

Institute for Applied and Interdisciplinary Mathematics

Proposal: University of Toronto Academic Initiatives Fund, January 2005

1. Vision and Priorities

Many of the hard challenges facing the modern technological world have such scope and complexity that they require mathematicians working in concert with experts from other domains to make significant progress. The scientific imperatives facing us range from fundamental questions about the building blocks of life and the universe, to conceptual and computational modelling possibilities in the nanoscale and biosphere, the design of molecules, aeroplanes, telescopes and medical imaging instrumentation, nonlinear wave and material dynamics, to the quantitative management of uncertainty, complexity, and security. We remain bound together by a common reliance on mathematical approaches and computational techniques, and the dramatic opportunities for impact rewarding the successful employment and invention of these.

University of Toronto hosts the strongest collection of mathematical scientists in Canada. Apart from those appointed to the mathematics department, many others are dispersed across three campuses — in engineering, statistics, physics, chemistry, computer science and the biomedical and social sciences. To date connections between such researchers have been formed mainly by serendipity, and few resources have been dedicated to nurturing these essential links, or to orienting students towards the challenges and opportunities emerging at the junction between mathematics, computation and the sciences.

We therefore propose a research institute (I-AIM) to bring together top researchers and students from the University and around the world to attack big problems with complementary knowledge and methodologies: scientific experiment, mathematical modelling and proof, computer simulation. This institute will:

- Hire new faculty working in interdisciplinary research vital to a forward looking university, but which would otherwise not be recruited by departments concerned to maintain their core strengths under budgetary constraints.
- Create new multidisciplinary training and research opportunities for graduate students and co-ordinate summer schools and research internships for undergraduates; this will attract strong students who would otherwise choose to go elsewhere, and will train tomorrow's leaders in emerging fields.
- Raise the profile of Applied and Interdisciplinary Mathematics at the University of Toronto and thereby attract research funds, which have, in the past, gone disproportionately to universities with more visible synergies between mathematics and the applied, computational, biological, and natural sciences.

The key resources required for this endeavour to flourish will be new 1) infrastructure and space; 2) faculty lines; and 3) fellowship funding for interdisciplinary graduate students, postdoctoral fellows, and distinguished visitors.

Faculty enthusiasm for the institute has been enormous: the proposal is supported by some 85 teaching faculty (see Appendix A) from more than a dozen departments in the Faculties of Arts and Science (54), Medicine (10), and Applied Science & Engineering (21).

2. Outcomes

Enhancing the student experience. I-AIM will increase the number and quality of students pursuing research and studies in areas at the interface of mathematics and applications, at both the undergraduate and graduate levels; and will enhance the quality of mentorship and the research and training opportunities for students in these areas, thereby adding value to the degrees they ultimately receive. Specific plans for the undergraduate program are described in more detail in Section 4, and the graduate program in Section 5.

I-AIM also addresses the student experience by bringing graduate students, postdoctoral fellows, undergraduate students and research assistants from different backgrounds under a single roof, where they may profit from each other's experiences.

Enhancing interdisciplinary, interdepartmental, interdivisional, and cross-campus collaborations. I-AIM is a manifestly interdisciplinary venture; it involves some 85 teaching faculty spread over three Faculties and a dozen departments. It will provide a physical space and an institutional structure to facilitate interdisciplinary research. Events such as regular seminars and occasional larger-scale workshops will stimulate discussion and possible research collaborations. Further incentive for such collaborations will be provided by I-AIM support for graduate students and postdoctoral fellows, as this support will be directed toward people carrying out genuinely interdisciplinary work.

I-AIM will serve as a conduit through which the University can make faculty appointments in vital interdisciplinary areas that do not fall neatly within the scope of any individual department or academic unit. See Section 3 for more details.

I-AIM will coordinate campus-wide activities in scientific computation, thereby serving as a focus for future proposals to obtain funds for acquisition of large-scale computing facilities. The successful PsiNet II CFI proposal for heterogeneous computing facilities involved several of the key research groups within I-AIM needing such facilities and provides a model that can be expanded upon to bring together additional researchers in future proposals. This will enable the development of a coordinated strategy for acquisition of large-scale computing facilities at the University of Toronto.

Bringing together undergraduate and graduate activities with research opportunities. I-AIM will bring undergraduate and graduate students into contact with interdisciplinary research opportunities, through interactions with I-AIM faculty and fellows at its physical location, novel classroom and seminar offerings, research collaborations, joint-supervision arrangements, and summer undergraduate internship placements. I-AIM will hold an annual weekend retreat, at which a selection of faculty and fellows showcase research programs developing in the Institute, with a view to apprising undergrads and graduate students of research opportunities and mentoring possibilities.

Connecting the University with the broader community.

Mathematics and applied mathematics community. The tremendous vitality of the University of Toronto's applied and interdisciplinary mathematics community is not fully appreciated within the Canadian mathematical community, partly because there is no formal institutional home at the University for such work. I-AIM will address this problem, raising the profile of applied mathematics at the University and showcasing the variety and depth of work taking place here. This will facilitate fundraising and recruitment of faculty and students with interests in interdisciplinary mathematical work.

I-AIM will also strengthen contacts with researchers in relevant fields throughout North America by bringing in seminar speakers, workshop participants, and other visitors.

Industry. I-AIM's space and human capital will allow it to function as an incubator for spinoff companies founded by our members; precedents include Khartika, RiskLab, and Sigma, in the data security and financial analysis sectors. Such industrial partnerships stimulate research of societal relevance through cross-fertilization and generation of novel perspectives and ideas. They also contribute significantly to the training and placement of students, and can play a pivotal role in securing governmental support for I-AIM.

The public. The annual retreat will include a public lecture by a distinguished scientist, with enough drawing power to capture the imaginations and bring a broad swath of the public together with the I-AIM community. Attendants may also learn about other I-AIM activities from the juxtaposed presentations.

Improving equity and diversity. I-AIM addresses the gender gap and hard science phobia, by establishing partnerships between hard sciences and the life sciences, where underrepresentation of women has tended to be less extreme.

3. I-AIM faculty

I-AIM faculty maintain an active research program in our designated topical areas (see Appendix B) and contribute to the management and definition of the Institute's research program.

Faculty can submit proposals for graduate student and postdoctoral fellow's stipends, they can use the Institute's facilities for their own research and as a platform for collaboration, intramurally, as well as with visiting scholars. They are encouraged to play an active role to shape the Institute's research program.

Faculty will contribute equitably to the Institute's activities such as teaching in team-taught or cross-listed courses, participating in recruiting activities, co-supervision of students and participation in supervisory committees, participating in the Institute's Executive Committees, participation in internal review of funding proposals, and in the participation in the writing of funding proposals for I-AIM activities.

To achieve a position of global leadership in interdisciplinary mathematics, new appointments are necessary to fill in critical gaps in our base of expertise, bind together existing strengths and open new directions on our research agenda. We have identified two topical areas in which we propose the creation of new faculty lines:

(A) **Mathematical and computational biology.** This is an area in which we see a very significant unmet need for novel theoretical approaches. I-AIM will recruit an individual with demonstrated potential involving the mathematization of biological concepts and objects. Such research would currently not be representable in either pure/applied mathematics or life-science departments, yet the lack of such approaches is currently the most important bottleneck in the advancement of theoretical contributions to the life-sciences.

(B) **Scientific Computing .** The University of Toronto has several groups that use and develop scientific computing to conduct world class research in specific application areas. This expertise is often not accessible to other groups with computationally intensive

problems, which may have a similar mathematical structure. I-AIM will recruit a top researcher with a background in applied mathematics with experience in scientific computing who can bridge the gap between these groups and position the university for future developments involving large scale calculations.

Departmental constraints and the need to cover core areas currently make hiring such cross-disciplinary researchers difficult. The two requested positions would fill important, recognised needs and the cross-appointed faculty would leverage the AIF contribution for a lasting impact on our research landscape.

4. I-AIM undergraduate program

I-AIM will strike a rotating Undergraduate Committee through its Advisory Board with the responsibility to co-ordinate and spearhead the following activities.

New team taught courses will be developed for advanced undergraduates and graduates. For instance, we plan a course on "**Current Directions in Computational Biology**". The course will be directed towards students in the life-sciences as well as in mathematics, statistics or computer science. To address the needs of students with very different backgrounds, the lectures will be supplemented by separate tutorials that bring theoretically oriented students up to date on concepts of molecular and cellular biology and familiarise biologically oriented students with the tools and methods of applied mathematics. If successful, this model will be used for other interdisciplinary courses.

The committee will act as a clearinghouse for catalysing and placement of undergraduates into summer research internships.

Annual Summer Schools will be co-ordinated by the Institute's Summer School Committee in a topical area of our work. They will be targeted towards Canadian and International undergraduates in the year before a potential application to the University's graduate programs. Funds will come in part from the Institute's base budget and in part from external sources. The potential of such activities to contribute to our graduate recruiting activities is obvious, however a significant critical mass of contributing faculty is required to make such programs a reality; this is hard to imagine outside I-AIM.

A close collaboration is anticipated with the newly approved interdepartmental, undergraduate Specialist Program in Bioinformatics and Computational Biology (BCB) which has explicitly identified I-AIM to be a key component in a coherent career trajectory in this field on campus. Boris Steipe, the program committee chair for BCB is a member of the I-AIM Advisory Board and co-author of this proposal.

5. I-AIM graduate program

I-AIM will strike a rotating Graduates and Fellows Committee through its Advisory Board, to assist in recruiting efforts and allocate fellowships.

The committee will solicit and evaluate graduate applications from talented students interested in I-AIM's topical areas in Canada and elsewhere. The applications will be screened for their eligibility according to the requirements of specific Departments, the committee will co-ordinate potential supervisors and then forward the application with a recommendation to the appropriate Departmental admissions committee. This procedure

allows I-AIM to become active in student recruitment, while maintaining the academic responsibility of Department and supervisor.

The committee will implement a system of graduate student and postdoctoral fellowships, which match AIF funds with individual faculty contributions to catalyse interdisciplinary graduate student and postdoctoral research. Up to ten graduate students will be concurrently funded through this program. Preference will be given to nominations submitted jointly by faculty members from two or more separate units, and distributed equitably among the different research directions comprising I-AIM. Students' performance and maintenance in the Program will be continuously reviewed. Further responsibilities of the Graduate Committee include:

- to co-ordinate a unified approach to course offerings of different units, and assist Departments in adapting these offerings for accessibility and relevance to cognate disciplines while reducing redundancies;
- to co-ordinate the introduction of new course offerings which bridge disciplines; many of these will be team taught, and geared towards orienting graduate and undergraduate students towards research opportunities;
- to support the development of *applied mathematics* and *computational science* designations, as additional certifications to various existing degrees.

6. I-AIM Fellows and Visitors program

The lifeblood of any research institute is a constant infusion of new ideas. For I-AIM, this means having a steady stream of top-quality student and postdoctoral talent, distinguished long-term sabbatical visitors, and dynamic interdisciplinary speakers passing through the institute. These Fellows not only contribute directly to I-AIM's research and teaching missions, but disperse into the world when their fellowships end to spread the word about University of Toronto and the scientific research programs here; (thus enhancing our future recruitment efforts).

We propose to implement a system of postdoctoral fellowships, allocated on similar terms as the graduate stipends through the Graduates and Fellows Committee. Three fellows are to be appointed per year, with a fellowship duration of roughly two years and the stipend covering 60% of salary cost. The competitive nature of these fellowships will help ensure quality.

7. I-AIM and the Fields Institute

I-AIM anticipates close collaboration and a beneficial partnership with the **Fields Institute for Research in the Mathematical Sciences**.

I-AIM's mission is complementary to that of the Fields Institute. The latter, although located on the St. George campus, is a seven-university consortium with no permanent faculty or degree programs, whose main activity is to host revolving one-year (and shorter) programs of a topical nature, selected to balance the needs of the regional, national, and international communities in pure and applied mathematics. Fields also engages in some longer term network-building invaluable to the local community, but its mandate leaves little room for sustained support to research and teaching activities (interdisciplinary or otherwise) internal to the University of Toronto.

A close relationship with Fields will enhance the missions and activities of both Institutes, by connecting students and researchers throughout the University to Fields' activities, and by providing interdisciplinary graduate and postdoctoral programs in applied math as a long term complement to these rotating programs. We have already begun planning a monthly joint seminar series and weekly teas with the Fields Institute, which has graciously offered to provide meeting space for the I-AIM annual retreat.

We expect that I-AIM will stimulate University of Toronto faculty members from a variety of departments and Faculties to submit proposals to the Fields Institute for thematic programs in applied and interdisciplinary mathematics, involving postdocs and visitors, and including workshops, graduate courses, and high-level cross-disciplinary conferences.

8. Supporting academic activities

Supporting academic activities will be co-ordinated by the Institute's rotating Program Committee. Specific initiatives include:

- high profile weekly interdisciplinary seminar series;
- annual Institute retreat;
- Encourage joint grant proposals in interdisciplinary research areas, catalyse I-AIM funding proposals for additional support of our activities and support an improvement in the success rate of interdisciplinary research proposals through offering an internal review process.

Further, a Large Scale Computing Committee will co-ordinate a unified approach to the sharing, acquisition, and development of high-performance computing resources in Toronto, and to educate students and researchers in their use;

9. Leadership and Organization

The organizational structure of I-AIM is shown in the Appendix. The Director coordinates the executive committees, and oversees the core faculty and visitors, implements the recommendations of the internal and external advisory boards, reports to the University, and liaises with funding agencies such as CIAR, MITACS, NCE, NSERC, and the NRC. The Director will be advised by an Advisory Board, who will also serve as liaisons between their home departments and I-AIM. An External Scientific Advisory Panel will be appointed to support maintenance of global standards of excellence. Graduate students and Fellows report to their supervisor in academic matters, they are members of their Departments and are overseen by the Graduates and Fellows Committee regarding their continued affiliation with I-AIM and their financial support, which is administered through the Institute's assistant. The roles of the Executive Committees have been described, they will distribute the numerous activities of the Institute equitably and ensure that they are consistently pursued with passion, coordinated by the Director.

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Appendix A: Faculty Support

The scope and shape of I-AIM continues to evolve, but the intellectual relevance of applied mathematics across the university is reflected by the widespread interest and broad support which this proposal has garnered. The following 85 faculty members have expressed strong support for the concept and their interest in affiliation with I-AIM. They include 19 members of the Department of Mathematics, 28 additional faculty from Arts and Science, 20 members of the Faculty of Applied Science, 10 members of the Faculty of Medicine, 7 from the School of Graduate Studies, plus the Director and Deputy Director of the Fields Institute. The concept for I-AIM was conceived by a Planning Committee consisting of twelve representatives (*), in consultation with an Advisory Committee consisting of 20 additional faculty (†).

- * Peter Abrams, Zoology
- † Robert Almgren, Computer Science and Mathematics; Mathematical Finance Program
Richard Bailey, Geology and Physics
Ian Blake, Electrical and Computer Engineering
- † Richard Bond, Canadian Institute of Theoretical Astrophysics
Allan Borodin, Computer Science
Mireille Broucke, Electrical and Computer Engineering
Paul Brumer, Chemistry
Ragnar Buchweitz, Mathematics
Markus Bussman, Mechanical and Industrial Engineering
Ray Carlberg, Astronomy and Astrophysics
- † Christina Christara, Computer Science
James Colliander, Mathematics
Al-Amin Dhirani, Chemistry
Andrew Emili, Medical Research, Medical Genetics & Microbiology; Proteomics & Bioinformatics
- * Wayne Enright, Computer Science
Ross Ethier, Mechanical and Industrial Engineering
Andrey Feuerverger, Statistics
Bruce Francis, Electrical and Computer Engineering
Simon Fraser, Chemistry
Jim Friesen, Banting and Best Department of Medical Research
- † Clinton Groth, Institute for Aerospace Studies
Jorn Hansen, Institute for Aerospace Studies
David Hogg, Medicine and Medical Biophysics
Kentaro Hori, Mathematics and Physics
Victor Ivrii, Mathematics
Ken Jackson, Computer Science
Sebastian Jaimungal, Statistics
- * Robert Jerrard, Mathematics
Mike Joy, Institute of Biomaterials and Biomedical Engineering
Velimir Jurdjevic, Mathematics
- † Raymond Kapral, Chemistry

- † Barbara Keyfitz, Fields Institute
Boris Khesin, Mathematics
- * Keith Knight, Statistics
Lev Kofman, Canadian Institute for Theoretical Astrophysics
Lisa Kramer, Rotman School of Management
- † Frank Kschischang, Electrical and Computer Engineering
J. Douglas Lavers, Electrical and Computer Engineering
- † Peter Lewis, Biochemistry and Medicine
Daniel Lidar, Chemistry
- † Hoi-Kwong Lo, Electrical and Computer Engineering and Physics
- † Manfredi Maggiore, Electrical and Computer Engineering
Steve Mann, Electrical and Computer Engineering
- † Peter Martin, Astronomy and Canadian Institute for Theoretical Astrophysics
Joaquim Martins, Institute for Aerospace Studies
Christopher Matzner, Astronomy
- * Robert McCann, Mathematics
Jerry Mitrovica, Physics
Michael Molloy, Computer Science
Stephen Morris, Physics
Norman Murray, Canadian Institute of Theoretical Astrophysics
- † Kumar Murty, Mathematics
- * Adrian Nachman, Electrical and Computer Engineering and Mathematics
- † Amanda Peet, Physics
- * Richard Peltier, Physics
Gerald Penn, Computer Science
- * Ue-Li Pen, Canadian Institute for Theoretical Astrophysics
Erich Poppitz, Physics
- * Mary Pugh, Mathematics
- † Jeremy Quastel, Mathematics and Statistics
- † Charles Rackoff, Computer Science
Joe Repka, Mathematics
Jeffrey Rosenthal, Statistics
- † Tom Salisbury, Fields Institute
- † Ted Sargent, Electrical and Computer Engineering
Costas Sarris, Electrical and Computer Engineering
- * Jeremy Schofield, Chemistry
- † Luis Seco, Mathematics
- † Theodore Shepherd, Physics
- † Michael Shub, Mathematics
Francis Skinner, Medicine - Neurology, Physiology, Biomaterials and Biomedical Engineering
- * Boris Steipe, Biochemistry, Molecular & Medical Genetics; Proteomics & Bioinformatics
Catherine Sulem, Mathematics
Frank Tall, Mathematics
Christopher Thompson, Canadian Institute for Theoretical Astrophysics
Elisabeth Tillier, Medical Biophysics

Michael Tropak, Hospital for Sick Kids
Shahrokh Valaee, Electrical and Computer Engineering
Balint Virag, Mathematics and Statistics
Stuart Whittington, Chemistry

† Shoshana Wodak, Biochemistry, Structural Biology, and Medical Genetics

Yanqin Wu, Astronomy and Astrophysics

Christopher Yip, Biomaterials, Biomedical & Chemical Engineering, Biochemistry

Wei Yu, Electrical and Computer Engineering

* David Zingg, Institute for Aerospace Studies

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Appendix B: I-AIM research topics

The members of I-AIM will work closely to foster interdisciplinary collaboration between the Departments of Mathematics and Aerospace Studies (UTIAS), Astronomy, CITA, Computer Science, Chemistry, Electrical & Computer Engineering, Mechanical & Industrial Engineering, Statistics, Physics, and the Faculty of Medicine, and students in such programs as Financial Mathematics, the Proteomics & Bioinformatics graduate Program, the undergraduate specialist program in Bioinformatics and Computational Biology, and the IBBME. Many of the faculty listed in Appendix A classify loosely into the following seven topical areas, which accordingly will become foci of I-AIMs activities:

(A) Communications and Control: I-AIM will provide a natural framework for collaborations of number theorists from the GANITA laboratory, computer scientists specializing in cryptography, the Communications group in ECE, and the Quantum Information and Quantum Control initiative, while bringing expertise on nonlinear waves and solitons within the mathematics department into contact with the design problems facing engineers. Signal and image processing represents another set of questions, where nonlinear partial differential equations combine with neural networks to address challenges in machine intelligence.

(B) Nonlinear Dynamics: There is a natural synergy of mathematicians studying partial differential equations, dynamical systems, and Hamiltonian mechanics, with scientists using these equations to model the atmosphere and oceans, geological and environmental processes, pattern formation, reaction chemistry, population biology, and dynamical cosmology. I-AIM will catalyze collaborations of its faculty in these areas.

(C) String Theory, Gravitation and Cosmology: Current challenges include understanding the connections between local and global notions of mass, the large scale geometry and topology of the universe, detecting gravity waves, and deriving testable predictions of string theory. I-AIM faculty representing these topics work in mathematics, physics, astronomy and astrophysics and CITA.

(D) Discrete Math – Algorithms, Complexity, Geometry, Graph Theory, Statistical Mechanics: Fundamental problems in computer science with widespread ramifications revolve around the discovery of fast algorithms or proofs that no fast algorithm exists. Similar problems arise in statistical mechanics, at larger scales in the self-organisation of biological systems. The same mathematics underlies these phenomena and I-AIM will bring together researchers from theory and application domains.

(E) Probability, Statistics, Data Mining: As large data sets require quantitative analysis, probabilistic and statistical techniques moved to the fore in many areas of science. Finance is the paradigmatic example because of its importance in society, but the same problems – modelling and managing randomness, coping with enormous data sets, implementing large-scale and distributed computation – recur in engineering, bioinformatics and genome-scale data analysis, economics, and the natural sciences.

(F) Scientific Computation and Modelling: Scientific computation and numerical simulation provide a new methodology in science and engineering whose importance can scarcely be overestimated. Computational fluid dynamics and optimization are two examples within scientific computing of great relevance to many current research activities at UT. Current groups on campus share a common methodology to design everything from molecules to aeroplanes, telescopes, and medical imaging instrumentation, and to model the spreading of disease, environmental contaminants, climate change, the evolution of matter in the universe,

(G) Biochemistry, Biology, Genetics, and Biomedical Research: The University of Toronto may well have the largest group of faculty that are active in Bioinformatics in North America. Vast quantities of epidemiological, genomic, molecular and imaging data, demand models, organizing principles, and data mining approaches.

Appendix C: Time frame and benchmarks

Preparations:

- April 22, 2004; full day I-AIM planning retreat attended by more than 30 faculty members
- Fall 2004: weekly interdisciplinary seminar series and tea commence
- April 2005: Acting Directorate and Advisory Board to be appointed upon AIF approval
- Begin constructions and renovations process
- Begin search for I-AIM faculty
- Consolidation of reporting structure within the university
- Begin planning interdisciplinary graduate program
- Begin website development
- Solicit applications for I-AIM Director
- September: First Annual I-AIM Retreat
- Strike executive committees
- Solicit nominations of first I-AIM graduate students and fellows from supporting faculty. Appointments to begin in Year 1 and to be ramped up to full complement over the year
- October: graduate curriculum recommendations completed in time for next academic year
- Hire assistant and halftime systems administrator

Year 1:

- Appoint I-AIM Director
- Official opening of the Institute
- Daily teas in new space
- Welcome first I-AIM Fellows (half complement: 3 PDFs, 5 graduate fellows)
- Begin forging collaborations and partnerships
- Clearinghouse in place for undergraduate summer research placements
- Weekly interdisciplinary seminar including high profile external speakers
- Regular teas held in partner departments
- Joint weekly teas with the Fields Institute
- Joint monthly colloquium series with the Fields Institute
- Locate space and renovate as necessary
- Develop fundraising strategy for long term support of the Institute and computational resources, including granting councils, NRC, OFI, CIAR, and private donors
- Unified webpage listing for Toronto area seminars of related interest

Year 2:

- Welcome full complement of Fellows and students
- Interdisciplinary graduate program in place, with lectures and seminars taking place in new space;
- Review undergraduate curriculum in applied mathematics and computational science;
- Submit applications to granting councils and continue fundraising efforts;
- Continue other activities as above.

Year 3:

- Undergraduate curriculum recommendation completed in time for next academic year;
- Continue fundraising efforts and other activities as above.

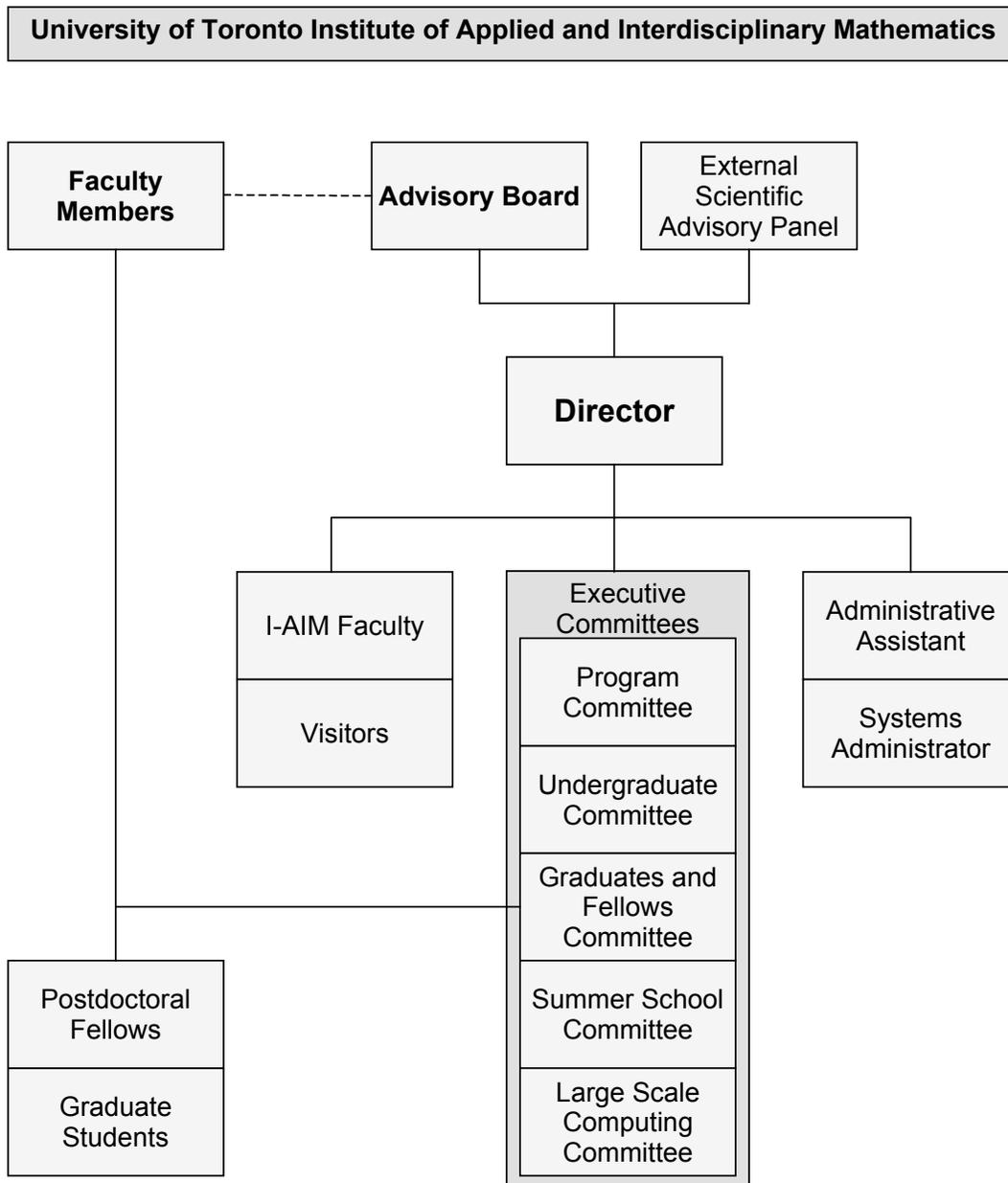
Year 4:

- Undergraduate certifications in computational science and in applied mathematics in place;
- Continue all major program activities.

Year 5:

- Continue all major program activities;
- Review and assess I-AIM development.

Appendix D: I-AIM organization



Appendix E: Space requirements and capital costs

In accordance with the activities outlined above, we request the following space allocations and funds for the associated development costs, (a) for a central location that is conveniently accessible by faculty from the diverse departments affiliated with I-AIM, (b) that supports our mandate of embedding this interdisciplinary approach in existing academic structures, (c) that provides a visible focus for students and colleagues who are interested in our activities, and (d) that allows us to colocate a critical mass of collaborators to generate a scientifically productive environment. **Ideally I-AIM would be located in the first floor of the Fields Institute Building.** I-AIM will require:

- A common space for use as lounge, seminar space and meeting room, supporting formal presentations and unstructured interactions ("tea room")
- Office space for the I-AIM members whose roles are described above. After ramp-up in the first year we anticipate the institute to house up to 28 members:
 - The Director of I-AIM;
 - One half-FTE administrator and one half-FTE systems administrator;
 - 10 graduate students;
 - 6 Postdoctoral Fellows;
 - 2 full-time Faculty;
 - 6 spaces for visiting Fellows;
 - 2 spaces for internal faculty; these will be used on a day-by-day basis by I-AIM faculty who visit the institute in the course of their collaborations
- A computer lab; for set-up of hardware, location of file- and Web-servers and small racks of computing clusters.
- A mail and photocopy room; required to support the day-to-day operations of the Institute.
- A storage room; required to support the day-to-day operations of the institute e.g. to store posters / exhibits for use in recruiting activities, poster-boards and secure archiving of personnel records and applications.

As for other capital costs, budget allocations for furnishings and consultations are being requested, as well as a fibre connection to the University's backbone with Gigabit capacity and wireless ports. Gigabit connectivity will support distributed storage schemes as well as real-time visualisation of large-scale computations, wireless connectivity will facilitate networking in the dynamic environment we anticipate.

Appendix F: OTO and operating budget request

OTO funds are requested to establish I-AIM as the autonomous workspace it needs to be. This includes funds for

- **Constructions and renovations:** based on the space and infrastructure requirements specified above, the Faculty of Arts and Science has detailed a development cost of \$708,717.79 . This figure is based on the University's experience with similar projects and detailed in AppendixH.
- **Workstations:** the Director, assistant, systems administrator, 16 students and PDFs each require a personal workstation. In addition 2 workstations will be held available as terminals and network access points on a short-term rotating basis. Accordingly we budget 21 workstations at an average cost of \$3,500 (\$73,500)
- **Office Equipment:** to support normal operations of I-AIM as an academic institute, we need to provide telephones, a photocopier, a shredder for personnel related documents, a central printer and a telefax. These items are budgeted at \$12,000.
- **Development of promotional media:** to enhance its profile, advertise its activities to the scientific community and support its recruitment activities, the Institute will have a Web-page and a printed brochure designed at a budgeted cost of \$10,000 for both.

Operating funds are requested to support I-AIM's academic activities. This includes:

- **Office operating costs:** we request a sum of \$500 annually per person (20 people) to cover telephone and Internet connectivity, mail and courier costs, photocopying, consumables, storage media and supplies;
- **Institute operating costs:** we request a sum of \$5,000 annually to cover miscellaneous items such as hospitality, recruitment activities, staff travel and contingencies;
- **Cleaning and maintenance costs** of \$ 5,000 annually;
- **A seminar budget** of \$25,000 annually to cover travel costs for invited speakers;
- **An Annual Retreat budget** of \$12,000 to cover space and audiovisual costs, travel for two external speakers, catering, and insurance;
- **A Topical Workshop budget** for 3 workshops annually at \$12,000 each to cover space and audiovisual costs, travel for three external speakers, catering, and insurance;
- **A summer school budget** of \$20,000 annually to contribute to preparation, advertising, space and audiovisual costs, administration; travel for one keynote speaker, catering, social activities and insurance;

A conference travel budget of \$15,000 annually, administered by the Director, to support applications from the two I-AIM faculty, graduate students and postdoctoral fellows for conference travel to present research results;

Salaries are requested for the following positions, budgeted as stated and including an estimated 4% annual increase of base salary and benefits;

- The I-AIM Director, cofunded at 0.5 FTE (0.5 of \$120,000 annually of base salary and benefits)
- 2 I-AIM Faculty funded at 2 x 1.0 FTE (2 x \$100,000 annually of base salary and benefits)
- An Administrative Assistant at 0.5 FTE (0.5 of \$30,000; annually of base salary and benefits) to support the Institute's Director and the executive committees and administer the Graduate Program.
- A System Administrator at 0.5 FTE (0.5 of \$80,000 annually of base salary and benefits) to support the high-performance computing facilities of I-AIM participants in the form of maintenance, liaison, and education of users (e.g. training of different team members on software developed by another collaborating partner).
- 10 PhD students, to be ramped up over the first year of operations (10 x \$23,000 annually of base salary and benefits);
- 6 Postdoctoral Fellows, to be ramped up over the first year of operations (6 x 0.6 of \$50,000 annually of base salary and benefits);

Appendix G: Projected Budget

AIF Financial Request - 2nd Round, 2005-06							
Proposal Name	Budget request *	Year 1	Year 2	Year 3	Year 4	Year 5	Subtotal
I-AIM	OTO						
	Equipment						
Institute of	Workstations	74					74
Applied	Office	12					12
Interdisciplinary	Operating						
Mathematics	Web Site and Brochure	10					10
	Construction/renovation						
	(development pro forma attached)	709					709
	Subtotal OTO	805	0	0	0	0	805
	BASE						
	Salaries and Stipends						
	Director (0.5 FTE)	60	62	65	67	70	325
	Faculty (2 x 1.0 FTE)	200	208	216	225	234	1,083
	Admin. Assistant (0.5 FTE)	15	16	16	17	18	81
	Systems Admin. (0.5 FTE)	40	42	43	45	47	217
	Graduate Stipend Program	115	239	249	259	269	1,131
	PDF Stipend Program	45	94	97	101	105	442
	Academic activities						
	Seminar series	25	25	25	25	25	125
	Annual retreat	12	12	12	12	12	60
	Topical Workshops	36	36	36	36	36	180
	Summer Schools	20	20	20	20	20	100
	Conference Travel	15	15	15	15	15	75
	Operating						
	Office operating	10	10	10	10	10	50
	Institute Operating	5	5	5	5	5	25
	Cleaning and Maintenance	5	5	5	5	5	25
	Subtotal Base	603	788	815	842	871	3,919
	Totals OTO + Base	1,408	788	815	842	871	4,724
	<i>Notes</i>						
	All figures in 1000 \$ CDN						
	* One-Time-Only (OTO):	Funds for activities that do not require continuing support from year to year.					
		One-time-only items are reversed in the next year's budget.					
	Base:	Expenses that occur year after year for the same amount.					

APPENDIX H: DEVELOPMENT PRO FORMA SUMMARY: I-AIM

	DESCRIPTION	Unit Cost	DRAFT budget
A	ASSUMPTIONS		
Please note this Pro-forma is activated by assumptions made			
B	MAIN CONSTRUCTION CONTRACT	\$	272,335.83
C	LANDSCAPING, ROADS, SIDEWALKS	\$	-
D	OTHER PROJECTS	\$	75,000.00
E	INFRASTRUCTURE SERVICES	\$	18,000.00
F	CONSULTANTS	\$	68,998.92
G	FURNISHINGS (LOOSE)	\$	133,750.00
H	EQUIPMENT	\$	13,500.00
J	SOFT COSTS	\$	60,812.59
K	ALLOWANCES	\$	17,300.00
L	PROJECT CONTINGENCIES	\$	49,020.45
M	FINANCING	\$	-
TOTAL			
		\$	708,717.79

Institute for Applied and Interdisciplinary Mathematics

CODE	DESCRIPTION	EXISTING ()							PROPOSED							GROW
		ALLOC	Room No.	No.Seats	NASM/St	NASF/St	NASM	NASF	ALLOC	Room No.	No.Seats	NASM/St	NASF/St	NASM	NASF	
	ACADEMIC															
1	Office Director								1	1	1	18.00	193.76	18.0	193.76	
2	Office: Visitors (6)								3	6	6	13.00	139.94	39.0	419.81	
3	Office: PHd (6)								2	6	6	4.00	43.06	24.0	258.34	
4	Office: PostDocs (6)								3	6	6	13.00	139.94	39.0	419.81	
5	Office: Faculty (2-full-time)								2	2	2	13.00	139.94	26.0	279.87	
6	Office Admin. Assist PHd (1)								1	1	1	13.00	139.94	13.0	139.94	
7	Photo/Mail room								1	na	na	13.00	139.94	13.0	139.94	
8	Small storage space								1	na	na	8.00	86.11	8.0	86.11	
9	Tea Room (multi-functional)								1	25	25	2.00	21.53	50.0	538.21	
10	Kitchenette (access to)								shared	shared	na	na	na	0.0	na	
	TOTAL						0	0	15	47				230.0	2,475.78	100%

DEVELOPMENT PRO FORMA: I-AIM

	DESCRIPTION	Space/Unit Cost	DRAFT budget
A ASSUMPTIONS			
	Net Assignable in Total SM	230	
	Net Assignable in Total SF	2476	
	Gross Floor Area		
	GFA/NA SPLIT		
	Net Assignable:renovated @ 215 Huron/Fields	230	\$ 272,335.83
	Net Assignable:renovated @ 215 Huron/Fields	2476	
	COST PER sm	\$ 1,184.07	
	COST PER sf	\$ 110.00	
	Approvals		

B MAIN CONSTRUCTION CONTRACT		<i>forward</i>	\$ 272,335.83
1	General Conditions	5.0%	\$ 13,616.79
2	Sitework	1.0%	\$ 2,723.36
3	Concrete	3.0%	\$ 8,170.07
4	Masonry	5.0%	\$ 13,616.79
5	Metals	2.0%	\$ 5,446.72
6	Wood & Plastics	10.0%	\$ 27,233.58
7	Thermal & Moisture Protection	6.0%	\$ 16,340.15
8	Door & Windows	10.0%	\$ 27,233.58
9	Finishes	15.0%	\$ 40,850.37
10	Specialties	5.0%	\$ 13,616.79
11	Equipment	5.0%	\$ 13,616.79
12	Furnishing (Built-in Only)	5.0%	\$ 13,616.79
13	Special Construction	0.0%	\$ -
14	Conveying Systems	0.0%	\$ -
15	Mechanical	10.0%	\$ 27,233.58
16	Electrical	10.0%	\$ 27,233.58
17	IT Connectivity	8.0%	\$ 21,786.87
	Sub-Total	100.0%	

C LANDSCAPING, ROADS, SIDEWALKS			\$ -
	Landscaping: Interior	\$ 8.00	\$ -
	Landscaping: Exterior	\$ 8.00	\$ -
	Roads		\$ -
	Service Lanes		
	Sidewalks		
	Ramps		
	Other		\$ -

D OTHER PROJECTS			\$ 75,000.00
	Secondary Effects	not included	not included
	Hazardous Removal		\$ -
	Code Compliance	\$ -	\$ 75,000.00
	Other		\$ -

E INFRASTRUCTURE SERVICES			\$ 18,000.00
	Central Plant		
	Hydro		
	Sewers		
	Water		
	IT Unfrastructure	21	\$ 5,250.00
	Fibre	\$ 7,500.00	\$ 7,500.00
	Telephone	21	\$ 5,250.00
	Other		

DEVELOPMENT PRO FORMA: I-AIM

	DESCRIPTION	Space/Unit Cost	DRAFT budget
A ASSUMPTIONS			
F CONSULTANTS			\$ 68,998.92
	Architect	15%	\$ 40,850.37
	Engineers	3%	\$ 8,170.07
	Disbursements	2%	\$ 5,446.72
	Fees		
	Legal		
	Survey		
	Soils		
	Project Management		
	Construction Management	3.5%	\$ 9,531.75
	In-House costs	code	\$ 5,000.00
	Other		
G FURNISHINGS (LOOSE)			\$ 133,750.00
	Administrative station	\$ 2,500.00	\$ 2,500.00
	Faculty private	\$ 3,500.00	\$ 10,500.00
	Faculty shared	\$ 2,000.00	\$ 36,000.00
	Student shared	\$ 1,000.00	\$ -
	storage cabinets	\$ 250.00	\$ 4,500.00
	lockers	\$ 300.00	\$ -
	lateral filing cabinets	\$ 400.00	\$ 10,000.00
	hooks	\$ 10.00	\$ 200.00
	Public Spaces Lounge seats/tables	\$ 300.00	\$ 3,000.00
	sofa/arm chair	\$ 700.00	\$ 4,200.00
	Classroom chairs	\$ 120.00	\$ -
	Classroom/Seminar tables per seat length	\$ 75.00	\$ -
	Classroom Instruction lecturn	\$ 250.00	\$ -
	Class Lab	\$ 500.00	\$ -
	Computer Station Study Carol	\$ 300.00	\$ -
	Library Study station	\$ 350.00	\$ -
	Language Lab station	\$ 350.00	\$ -
	tables (meeting 10-12)	\$ 2,000.00	\$ -
	tables (mobile)	\$ 650.00	\$ -
	table (small 4)	\$ 400.00	\$ -
	table (small 6)	\$ 600.00	\$ -
	table (small 8)	\$ 800.00	\$ -
	tables (café)	\$ 450.00	\$ -
	tables (meeting)	\$ 2,000.00	\$ 6,000.00
	stools	\$ 200.00	\$ -
	guest chairs	\$ 150.00	\$ 5,250.00
	meeting chairs	\$ 200.00	\$ -
	lab chairs	\$ 215.00	\$ -
	task chairs	\$ 300.00	\$ 6,600.00
	panel systems per 3 feet lengths	\$ 500.00	\$ -
	shelving standard per standard off	\$ 1,500.00	\$ 45,000.00
	shelving heavy duty	\$ 2,500.00	\$ -
	Other		
H EQUIPMENT			\$ 13,500.00
	Computer Station	\$ 2,000.00	\$ -
	Library Station		
	Language Processing Equipment		
	Language Security Gates	\$ 12,000.00	\$ -
	Language Lab Station	\$ 750.00	\$ -
	AV requirements Learning Environ.partial	\$ 10,000.00	\$ 10,000.00
	AV requirements wireless	\$ 3,500.00	\$ 3,500.00
	Other		
J SOFT COSTS			\$ 60,812.59
	Applicable taxes		\$ 28,132.29
	Fees		\$ 2,723.36
	Insurance		\$ 8,170.07
	Permits Zoning		
	Permits Construction		\$ 21,786.87
	Other		

DEVELOPMENT PRO FORMA: I-AIM

	DESCRIPTION	Space/Unit Cost	DRAFT budget
A	ASSUMPTIONS		
K	ALLOWANCES		\$ 17,300.00
	Advertizing		
	Art work		\$ -
	Decorative items		
	Donor Recognition		
	Project Opening		\$ -
	Security: Door Access System	\$ 3,600.00	\$ 14,400.00
	Security: Intrusion System		
	Signage: Interior	\$ 70.00	\$ 1,400.00
	Signage: Exterior A	\$ 3,000.00	\$ -
	Signage: Exterior B	\$ 500.00	\$ 1,500.00
	Other		
L	PROJECT CONTINGENCIES		\$ 49,020.45
	Construction Contingency 5%	5%	13,616.79
	Design Contingency 5%	5%	13,616.79
	Cost Escalation 6%	6%	16,340.15
	Other (NA compliance)	2%	\$ 5,446.72
M	FINANCING		\$ -
	Financing Partners		
	Partner		
	Financing Costs		
	Other		