UNIVERSITY OF TORONTO

OFFICE OF THE GOVERNING COUNCIL

FOR RECOMMENDATION **PUBLIC** **OPEN SESSION**

TO:	UTM Campus Affairs Committee
SPONSOR:	Professor Rhonda McEwen, Vice-Principal Academic & Dean
CONTACT INFO:	vpdean.utm@utoronto.ca
PRESENTER:	As above
CONTACT INFO:	
DATE:	May 5, 2022 for May 12, 2022
AGENDA ITEM:	3

ITEM IDENTIFICATION:

Proposal to Establish an Extra Departmental Unit C (EDU:C): Centre for Nonlinear Analysis and Modeling (CNAM), UTM

JURISDICTIONAL INFORMATION:

Section 5.8.1 of the Committee's Terms of References notes that the Committee makes recommendations to the UTM Council on plans and proposals to establish, disestablish, or significantly restructure academic units, here defined as faculties, schools, colleges, departments, centres and institutes with teaching, or teaching and research functions, undergraduate degree programs, and graduate degree programs, regardless of the source of funds.

Proposals to establish Extra-Departmental Units are considered and recommended for approval pursuant to the *Policy on Interdisciplinary Education and Research Planning* and pursuant to *University of Toronto Guidelines for Extra-Departmental Units*.

GOVERNANCE PATH:

- **UTM Campus Affairs Committee [for recommendation] (May 12, 2022)**
- UTM Campus Council [for approval] (May 24, 2022)
- Executive Committee [for confirmation] (June 14, 2022)

PREVIOUS ACTION TAKEN:

None

HIGHLIGHTS:

This is a proposal to establish an Extra-Departmental Unit (EDU): C – Centre for Non-Linear Analysis & Modeling (CNAM) to be housed at the University of Toronto Mississauga (UTM), effective July 1, 2022. An EDU:C is a multi-disciplinary and/ or multi-departmental research and/ or academic unit with a defined research domain in a particular area of academic work. It exists to foster research and scholarly interest in the area, but does not register students.

The University of Toronto is internationally recognized to have one of the leading groups of dynamicists in the world who look to understand changes in variables, which may appear to be chaotic, unpredictable, and unrelated, over time. For example, examining various aspects of weather that impact accurate long-term forecasts; examining various seemingly unrelated factors in pregnancy and early childhood development to diagnose and detect developmental problems; and examining human behaviour and movement to predict movement and spread of a virus in a pandemic. This group primarily consists of UTM faculty, and they will form the core of the proposed Centre. The Centre aims to harness this existing expertise to advance the development of new tools for analyzing complex systems and to formulate the strategies and approaches for the dynamical modelling of the ever-changing world. While keeping the focus on UTM-based activities, the projects spearheaded by the Centre will involve faculty from all three campuses, as well as nationally and internationally recognized research affiliates.

The vision of CNAM is to enable researchers in nonlinear analysis and modelling at UTM, and the larger U of T, to strengthen and establish new connections outside of their traditional disciplinary networks. Building on the existing strengths and collaborations from UTM faculty, particularly in the Department of Mathematical & Computational Sciences (MCS), CNAM will provide opportunities for visiting scholars to come to UTM and strengthen current research and teaching activities, establish new collaborations, and explore new opportunities within applied nonlinear dynamics. Each year, CNAM will support four (4) postdoctoral fellows and one (1) Visiting Research Professor from international institutes to gather a critical mass of experts, establishing itself as a global leader in nonlinear analysis based on dynamical and statistical modelling of real-life problems.

At its establishment, CNAM will focus its efforts on four (4) existing research directions where UTM has particular strengths and collaborators:

(1) **Fully developed turbulence.**
(2) **Mathematical modelling of complex systems.**
(3) **Applications of Mathematics to Medicine.**
(4) **Connections with Statistical Mechanics.**

By being established at UTM, the CNAM will attract significant faculty members from all three disciplines (Mathematical Sciences, Applied Statistics, and Computer Science) in the Department of Mathematical and Computational Sciences. Association from faculty with primary appointments at other campuses, including the St-George campus-based Department of Mathematics (Faculty of Arts & Science (FAS)) and the Department of Computer and Mathematical Sciences at the University of Toronto Scarborough (UTSC) as well as faculty with clinical appointments who work at the U of T affiliated Hospitals.

Wide consultation was sought during the development of CNAM. Chairs from the Departments of Chemical & Physical Sciences (UTM), Mathematics (Faculty of Arts & Science), Computer

Science (Faculty of Arts & Science), Statistical Sciences (Faculty of Arts & Science), and Computer & Mathematical Sciences (UTSC) were involved in the development of this proposal. All feedback received was incorporated into the final proposal.

The CNAM Director will report to the Vice-Principal Academic & Dean, UTM on academic and budgetary matters.

RECOMMENDATION:

Be it Recommended

THAT the proposal to establish the Extra-Departmental Unit C (EDU:C): Centre for Nonlinear Analysis and Modeling (CNAM), UTM, as detailed in the proposal dated May 2, 2022, be approved, effective July 1, 2022.

DOCUMENTATION PROVIDED:

- Proposal for a new EDU:C, Centre for Nonlinear Analysis and Modeling (CNAM), UTM

Proposal for a new EDU:C

Centre for Nonlinear Analysis and Modeling (CNAM)

May 2, 2022

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1. Statement of Purpose.

This is a proposal for the creation of a new EDU:C – the Centre for Nonlinear Analysis and Modeling (further referred to as CNAM or the 'Centre'). The Centre will be hosted at the University of Toronto Mississauga (UTM) with tri-campus involvement. UTM will be the lead division, assuming administrative and budgetary responsibilities for the unit. A list of participating faculty is provided in Appendix A. At its establishment, CNAM will have participation from faculty in academic units that span all three campuses. At UTM this will include the Department of Mathematics & Computational Sciences (MCS) and the Department of Chemical & Physical Sciences (CPS); at the University of Toronto Scarborough (UTSC) this will include the Department of Computer & Mathematical Sciences; and at the St. George campus this will include the Department of Mathematics (in the Faculty of Arts & Science), the Department of Computer Science (Faculty of Arts & Science), and the Faculty of Medicine.

The proposed start date of CNAM is July 1, 2022.

2. Academic Rationale.

a. Background.

We are living in a time when both government and commercial policy decisions are driven by mathematical modelling of dynamical processes. There is no more salient illustration of this than the modelling of the spread of infectious diseases, which is now at the forefront of public health decision-making because of the COVID-19 crisis.

The world around us is overwhelmingly complex, and there is seemingly an intractable number of parameters that describe any dynamical system. There are two intertwined approaches for handling this complexity. The first one uses low-dimensional nonlinear models, in which the multitude of parameters is replaced by a few average values. In a model of an epidemic, for example, the population is grouped into "infected," "immune," and so on – and each member of the group is assumed to behave the same on average. This leads to a type of model which is analyzed using the mathematical tools of Chaotic Dynamics. Such an analysis predicts future outcomes based on changes in average behaviour, and its conclusions can be used to formulate large-scale policy prescriptions in an attempt to modify average behaviour (for instance, social distancing in an epidemic). A complementary approach lies in interpreting the population as a very large-scale stochastic model in which each person represents an independent agent (a "random particle"). Statistical analysis of such a model describes clusters of the infection spreading around some of the particles. It can lead to complementary policy prescriptions aimed to locate and isolate the clusters, such as aggressive contact tracing.

The challenges of these complementary approaches are at the forefront of research in

Dynamical Systems and related disciplines. The University of Toronto is internationally recognized to have one of the leading groups of dynamicists in the world. This group primarily consists of UTM faculty and they will form the core of the proposed Centre. The Centre aims to harness this existing expertise to advance the development of new tools for analyzing complex systems and to formulate the strategies and approaches for the dynamical modelling of the ever-changing world. While keeping the focus on UTM-based activities, the projects spearheaded by the Centre will involve faculty from all three campuses, as well as nationally and internationally recognized research affiliates.

To elaborate on some of the principal challenges in the study of complex nonlinear processes, a fundamental obstacle to mapping out the future behaviour of a dynamical system is the great sensitivity of both natural systems and their mathematical models to minor errors in computation and measurement. This phenomenon is popularly known as "chaos" and has given way to the field of Chaotic Dynamics. Its presence makes seemingly simple and deterministic models behave in unpredictable fashions. Chaos unavoidably appears in dynamical systems even when they are low-dimensional.

Indeed, chaotic dynamics typically emerges even if only three degrees of freedom are present! This somewhat startling mathematical discovery originated in the study of the Solar System, particularly, the still open Three-body Problem which asks for a mathematical model for the long-time behaviour of three celestial bodies, the Sun, the Earth, and the Moon, all of which are mutually connected by the Newtonian force of gravity.

Students taking their first course in Nonlinear Dynamics are often shocked to discover that a double pendulum (that is a pendulum attached to another pendulum) is a chaotic dynamical system: if it is given enough of an initial push from the equilibrium, then its trajectory becomes unpredictable both theoretically and numerically. If such "simple" systems can behave in a non-deterministic fashion, imagine the challenges that may arise in, for instance, space exploration or robotics. Taming of chaos has been one of the central subjects in the study of Dynamical Systems in the last several decades. Its principal goals can be formulated as follows:

- Develop mathematical and statistical language for describing chaotic behaviour of dynamical systems;
- Describe the typical conditions under which chaos arises in low-dimensional dynamics, and describe the mechanism by which a deterministically defined system becomes chaotic; and
- Understand the limitations of mathematical modelling of chaos and develop numerical tools for its study.

A complementary and very modern approach to analyzing the complexity is to encode it in a model with a very large number of agents each of which interacts with its "neighbours." When the model is viewed as a whole, each agent becomes microscopic, and probabilistic averaging techniques can be brought to bear to understand the

aggregate behaviour of the system.

This approach was pioneered in the second half of the 20th century and has its roots in Statistical Mechanics, which is the study of gases and fluids. As the name suggests, statistical techniques become key in their analysis to understand both the typical state of the system and the deviations from the mean. The key insight here is that even in the dynamics of homogeneous media, such as gases, there could be violent, spontaneously emerging deviations from the mean statistical behaviour, which will dominate the behaviour of the system. The mathematical theory of such phenomena, known in hydrodynamics as turbulence, is still in its developing stages. Once again, turbulent behaviour renders a statistically deterministic system effectively unpredictable. The principal aims of this approach are to :

- Develop mathematical and statistical language to describe the emergence of large-scale fluctuations of homogeneous microscopic systems; and
- Describe the effective large-scale parameters of such systems, and explain how they can be modelled, building the bridge between statistical-mechanical models and low-dimensional Chaotic Dynamics. Particularly, explain such examples as clustering effects of epidemic spread, and turbulence in the dynamics of gases and fluids.

b. Vision Statement.

The vision of CNAM is to enable researchers in nonlinear analysis and modelling at UTM, and the larger U of T, to strengthen and establish new connections outside of their traditional disciplinary networks. Building on the existing strengths and collaborations from UTM faculty, particularly in the Department of Mathematical & Computational Sciences (MCS), CNAM will provide opportunities for visiting scholars to come to UTM and strengthen current research and teaching activities, establish new collaborations, and explore new opportunities within applied nonlinear dynamics. Each year, CNAM will support up to four (4) postdoctoral fellows and one (1) Visiting Research Professor from international institutes to gather a critical mass of experts, establishing itself as a global leader in nonlinear analysis based on dynamical and statistical modelling of real-life problems.

With its focus in real-world or societal application, CNAM will necessarily be a multi- and inter-disciplinary unit, bringing together experts from mathematics, statistics, biology, chemistry, phsysics, medicine, computer science, and robotics. It will, in particular, build on the existing connections with the medical community, which at present is a principal source of mathematical problems in nonlinear modelling. It will also explore synergies with the developing Robotics cluster at UTM since nonlinear dynamical modelling is central to research in Robotics.

At its establishment, CNAM will focus its efforts on four (4) existing research directions where UTM has particular strengths and collaborators:

(1) **Fully developed turbulence.** Recently the ideas of spontaneous stochastization in connection with the problem of turbulence for Euler flows are becoming more and

more popular. While rigorous mathematical analysis is still out of reach, one can look at the phenomenon of spontaneous stochastization from different angles: numerics, physics, and applied mathematics. From this point of view the exciting new direction of spontaneous stochastization is truly interdisciplinary. At UTM, Professor Khanin is a leader in this area.

(2) **Mathematical modelling of complex systems.** Development of a new approach based on extensive expertise in chaotic dynamics, hyperbolic dynamical systems, random dynamical systems, and the theory of instabilities in Hamiltonian systems. This will allow for the application of new ideas and methods which were developed in the past 10-15 years. The focus will be on numerous applications such as statistical epidemiology, pollution, climate change, etc. Professors Zhang and De Simoi in MCS work extensively in this area.

(3) **Applications of Mathematics to Medicine.** The study of the human placenta is key to understanding early human development and diagnose and detect developmental problems. Professor Yampolsky (MCS) is an expert on mathematical modeling of human placental development with a significant number of papers published in leading journals in the field. His current research project, joint with Drs. Lena Serghides (University Health Network) and Alex Shlakhter (Alberta Health Services) concerns mathematical modeling of placental growth in HIV positive pregnancies, to gain an insight on the effects on maternal and fetal health.

(4) **Connections with Statistical Mechanics.** There has been dramatic recent progress on the rigorous understanding of Conformal Filed Theory. The advances are based on the collaboration between mathematicians and theoretical and experimental physicists. Professor Binder (MCS) currently collaborates with leading Physics experts, such as Professors Bertrand Duplantier (Saclay), Ilia Gruzberg (Ohio State), and Pavel Wiegmann (University of Chicago).

c. Objectives.

i. Research.

The establishment of CNAM will provide a home at U of T to foster collaborations (existing and potential) between the UTM-based cluster of researchers, other tri-campus faculty, and international collaborators. Through the support of a Visiting Professor each year, CNAM will encourage and increase collaborations, networking, and facilitate larger-scale research projects, helping to increase its national and international presence. Locally, the U of T community and overall education mission will be enhanced with CNAM bringing Visiting Professors to participate in seminar and lecture series (e.g. UTM's Lecture Me! Series[1]) and giving

[1] https://www.utm.utoronto.ca/experience/lecture-me-series

guest lectures in courses.

CNAM will leverage the current expertise and collaborations in nonlinear dynamics and modelling at U of T by initially focusing on four (4) key research directions – fully developed turbulence; mathematical modelling of complex systems; applications of mathematics to medicine; and connections with statistical mathematics (described in Section 2.b.,above). Additional areas of focus may be added as new partnerships are established and collaborative mentoring of graduate students and postdoctoral fellows (up to 4 per year) grows. Research partnerships are expected to include funding from international sources, such as the National Science Foundation[2], National Institute of Health[3], Simons Foundation[4], and others.

ii. Education and Training.

Through its research objective and dedicated focus on the application of non-linear analysis in real-life situations, CNAM will support UTM education and training at the graduate and undergraduate levels.

Graduate. CNAM will attract graduate students looking to explore how mathematics intersects with other disciplines and allows for real-world application. Faculty members in CNAM will supervise graduate students through the graduate units where they hold graduate faculty appointments. For the most part, this will be the tri-campus Mathematics Graduate Department, which currently offers an MSc and PhD program in Mathematics. Other tri-campus graduate departments that cover this area of research include Chemistry (with an MSc and PhD program as well as collaborative specializations in Biomedical Engineering, Environmental Studies, and Next-Generation Precision Medicine) and Computer Science (offering an MSc and PhD in Computer Science, a Master of Applied Computing, collaborative specializations in Genome Biology and Informatics, Knowledge Media Design, and Neuroscience). Graduate course offerings in the area of mathematics, statistics, robotics, and related disciplines from the perspective of analysis and societal application will be developed from work done in CNAM. With its strong research focus and commitment to bringing together researchers at the international level, CNAM will facilitate collaborative mentoring of graduate students.

Undergraduate. The Centre will also be looking to extend their training and teaching opportunities to the undergraduate level. Much of the work in CNAM will be a natural fit for direct/ one-on-one mentoring opportunities for senior undergraduate students (in the form of senior thesis projects or Research Opportunity Program (ROP) projects). Beyond individual projects,

[2] https://www.nsf.gov/
[3] https://www.nih.gov/grants-funding
[4] https://www.simonsfoundation.org/funding-opportunities/

CNAM aims to develop advanced undergraduate courses to be offered through the Department of Mathematical & Computational Sciences at UTM. These may include joint courses with other academic units that have faculty active in CNAM (e.g. UTM Biology, UTM Chemical & Physical Sciences, etc.). As a long-term goal, CNAM will support the development of an interdisciplinary major in Applied Mathematics, to be offered through an academic unit at UTM.

iii. Collaborations.

Nonlinear Dynamics is central both to modern mathematical research and to interdisciplinary applications. UTM faculty have collaborated across a wide range of disciplines, such as Mathematical Medicine and Computer Science. CNAM will provide a structure for further expansion of these efforts and will attract research and industry connections and funding. It will cultivate new cross-discipline connections, particularly with such fields as Robotics, and Medical Sciences, development of which is prioritized by UTM.

d. University and Divisional Strategic Goals.

With its key objectives as outlined above, CNAM fits strongly into the strategic goals of UTM's Academic Plan. Specifically, UTM aims to "inspire student success by supporting a rigorous and innovative academic environment." CNAM will be a perfect fit for this objective by creating an extra-departmental research unit that will foster interdisciplinary research across the University and will create opportunities for innovative mentoring of graduate students.

One of the key Research objectives of the UTM's Academic Plan is to "demonstrate that UTM is a home for world-class research." CNAM will help to enhance the recognition and quality of the research faculty in non-linear dynamics which is centred at UTM. It will become a leading academic cluster in this exciting field of research and will highlight the academic profile of UTM. CNAM will facilitate the creation of new interdisciplinary research projects funded by Canadian and international funding agencies.

As one of the stated UTM's strategic goals, CNAM will "educate future leaders to be global citizens meeting complex challenges and increase student awareness of global issues." In particular, CNAM will expose undergraduate students to real-life challenges of planning and forecasting in the complex world, in the format of directed research projects and new upper-year course offerings from faculty who are CNAM members. These courses will be offered through the undergraduate programs in which they teach.

UTM's Academic Plan highlights the "focus on transformation and innovation to create a sustainable and cohesive community by attracting outstanding faculty who conduct path-breaking research." CNAM will attract some of the best and the brightest young researchers and will facilitate collaborative mentoring of graduate students and postdoctoral fellows.

Also, the Centre aligns perfectly with several thematic priority areas of the University of Toronto's Institutional Strategic Research Plan[5]. In particular, it fits into the following themes:

- "Discover" by advancing an understanding of complex nonlinear processes;
- "Promote" by raising the profile of the University's research faculty via international collaboration and scientific leadership; and
- "Innovate" by mapping out the new directions and the main mathematical problems in the analysis of non-linear dynamical systems.

e. Distinctiveness.

CNAM will standout at the University of Toronto in its focus on applied mathematics. The Centre will have no direct parallels locally (within Canada) and very few globally. The closest existing initiatives can be found at a select few top research universities outside of Canada. They include the Center for Nonlinear and Complex Systems at Duke University[6], the Oxford Centre for Nonlinear Partial Differential Equations at the University of Oxford[7], and the Center for Nonlinear Analysis at Rutgers University[8]. These Centres' foci are more narrow with less emphasis on applications in the physical world. In this way, CNAM will be unique, encapsulating the four research directions identified in the Vision Statement (Section 2.b., above) through an applied lens and allowing for expansion into new areas as CNAM and the interests of its researchers grow. While these Centres have a different focus than CNAM, they will present opportunities for collaboration at the international level. Additionally, CNAM will be the first Centre in Canada with a focus in applied mathematics.

3. Consultation.

Plans for the creation of the CNAM at the University of Toronto Mississauga have been in gestation for several years. The idea was to build upon the unique strength in the broad area of Nonlinear Analysis. We have consulted broadly within the U of T community, namely with Amrita Daniere (former Vice-Principal, Academic & Dean, UTM), Ulli Krull (former Vice-President and Principal, UTM), Kent Moore (Vice-Principal Research, UTM), Bryan Stewart (former Vice-Principal Research, UTM), Lindsay Schoenbohm (Chair, Department of Chemical & Physical Sciences, UTM), Jeremy Quastel (Chair, Department of

[5] https://research.utoronto.ca/reports-publications-metrics/institutional-strategic-research-plan#:~:text=The%20Plan%20identifies%20five%20strategic,Inclusion%20across%20Research%20and%20Innovation

[6] https://services.math.duke.edu/cncs/

[7] https://www.maths.ox.ac.uk/groups/oxpde/oxford-centre-nonlinear-pde#:~:text=The%20Oxford%20Centre%20for%20Nonlinear,mathematical%20description%20of%20many%20phenomena.

[8] https://www.math.rutgers.edu/research/research-centers/center-for-nonlinear-analysis

Mathematics, Faculty of Arts & Science), Marsha Chechik (Chair, Department of Computer Science, Faculty of Arts & Science), Radu Craiu (Chair, Department of Statistical Sciences, Faculty of Arts & Science), Michael Molloy (Chair, Department of Computer & Mathematical Sciences, University of Toronto Scarborough), and George Arhonditsis (Chair, Department of Physical & Environmental Sciences, University of Toronto Scarborough). The consensus is that there has never been a more urgent need to develop such a centre in Canada than there is now.

The UTM Office of the Dean has also reached out to the Faculty of Arts & Science (Vince Tropepe, Vice-Dean Research) and UTSC (Irena Creed, Vice-Principal Research) as well as the Council of Health Sciences for review. Any feedback received will be incorporated into the proposal before it enters governance. Furthermore, this proposal was sent to the Faculty of Applied Science & Engineering (FASE) and the Data Sciences Institute (DSI) at the St. George campus to invite feedback and explore potential collaborations.

4. Faculty Participation.

By being established at UTM, the CNAM will attract significant faculty members from all three disciplines (Mathematical Sciences, Applied Statistics, and Computer Science) in the Department of Mathematical and Computational Sciences. We further anticipate association from faculty with primary appointments at other campuses, including the St. George campus-based Department of Mathematics (Faculty of Arts & Science) and the Department of Computer and Mathematical Sciences at the University of Toronto Scarborough (UTSC) as well as faculty with clinical appointments who work at the U of T affiliated Hospitals. The Department of Physical & Environmental Sciences at UTSC has also expressed interest in participating and collaborating in CNAM activities and projects, noting that a number of their faculty are very active in mathematical modeling.

Provided in Appendix A is a list of current U of T faculty who have expressed interest in engaging with the CNAM and agreed to participate as members. As an EDU:C, CNAM will hold only non-budgetary cross-appointments of tenure and teaching stream faculty.

5. Administration and structure.

A Director, in consultation with an Advisory Board, will lead the operations and activities of the CNAM. The Director will be appointed by the Vice-Principal, Academic and Dean for a five (5) year term. The Advisory Board will be appointed by the Director in consultation with the Chair of the Department of Mathematical & Computational Sciences (MCS) and will be in line with the Provost's Statement on the Role of Advisory Bodies.[9] The Advisory Board will consist of four members: two drawn from the affiliated faculty, and two external

[9] https://www.provost.utoronto.ca/planning-policy/advisory-bodies-role-provost-statement/

researchers with international representation.

The proposed CNAM is an EDU:C and as such, the Director is not appointed under the Policy on Academic Administrative Appointments. As a consequence, an EDU:C may not administer research funds or enter directly and on its own authority into commitments/ agreements/contracts. All monies and research funding will flow through the Office of the Dean in line with UTM's normal practice. Any research contracts or agreements similarly require approval and the signature of the Vice-Principal, Academic and Dean.

The Director in consultation with the Advisory Board will be responsible for overseeing all aspects of the CNAM, including the direction and administration of its research programs, the establishment of strategic collaborations, implementation of policies, and approval of budgets. It is the Director's responsibility to provide annual reports on the operations of the CNAM to the UTM Vice-Principal, Academic and Dean (or appointed designate).

The Director will conduct biannual meetings with the Vice Dean, Graduate Studies & Postdoctoral Affairs, who has been designated by the Dean to oversee the management of EDU:Cs at UTM. Also, an annual report will be provided to the Office of the Dean that describes the annual activities and successes of the EDU.

The achievements and accomplishments of the Centre will be reviewed every 5-7 years (coinciding with the appointment or re-appointment of a Director, when possible) by the Dean (or appointed designate). Reviews of EDU:Cs will follow the process and timelines outlined in the UTM Terms of Reference for *Reviews of Extra-Departmental Units, Category C and Category D* (see Appendix B). An outcome of the review could be a decision to close the EDU. The first review of CNAM is scheduled for the 2026-2027 academic year.

6. Space requirements.

CNAM will support up to four (4) postdoctoral fellows and one (1) Visiting Research Professor (for a period of 6-12 months) annually. To accommodate this, CNAM will require the use of two offices. This space has been allocated at UTM in the Deerfield Hall building.

Appendix A – Faculty List.

The following is a list of faculty members and affiliated researchers who have expressed interest in becoming CNAM members. As an EDU:C, CNAM will only hold non-budgetary cross-appointments of tenure and teaching stream faculty.

Faculty Member	**Rank**	**Unit of Appointment**
Professor Konstantin Khanin	Professor	Mathematical & Computational Sciences (MCS, UTM)
Professor Ilia Binder	Professor and Chair	Mathematical & Computational Sciences (MCS, UTM)
Professor Michael Yampolsky	Professor	Mathematical & Computational Sciences (MCS, UTM)
Professor Jacopo De Simoi	Associate Professor and Associate Chair	Mathematical & Computational Sciences (MCS, UTM)
Professor Ke Zhang	Associate Professor	Mathematical & Computational Sciences (MCS, UTM)
Duncan Dauvergne	Assistant Professor	Mathematical & Computational Sciences (MCS, UTM)
Yakov Shlapentokh-Rothman	Assistant Professor	Mathematical & Computational Sciences (MCS, UTM)
Professor Jessica Burgner-Kahrs	Associate Professor, Associate Chair, and Director of Continuum	Mathematical & Computational Sciences (MCS, UTM)
Professor Florian Shkurti	Assistant Professor	Mathematical & Computational Sciences (MCS, UTM)
Professor Dehan Kong	Assistant Professor	Mathematical & Computational Sciences (MCS, UTM)
Professor Andreas Hilfinger	Assistant Professor	Chemical & Physical Sciences (CPS, UTM)
Professor Sarah Rauscher	Assistant Professor	Chemical & Physical Sciences (CPS, UTM)
Professor Adam Stinchcombe	Assistant Professor	Mathematics (FAS)
Professor Michael Goldstein	Professor	Computer and Mathematical Sciences (UTSC)
Professor Giulio Tiozzo	Assistant Professor	Computer and Mathematical Sciences (UTSC)

Professor Lena Serghides	Scientist Assistant Professor	Toronto General Hospital Research Institute, University Health Network Department of Immunology and Institute of Medical Sciences (Medicine)
Professor Michael Brudno	Professor Chief Data Scientist	Computer Science (FAS) University Health Network
Professor Anna Goldenberg	Senior Scientist Assistant Professor	Genetics and Genome Biology, Sick Kids Hospital Computer Science (FAS)
Dr. Lueder Kahrs	Scientist Assistant Professor	Sick Kids Hospital Mathematical & Computational Sciences (MCS, UTM)
Dr. Oleksandr Shlakhter	Senior Health Operations Researcher, Data & Analytics	Strategic Analytics, Alberta Health Services

Appendix B – UTM Terms of Reference for Reviews of Extra-Departmental Units, Category C and Category D

Reviews of Extra-Departmental Units, Category C and Category D

Terms of Reference

EDU Under Review:	
EDU Category:	
Date of Review:	

I. Purpose

The Terms of Reference are intended to establish the parameters of, and provide a framework, for the review process of extra-departmental units (hereafter "EDUs"), category C (hereafter "EDU:C') and category D (hereafter "EDU:D"). Under the Guidelines for Extra-Departmental Units, EDU:Cs and EDU:Ds should be reviewed periodically to consider the unit's sustainability, performance, and achievements relative to the goals set out at its establishment and/ or previous review.

II. Procedure & Process

- Reviews of EDU:Cs and EDU:Ds are commissioned by the UTM Vice-Principal, Academic & Dean or the Dean's Designate (hereafter "Commissioning Officer").
- Reviews will normally be conducted every 5-7 years in conjunction with the appointment or re-appointment of a Director/ Coordinator, or as deemed appropriate/ necessary by the Commissioning Officer.
- The review will be announced by the Commissioning Officer through the Program & Curriculum Unit (hereafter "PCU") within the UTM Office of the Vice-Principal, Academic & Dean a minimum of four (4) months prior to the scheduled review (normally February of the year of review). Written notification by e-mail communication will be provided to the Director/ Coordinator.
- The review will be conducted by a pre-established Review Committee (see *Section III. Review Committee* below) that is determined by the Commissioning Officer. Written notification by e-mail

communication of the Review Committee membership will be provided to the Director/ Coordinator a minimum of one (1) month before the review (normally May of the year of review).

- A written report is to be provided that summarizes the EDU's activities since its establishment/ previous review; highlights key achievements that speak to outcomes set at its establishment/ previous review; describes research, teaching, and/or community engagement; and outlines long-term planning goals (as appropriate).
    - The report is to be submitted to the PCU by the Director/ Coordinator no later than May 1st of the year of review. The PCU will provide the report and send all review documentation to the Review Committee (see *Section IV. Report* below).
- Additional information specific to the nature, goals, and operation of the EDU under review may be requested in the report at the discretion of the Commissioning Officer. Such request will be made in writing (via e-mail communication) to the Director/ Coordinator a minimum of two (2) months before the submission of the report (normally March of the year of review).
- The written report will be reviewed by the Review Committee (normally in June of the year of review).
- An in-person meeting of the Director/ Coordinator and the Review Committee may be requested by the Commissioning Officer. Such a meeting would normally occur in June of the year of review.
- The review will conclude with a written statement from the Commissioning Officer (distributed by e-mail communication) that confirms the outcome of the review (see *Section V. Final Assessment & Outcomes* below).
- At the discretion of the Commissioning Officer, the review schedule and timelines can differ from the above described.

III. Review Committee

- The composition of the Review Committee is determined by the Commissioning Officer and will normally include:
    - the Committee Chair (Commissioning Officer),
    - an academic administrator from the UTM Office of the Vice-Principal, Academic & Dean; and
    - an additional U of T faculty member at arm's length from the EDU.
- Where appropriate, the Commissioning Officer may invite additional members to serve on the Review Committee. These individuals can include faculty, librarians, staff, and others who are external to the U of T community.
- The composition of the Review Committee will be finalized and announced to the Director/ Coordinator approximately 1 month before the report submission date.

IV. Report

- A written report by the Director/ Coordinator shall be submitted to the PCU no later than May 1st of the year of review.
- The report will summarize the activities of the EDU since its establishment/ previous review, with specific reference to its original proposal or recommendations from the previous review.
- The report will also discuss:

- key achievements that speak directly to stated outcomes (set at establishment/ previous review),
- the value of the EDU, and how its achievements are different than UTM's existing academic units (this should include a discussion of the EDU's efforts to engage in areas such as: research dissemination, teaching impact, student training, and work with communities),
- an analysis of the budget and financial status of the EDU, with specific reference to previously identified plans and outcomes,
- a survey of resource allocation and usage (staffing, physical resources, etc.) of the EDU, with specific reference to previously identified plans and outcomes,
- a summary of the consultation undertaken throughout the normal activities of the EDU and the writing of this report; and
- long-term plans and goals of the EDU for the next 5-7 years, including a clear request for continuation of the EDU for a further 5-7 years (if appropriate) as well as financial and other resource implications.

- Additional information specific to the nature, goals, and operation of the EDU under review may be requested in the report at the discretion of the commissioning officer. Such request will be made in writing (via e-mail) to the Director/ Coordinator a minimum of two (2) months before the submission of the report (normally April of the year of review).
- If the EDU is seeking research funding, a description of consultation undertaken with the Office of the Vice-Principal, Research should be included.
- The written report will be reviewed by the Review Committee (normally in June of the year of review).

V. Final Assessment & Outcomes

- The review will conclude with a written statement (hereafter "Final Assessment") from the Commissioning Officer (distributed by e-mail communication) that confirms the outcome of the review. Such communication will normally occur approximately 8 weeks following the appraisal of the report by the Review Committee.
- Outcomes can include:
  - the continuation of the EDU as it is currently operating (i.e., no changes),
  - the continuation of the EDU under updated terms,
  - the recommendation to propose a re-structuring of the EDU to a different EDU category; or
  - the recommendation to propose the closure of the EDU.
- The Final Assessment will also state the anticipated year of the next review for the EDU (if appropriate).