Singapore-MIT Alliance for Research and Technology

Introduction

On July 1, 2007, in partnership with the National Research Foundation (NRF) of Singapore, MIT launched a new research center with a bold and unique vision. The Singapore-MIT Alliance for Research and Technology (SMART) Centre was founded on the premise that several of the major challenges facing society are interdisciplinary in nature and that solving them requires global collaboration in strategically located centers of research excellence.

The mission and vision of the SMART Centre is to:

- Be a world-class interdisciplinary research center that maintains the same standards of excellence as at MIT
- Identify and conduct research on critical problems of societal significance
- Develop robust partnerships with local universities and institutions in Singapore, and, in particular, integrate research with graduate and postgraduate education through co-supervision
- Be a magnet for attracting and anchoring global research talent to Singapore
- Help instill a culture of translational research, entrepreneurship, and technology transfer
- Be a platform for Singapore and MIT to develop global interactions within and beyond Singapore

The SMART Centre currently has five interdisciplinary research groups (IRGs) and an Innovation Centre. Over 100 researchers from MIT and Singapore participate in each IRG. Each IRG has an initial five-year term, and subject to review and approval may receive an additional five-year term.

The SMART Centre is MIT's largest international endeavor and it is the only research center of its kind outside of Cambridge, Massachusetts. It enables MIT faculty members and students to engage in certain types of research that cannot be carried out in Massachusetts. Examples of this research include infectious diseases (such as malaria, dengue and tuberculosis), environmental phenomena (such as the unique equatorial ocean-air coupling and the resulting weather patterns), and the development of microfluidic stem cell technologies in therapeutics for diseases that are most prevalent in the Singapore region (such as certain liver diseases). The SMART Centre gives MIT access to the deep pool of research talent in Singapore, as well as to those who are attracted to Singapore from the rest of Asia. It also provides MIT researchers with access to certain dedicated facilities not available on the Cambridge campus (such as the biosafety level three laboratories) as well as to clinical and field work essential to these research problems.

One measure of MIT's strong commitment to SMART is the amount of time MIT researchers spend in Singapore. Each principal investigator (PI) spends at least 20%

of their time at the SMART Centre during the life of the IRG, which must include one continuous stay of six months. During that time, the faculty member is not on sabbatical or a leave of absence. Moreover, at least one PI from each IRG is in long-term residency in Singapore at all times. Some faculty members have chosen to stay longer because they find the environment conducive to their research. In addition to the PIs, there is a steady circulation of MIT faculty, postdoctoral-, doctoral-, and undergraduate student researchers via short-term visits. As a result, the atmosphere at the SMART Centre is very dynamic.

The SMART Centre is located at the Campus for Research Excellence and Technological Enterprise (CREATE) in Singapore. CREATE is a complex of state-of-the-art research laboratories developed in Singapore by NRF and that is occupied by world-class research universities and corporations. A number of such universities (Ben-Gurion University, Cambridge University, ETH Zurich, Hebrew University, Peking University, Shanghai Jiao Tong University, Technical University of Munich, and the University of California, Berkeley) have set up research laboratories at CREATE. SMART is the largest research entity at CREATE in terms of participants and space. This co-location of a number of research teams from several different organizations leads to stronger collaboration among the IRGs as well as to collaboration among the various international research entities. Construction was completed in the fall of 2012 and all five IRGs, the innovation centre, and headquarters are located at CREATE.

Interdisciplinary Research Groups

Research at SMART is carried out in IRGs. As of July 1, 2014, SMART has five IRGs focused on the following topics: infectious diseases, environmental sensing and modeling, biosystems and micromechanics, future urban mobility, and low-energy electronic systems.

The SMART Centre maintains its quality through careful selection and subsequent nurturing of each IRG. Once chosen, the IRG receives substantial funding and other resources. Its progress is periodically evaluated by IRG-specific scientific advisory boards (SABs) comprised of non-MIT experts. The feedback from the SABs is meant to nurture the IRGs, especially through constructive criticism, which help the IRGs grow stronger. In addition, the SMART Centre presents semi-annual reports to its governing board, which is co-chaired by the provost of MIT and the former president of the National University of Singapore (NUS).

The topic and team for each IRG is selected through an annual MIT-wide competition that begins with an open call for white papers. Teams of faculty self-organize and submit papers. The SMART Centre's Advisory Committee—comprised of department heads from MIT's School of Engineering and School of Science—reviews them and then asks for full proposals from the shortlisted teams. After reviewing the full proposals, the advisory committee picks a single proposal and submits it to the board of the National Research Foundation of Singapore for consideration. The process is very competitive with several proposals making it to the final pool. Faculty members on participating teams are among the most research-active tenured faculty at MIT. Key selection criteria include the significance of the proposed problem, its interdisciplinary character, the innovativeness of the research approach, and the strength of the faculty team. Other considerations include its applicability to Singapore and why the MIT faculty would choose to go to Singapore rather than working on the problem in Massachusetts.

The research in each IRG is multidisciplinary in nature and consequently draws on faculty from several departments at MIT as well as faculty from NUS and Nanyang Technological University (NTU), research institutes, and governmental agencies in Singapore. The total number of participants in a single IRG is roughly 145, including about 15 MIT faculty members. The other IRG participants include faculty from the universities in Singapore, senior researchers from Singapore research institutes and agencies, postdoctoral researchers, doctoral students, and even undergraduate researchers during the summer.

Faculty members participating in SMART have received numerous honors and awards. These include election to the National Academy of Sciences, National Academy of Engineering, Guggenheim Fellowships, and several other awards. The SMART Centre has been featured prominently in several magazines, newspapers, and television programs.

Below, we summarize the research problems identified by each IRG.

Infectious Diseases

The major goals of this IRG are to advance basic understanding of pathogen-host interactions at the cellular and molecular levels; develop technology platforms that will be useful for studying infectious diseases; use this basic knowledge to develop diagnostics, prophylactics, and therapeutics for specific infectious diseases; and train a new generation of leaders for academia and the pharmaceutical and biotechnology industries. The infectious diseases IRG has been renewed for an additional five years beginning January 1, 2013.

Center for Environmental Sensing and Modeling

The goal of this IRG is to develop an accurate and predictive model of the natural and built environment of Singapore that would seamlessly transition between different scales—from the level of a single building or facility to the level of the state, including the surrounding ocean. This model will integrate a variety of data sources (many from novel sensors) and allow users to understand how changes at any scale impact the overall system, for example how a rise in sea level would impact meso-scale facilities like Marina Bay and small-scale facilities like waste outflows. Conversely, buildings contribute to a heat-island effect that is reflected in the atmospheric state; or contaminant discharges is refleced in meso-scale water bodies and ultimately in the ocean. This IRG has been renewed for an additional five years beginning January 1, 2013.

Biosystems and Micromechanics

By merging diverse engineering and bioscience areas—such as microfluidics, nanomechanics, imaging, computational modeling, materials science and biology—this IRG aims to develop disruptive technologies and become better able to diagnose, treat, and mitigate diseases while simultaneously educating the next generation of biological engineers. The larger vision is that this IRG (and Singapore itself) will become the focal point for translating cutting-edge science into novel technology for human health care. The Biosystems and Micromechanics IRG has been renewed for an additional five-year term effective January 2014.

Future Urban Mobility

This IRG intends to develop a modeling/simulation platform with an integrated model of human and commercial activities, land use, transportation, environmental impacts, and energy use. This modeling engine will be linked to a range of networked computing and control-technology-enabled mobility innovations—along with operations research–based decision models—to analyze the impacts of various novel concepts, including real-time information and management systems, and innovative mobility services such as mobility-on-demand and green logistics. This will yield a new paradigm for the planning, design, and operation of future urban mobility systems in and beyond Singapore. The IRG has submitted a renewal proposal for an additional five-year term effective January 2016.

Low Energy Electronic Systems

This IRG aims to identify new integrated circuit technologies that will become the new added value for reduced energy per function, lower power consumption, and higher performance in our electronics infrastructure. These integrated circuits of the future are expected to impact applications in wireless communications, power electronics, LED lighting, printing, displays, and computing. The research is performed by teams that have expertise in materials, devices, and circuits, invoking new advances at all levels to produce electronic systems that perform new functions while decreasing system energy. The initial technology goals are in the areas of power electronic systems, efficient communications, and multi-functional displays and lighting systems.

Innovation Centre

In addition to the IRGs that carry out research, SMART has also established an Innovation Centre modeled after MIT's Deshpande Center for Technological Innovation but adapted to the culture and practices of Singapore. Its mission is to instill a culture of translational research, entrepreneurship, and technology transfer.

The SMART Innovation Centre provides funding for faculty and students to further develop their ideas with an eye toward the marketplace. A condition for receiving funding is an agreement by the researchers to team-up with "catalysts"—entrepreneurs and/or venture capitalists with experience starting companies. The Innovation Centre has identified and trained a strong group of catalysts in Singapore. Three types of awards are given: Ignition Grants (for early proof-of-principle development), Innovation Grants (for further proof-of-concept development), and Explorer Grants (for student teams).

This approach, borrowed from the Deshpande Center, increases the chances of product commercialization. Even when an idea does not reach the marketplace, its inventors receive an invaluable education in the process of commercialization. The Innovation Centre has brought together a strong team of catalysts and is developing a network of venture capitalists from both Boston and Singapore.

The Innovation Centre also conducts educational programs that team up students from NUS and NTU with students from the Institut Européen d'Administration des Affaires—a leading graduate business school in Singapore—and Singapore Management University.

Through SMART funding, 120 invention disclosures have been filed and 13 companies established.

Outreach

Through generous gifts, the SMART Centre established a summer research internship program called SMURFs: Singapore-MIT Undergraduate Research Fellows. It is open to all undergraduates at NTU, NUS, and MIT, and gives students an opportunity to engage in research at the SMART Centre over the summer. SMURFs work in their faculty supervisors' labs, actively participate in the research projects, and engage with postdocs, graduate students, and other researchers. SMART expects that these opportunities will stimulate student interest in research and encourage them to consider a career in research. Academic experiences are supplemented with numerous arranged social activities. Based on feedback from the students, the SMURFs greatly value their experiences at SMART and the community ties established during their time in Singapore.

SMART also engages the wider research, technology, and entrepreneurial communities in Singapore through outreach in the form of special symposia, short courses, and seminars given by eminent members of the MIT community. These are open to the public, free of charge, and very well attended.

In order to encourage an open and interactive culture, SMART organizes career development and social activities for its researchers. The intent is for people from different IRGs to meet one another casually, leading to more social or technical conversations. In addition, SMART holds monthly Friday afternoon socials to which all SMART participants are invited.

SMART has been fortunate enough to secure funding from the Singapore Ministry of Education (MOE) for 100 MOE-funded doctoral students to work at SMART. The funding provides a four-year grant to cover full tuition, stipend, travel, and supplemental expenses. The doctoral students must be admitted to NUS or NTU, do a significant part of their research at the SMART Centre, have co-advisors from their home university and MIT, and be able to spend six months in residence at MIT.

In addition to the postdocs from MIT, NUS, and NTU who conduct research at SMART, the IRGs also advertise and recruit postdocs from around the world to be based permanently at the SMART Centre.

Finally, SMART has set up the SMART Fellows program (modeled after the Humboldt Fellows program) to recruit a small number of extremely talented postdoctoral researchers each year to work on their own research projects, provided the project connects in some way to an IRG theme. The SMART Fellows receive a particularly attractive stipend and research funding of their own. An MIT SMART faculty member serves as a mentor, so that the SMART Fellow has access to mentoring as and when needed.

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