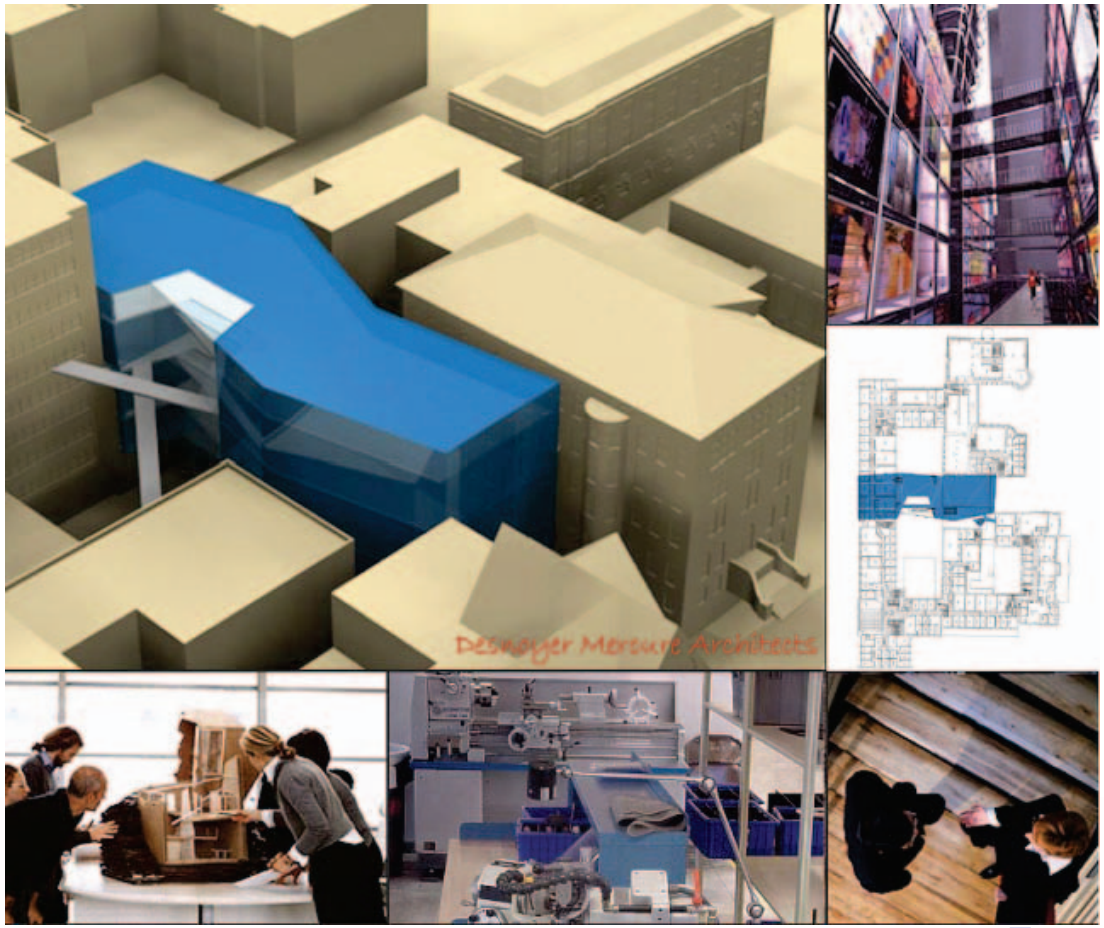
Our Mission

- The creation and development of a culture of robust design and sustainability among mentors and trainees



Our Vision

- An educational environment with interdisciplinary projects at the undergraduate, graduate and postdoctoral levels



Summary

- Strengthening of the design courses offered in the various FoE units by means of interdisciplinary and project-based courses open to students of the whole University, regardless of the students' unit of origin;
- Continuation of the *Design Seminars*, with an average of six lectures per semester
- Enhancement of the design-research activity by means of honours and graduate theses on design
- Promotion of the participation of undergraduate and graduate students in Canadian and international design competitions

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Summary (Cont'd)

- Networking with all DE and DEE Chairs, in addition to design environments of recognized excellence from all over the world
- Creation of a *Minor in Design*, open to all students registered in FoE programs;
- Further promotion of the *Design Concentration* of the undergraduate program in Mechanical Engineering, while emphasizing innovation, robustness and sustainability
- Planning of the long-term viability of the design effort supported by the Chair by the creation of the *Institute for Design in Engineering and Architecture, IDEA*.

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Achievements: Training

- New course serving 5 programs, one outside the FoE: MECH 289 Design Graphics
- New courses in the Design Concentration: MECH 498 (499) Interdisc. Design Proj. 1 (2); MECH 593 Design Theory and Methodology; ARCH 515 Sustainable Design
- One-day workshops on Maple and Unigraphics
- Flash tutorials on Maple, Autocad, Pro/Engineer and SolidWorks
- Various M.Eng. and Ph.D. theses on product design and the design process

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Achievements: D&D

Various innovative products have been developed by DEE Team members, some leading to patents:

- The Electric Snowmobile (P. Radziszewski, S. Ouellette)
- The McGill Schönflies-Motion Generator (J. Angeles, A. Morozov)
- Driving and Transmission Unit for Use in Rolling Vehicles (J. Angeles)
- Radioactivity Local Delivery System (R. Mongrain et al.)
- Pediatric Stent (R. Mongrain et al.)
- etc.

All these projects involved training at all levels, from undergraduate to M.Eng. and Ph.D.

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Achievements: Collaboration

Collaboration activities include:

- Joint projects among DEE Team members
- Joint projects with CDEN: Linkage-dimensioning module; DBDB
- Joint projects with Canadian colleagues: EDE & DE Chairs; other universities (UWO, UOIT, Poly, etc.)
- Joint projects with colleagues abroad: Nantes (FR); Polytechnique (FR); TU Berlin; Luminy (FR); Cassino (IT)
- Joint projects with R&D partners: MDA; CSA; 123Certification; Mechtronix; Technospin
- Joint projects with other companies: Coroneo; Baylis; Machines Roger Int'l Inc.; Ferrari SpA; etc.

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Achievements: Promotion

- Design Seminars
- Hosted Inaugural CDEN Conference; session-organization in other CDEN conferences
- Promotion in our website of design-related conferences
- Sponsoring of student participation in design contests
- Support of the Electric Snowmobile as the DE Chair flagship project

In summary: *We are glad to report that we have succeeded in creating a culture of design among mentors and trainees, mostly within the Department of Mechanical Engineering and the School of Architecture. We expect to spread the same to the whole Faculty of Engineering and to other Faculties.*

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Chair's Objectives

- *Training* at all levels by means of interdisciplinary and project-based courses, besides seminars and workshops, where the open-endedness of design problems will be both emphasized and exploited
- *Design and development*, by virtue of projects calling for innovative solutions, especially targeting problems of *design for extreme environments*
- *Collaboration* among industry, colleagues and students of various academic departments of McGill University, across Canada and abroad, by means of interdisciplinary design projects
- *Promotion* of engineering design and the activities of the Chair by stressing *innovation* in design from the first year of the undergraduate curriculum to the postdoctoral level, with the aim of producing design solutions that will lead to patent filings.

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Self-Evaluation

Original Plan	Outcome
Sustainability of the Chair	Not yet done. External factors
Meetings with all D&D partners & other chairs	Not done as planned. CDEN conferences instead
Revision of design and design-related courses	Done
Revitalization of the Design Concentration	In progress. Current enrollment of four students
Learnware development	Lecture Notes, tutorials, flash tutorials, and exercises for MECH289; Design-software workshops; CDEN Module; DBDB Project

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Self-Evaluation (Cont'd)

Original Plan	Outcome
New initiatives	Minor in Mining Engineering; ARCH405 Sustainable Design Studio; ARCH541 Sustainable Design
Design & Development	Space mining activity: microwave-assisted rock breakage for possible space mining applications
Promotion • Develop a culture of design • Encourage participation in design competitions	Design Seminars; Active and successful participation of UG student teams in national & international design competitions

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University's Design Strategy

- **General Nature and Level of Current Design Engineering Activities within the University**
  Design Engineering activities at McGill mainly in the Faculty of Engineering, but other entities also display important activities in DE: Department of Bioresource Engineering (FoA&ES) and the Department of Biomedical Engineering (FoM). Our strategy for the second phase includes the spreading of the design strength among all units of the FoE and beyond.

University's Design Strategy (Cont'd)

- **Vision and Anticipated Evolution**

An educational environment whereby:

first-year Arts students team up with first-year Engineering students to develop design solutions to real-life social and technical problems;
fourth-year Management students team up with their Engineering counterparts to develop business plans and to prototype innovative products;
Ergonomics students team up with Engineering and Architecture students to propose designs of sustainable working environments;
Mining and Mechanical Engineering students team up to conceptualize and develop innovative, operator- and environment-friendly mining equipment.

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University's Design Strategy (Cont'd)

- **Strategies to Enhance the Prestige, Status and Profile of Design Engineering within the University.**

  In the first phase the DE Chair succeeded in promoting a *design culture* within the Faculty of Engineering, the impact being felt mostly in the Department of Mechanical Engineering. Our strategy for the next five years aims at equally impacting all units of the FoE and beyond.
  The implementation of our design strategy is in the hands of the DEE Team, composed of the major student bodies, the *Engineering Undergraduate Society* and its departmental branches, besides 19 professors of the FoE and supporting staff.

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University's Design Strategy (Cont'd)

- **Positioning of the DE Chair, and Its Role and Importance w.r.t. the University's Design Strategy.**
  - Chapter 3 of the Strategic Research Plan (2006): *"Considerations of urban design and healthy environment come into play through our School of Architecture; eco-friendly design arises in Engineering; protection of land and water resources and biodiversity; sustainable development, conservation and habitat."*
  - The Plan goes on to state that *"A major initiative is underway to remodel engineering around the theme of design ..."*
    In this remodelling, the DE Chair activities have played a key role, as they have led to an expanded design component in the ME and Architecture curricula.

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University's Design Strategy (Cont'd)

- The Chair's activities will be linked to the University's strategy, while raising the profile of design within the University scholarly activities. We will work on three fronts:
  - The **Minor in Design**
  - **Innovation in Design**
  - The creation of the **Institute for Design in Engineering and Architecture, IDEA**

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Proposed Activities: Minor in Design

- Minors are coherent sequences of courses which may be taken in addition to the courses required for the B.Eng. degree. Minor programs normally consist of 18–24 credits, allowing 9–12 credits of overlap with the degree program. The real credit cost to the student is typically 9 to 15 credits, representing one term beyond the B.Eng. degree program. All courses in a Minor program must be passed with a grade of C or better.

Proposed Activities: Minor in Design (Cont'd)

- **Degrees and Programs Offered by the FoE**
  - CO-OP Programs
    - Materials Engineering
    - Mining Engineering
  - Major Programs
    - Architecture (B.Sc.)
    - Chemical Engineering (B.Eng.)
    - Civil Engineering (B.Eng.)
    - Computer Engineering (B.Eng.)
    - Electrical Engineering (B.Eng.)
    - Mechanical Engineering (B.Eng.)
    - Software Engineering (B.S.E.)

Proposed Activities: Minor in Design (Cont'd)

- Honours Programs
  - Electrical Engineering (B.Eng.),
  - Mechanical Engineering (B.Eng.),
- Minors
  - Arts
  - Biomedical Engineering
  - Biotechnology
  - Chemistry/Chemical Engineering
  - Computer Science
  - Construction Engineering and Management
  - Economics
  - Environment Engineering
  - Environment
  - Management
  - Materials
  - Mathematics
  - Physics
  - Technological Entrepreneurship
  - Software Engineering

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Proposed Activities: Minor in Design (Cont'd)

- Academic Programs

Program	*No. of credits*
B.Sc.(Arch.)	100
B.ENG. DEGREE IN CHEMICAL ENGINEERING	111
B.ENG. DEGREE IN CIVIL ENGINEERING	109
B.ENG. DEGREE IN ELECTRICAL ENGINEERING (H)	109-110
B.ENG. DEGREE IN ELECTRICAL ENGINEERING	109-110
B.ENG. DEGREE IN COMPUTER ENGINEERING	107 -110
BACHELOR OF SOFTWARE ENGINEERING (B.S.E.)	106-114
B.ENG. DEGREE IN MECHANICAL ENGINEERING	112
B.ENG. DEGREE IN MECHANICAL ENGINEERING (H)	112
B.ENG. DEGREE IN MATERIALS ENGINEERING	117-118
B.ENG. DEGREE IN MINING ENGINEERING	119-121

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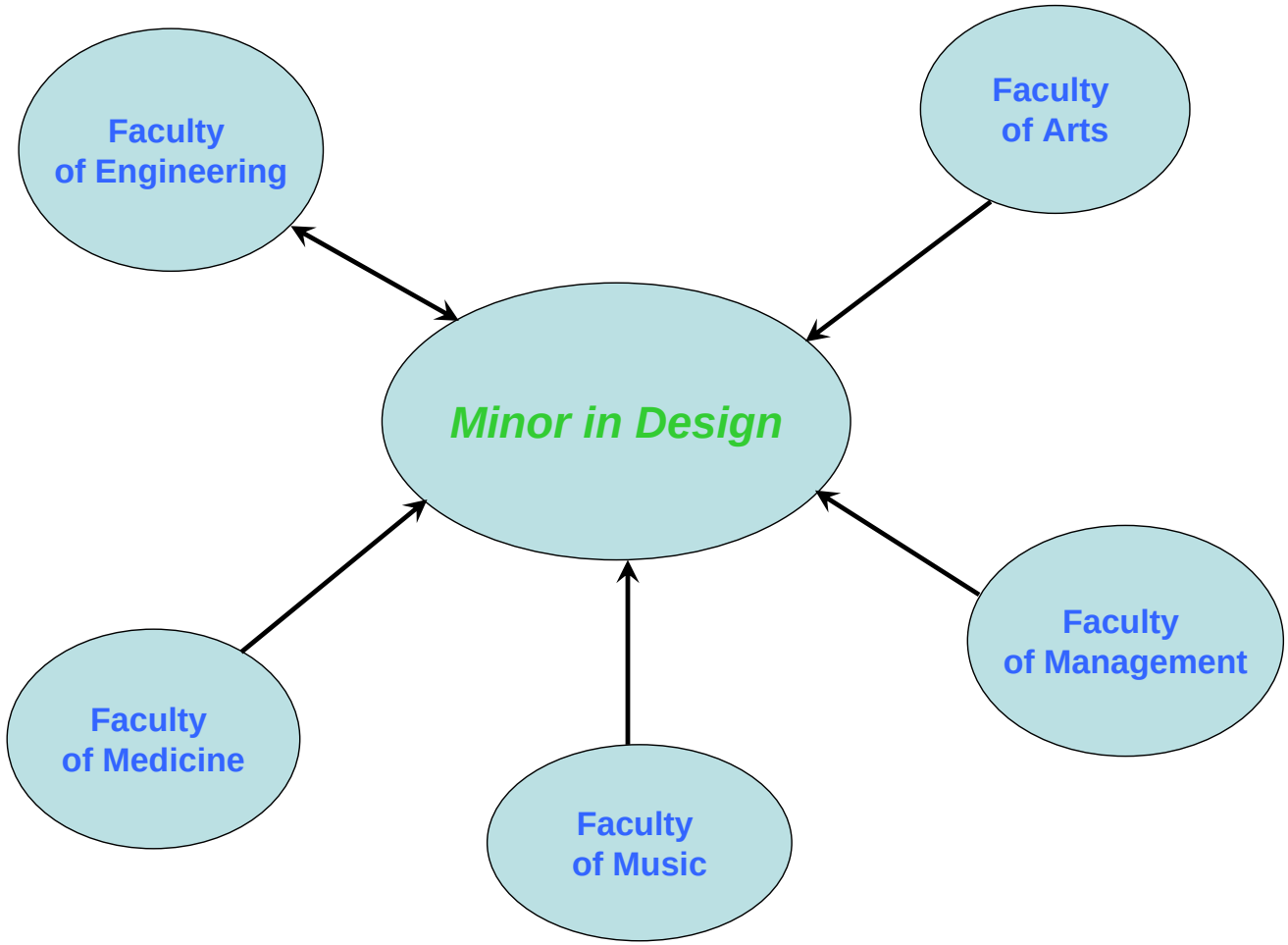
Proposed Activities: Minor in Design (Cont'd)



Proposed Activities: Innovation

- The DE Chair in its second phase will aim at exploiting Canada's expertise and strategic interests to build strength in *innovative design* at McGill University and its circle of influence: Montreal, Quebec, Canada and beyond. By promoting innovative design, the DE Chair aims at enriching the intellectual-property pool of McGill University by means of patents and industrial contracts with and licenses to the production sector.

Proposed Activities: Innovation (Cont'd)

- The Chair will work with its industrial partners on the problems inherent to extreme environmental conditions typical of the Canadian landscape and the outer-space domain.

Proposed Activities: Innovation (Cont'd)

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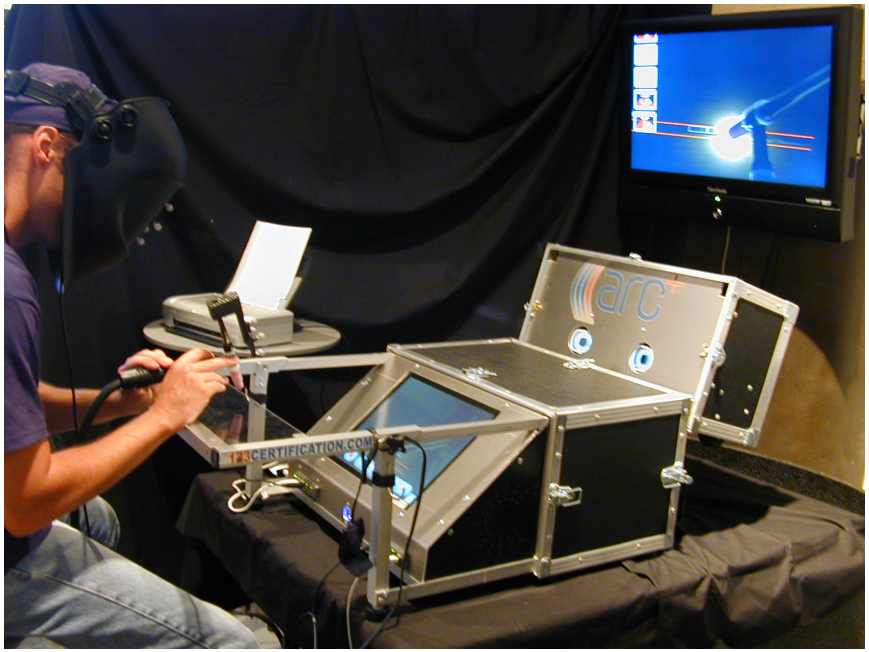

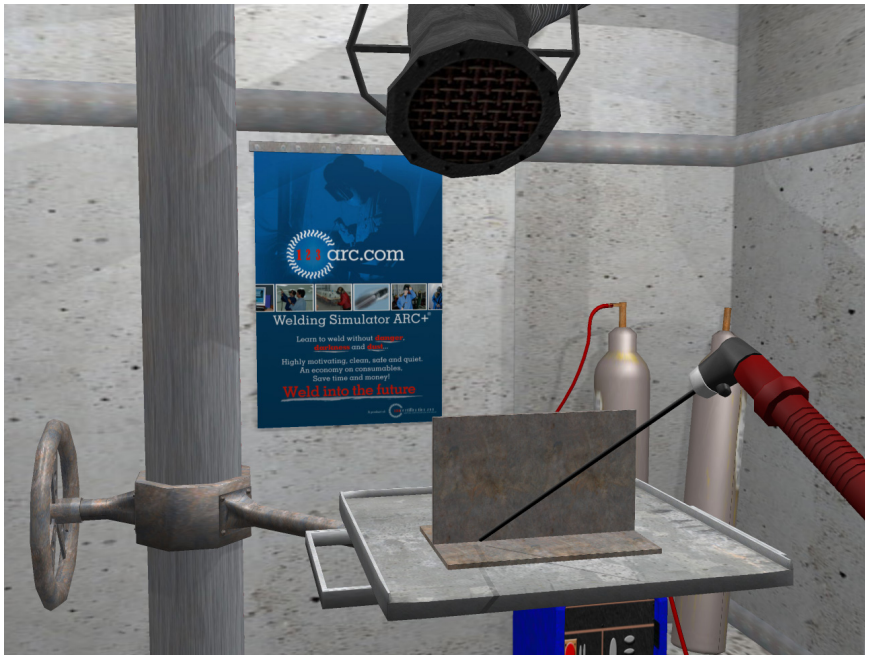

Proposed Activities: Innovation (Cont'd)

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Proposed Activities: Innovation (Cont'd)

Interaction between academic and practicing designers will be promoted via:

- Design projects for the capstone design courses (CIVE 418, ECSE 474, 475 & MECH 463)
- Interdisciplinary Design Project 1 & 2 (MECH498 & MECH499)
- Short design projects (MECH497, MECH577, MECH593)
- Workshops on Innovative Design
- Symposia on Innovative Design

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Proposed Activities: Partnerships with Industry

CSA ASC

Maplesoft
command the brilliance

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Examples of Innovation Projects

- The VERT Project
- The Design of Smart Systems for Percutaneous Intervention in Heart Surgery
- Design of Highly Accurate Mechanisms for Haptic Systems
- Design of Anthropomorphic Mock-Ups for Cardiovascular Physiological Research
- Virtual-Reality (VR) Environments for the Training of Professional Welders and Surgeons
- Haptic Devices and Systems for Flight Simulators
- Devices and Systems for Space Exploration and Exploitation
- MEMS Accelerometers for Sports and Medical Applications
- Development of a System for Ice Structures in Architecture

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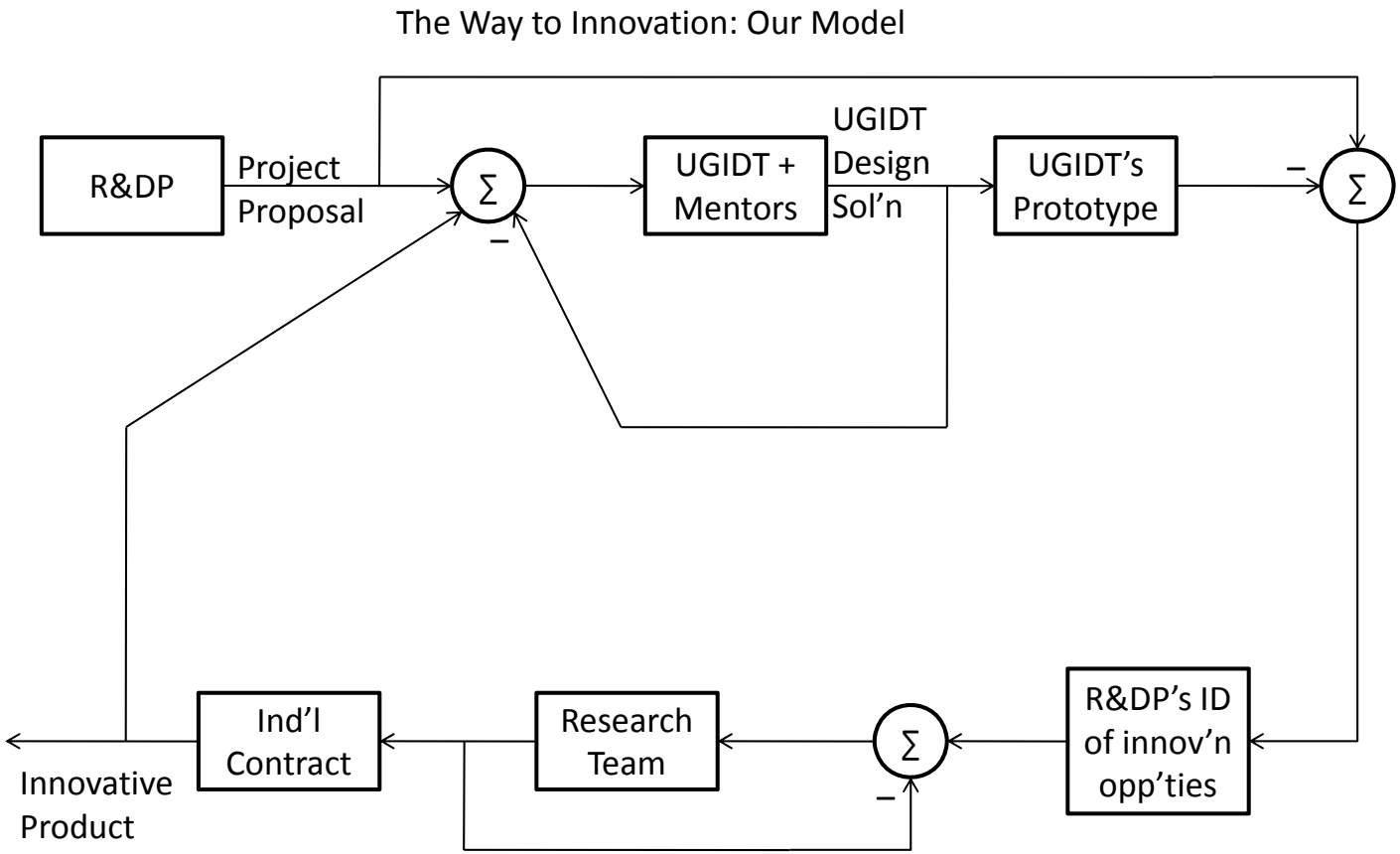
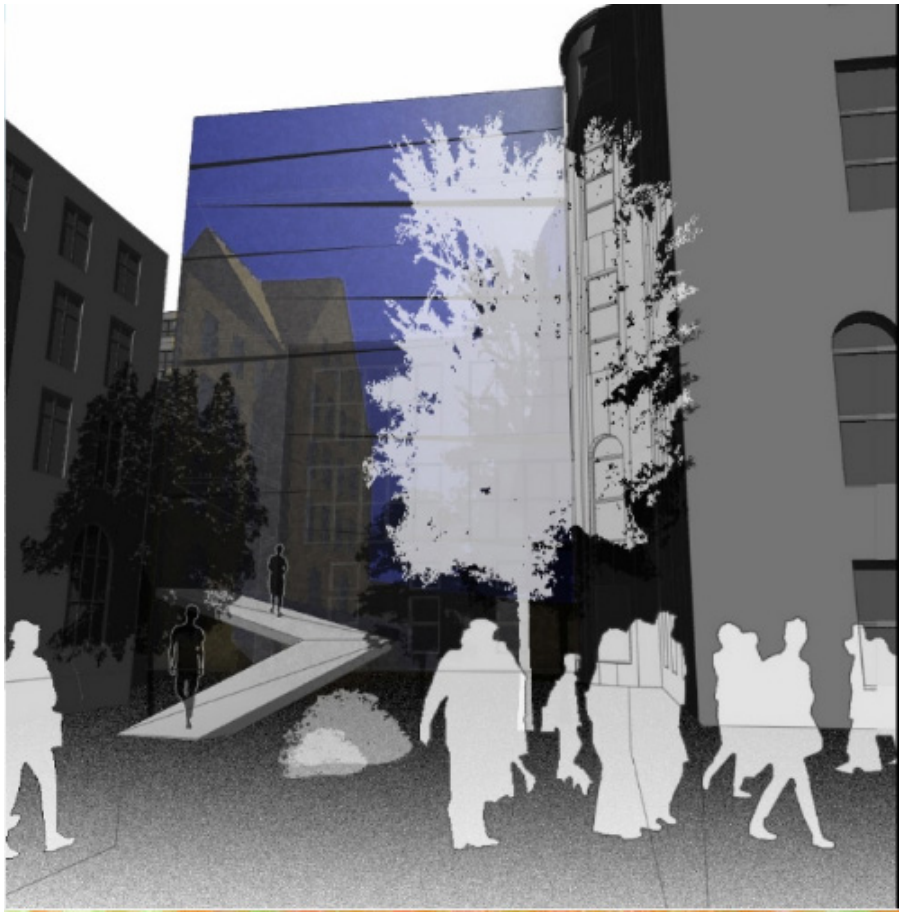
The Way to Innovation



R&DP: R&D partner
UGIDT: Undergraduate Interdisciplinary Design Team

Proposed Activities: IDEA

Institute for Design in Engineering and Architecture, IDEA



Proposed Activities: IDEA (Cont'd)

Objectives:

- To allow for the continuation of the DE Chair's activities past the NSERC funding period
- To support *design research* and *innovation in design*
- To serve as a *design think tank*, to help Canada become a "design country"
- To bring the brightest design minds as guest professors to enrich the intellectual atmosphere on campus
- To serve as an instrument to educate the best design professionals

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Milestones

	Tasks	Year 1			Year 2			Year 3			Year 4			Year 5		
		W	S	F	W	S	F	W	S	F	W	S	F	W	S	F
1.	**Minor in Design**															
1.1	*Proposal drafting*			×												
1.2	*Consultation on proposal*					×										
1.3	*Submission*						×									
1.4	*Initiation*									×						
1.5	*Revision of the implementation*												×			
1.6	*Evaluation of first 2 years*															×
1.7	*Recommendation to FoE*															×
2.	**Meetings on Innovative Design**															
2.1	*First workshop*			×												
2.2	*Second workshop*						×									
2.3	*Symposium in ASME IDETC 2010*									×						
2.4	*Symposium in ICED 2011*												×			
2.5	*Third workshop*															×
3.	**IDEA**															
3.1	*Setting up a Task Force*			×												
3.2	*Drafting a plan*						×									
3.3	*Plan submitted to the FoE*									×						
3.4	*Securing funding*										×	×	×	×	×	
3.5	*Initiation*															×

Thanks!