Singapore-MIT Alliance for Research and Technology

On July 1, 2007, in partnership with the National Research Foundation of Singapore (NRF), MIT launched a new research center with a bold and unique vision. The Singapore-MIT Alliance for Research and Technology Centre (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 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.

As MIT's largest international endeavor, the SMART Centre enables MIT faculty members and students to engage in certain types of research that cannot be carried out in Massachusetts. Examples include studies of infectious diseases such as malaria, dengue, and tuberculosis; research on environmental phenomena such as the ocean-air coupling unique to equatorial regions and the resulting weather patterns; and investigations focusing on the development of microfluidic stem cell technologies in therapeutics for the diseases that are most prevalent in the Singapore region (e.g., certain liver diseases). The SMART Centre gives MIT access to the deep pool of research talent in Singapore, as well as 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 biosafety level three laboratories) and to clinical and field work essential to these research problems.

The SMART Centre is located at the Campus for Research Excellence and Technological Enterprise (CREATE), a complex of state-of-the-art research laboratories developed in Singapore by NRF and occupied by world-class research universities and corporations. A number of other universities (Ben-Gurion University, Cambridge University, ETH Zurich, Hebrew University, Peking University, Technical University of Munich, Shanghai Jiao Tong University, and the University of California, Berkeley) have set up research laboratories at CREATE. SMART is the largest research entity at CREATE in terms of both participants and space.

Interdisciplinary Research Groups

Research at SMART is carried out in IRGs. As of July 1, 2015, SMART's five IRGs are focused on infectious diseases, environmental sensing and modeling, biosystems and micromechanics, future urban mobility, and low-energy electronic systems.

The SMART Centre maintains quality through its careful selection and subsequent nurturing of each IRG. Once chosen, the IRG receives substantial funding and other resources needed to carry out its work. Progress is periodically evaluated by IRG-specific scientific advisory boards (SABs) composed of non-MIT experts in the field

of the IRG. The feedback from the IRG SABs is meant to nurture the IRGs, especially through their constructive criticisms, which help the IRGs grow stronger. In addition, the SMART Centre presents semiannual 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 are selected through an annual MIT-wide competition that begins with an open call for white papers to all MIT faculty members. Teams of faculty self-organize and submit white papers. The SMART Centre's advisory committee, composed of department heads from MIT's School of Engineering and School of Science, reviews these white papers and then asks for full proposals from the shortlisted teams, which typically amount to five. After reviewing the full proposals, the advisory committee selects a single proposal that is submitted to the NRF board for consideration. The process is very competitive, with several high-quality proposals making it to the final pool. The faculty members on the participating teams are among the most research-active tenured faculty at MIT. The key selection criteria include the importance of the problem proposed for study, the interdisciplinary character of the problem, the innovativeness of the proposed approach, and the strength of the faculty team. Other considerations include the importance of the problem to Singapore and the reasons why MIT faculty would choose to go to Singapore to work on this problem rather than working on it in Cambridge.

The research in each IRG is multidisciplinary in nature, drawing on faculty from several departments at MIT, NUS, and Nanyang Technological University (NTU) as well as 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 are faculty from Singapore universities, senior researchers from Singapore research institutes and agencies, postdoctoral researchers (from MIT, Singapore, and the SMART Centre), doctoral students (from MIT and universities in Singapore), and even undergraduate researchers (from both MIT and Singapore) during the summers.

We summarize below 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 was renewed for an additional five years beginning January 1, 2013.

Center for Environmental Sensing and Modeling

The ultimate 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. Examples include how a rise in sea level would affect meso-scale facilities (e.g., Marina Bay) and small-scale facilities (e.g., waste outflows), how buildings contribute to a heat-island effect that reflects itself in the atmospheric state, and how contaminant discharges reflect themselves in meso-scale water bodies and, ultimately, the ocean. The Center for Environmental Sensing and Modeling IRG was 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, the BioSystems and Micromechanics IRG aims to develop disruptive technologies to diagnose, treat, and mitigate diseases while educating the next generation of biological engineers. This IRG's vision is that it, and Singapore, will become the focal point for translating cutting-edge science into novel technology for human health care. The BioSystems and Micromechanics IRG was 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 with a range of networked computing and control-technology-enabled mobility innovations, and 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 Future Urban Mobility IRG has submitted a renewal proposal for an additional five-year term effective January 2016.

Low Energy Electronic Systems

The Low Energy Electronic Systems IRG aims to identify new integrated circuit technologies that reduce energy per function, lower power consumption, and increase performance. These integrated circuits of the future are expected to impact applications in wireless communication, power electronics, LED lighting, printing, displays, and computing. Initial technology goals are in the areas of power electronic systems, efficient communications, and multifunctional 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 develop their ideas with an eye toward the marketplace. A condition for receiving this funding is that the researchers must agree to team 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 grant awards are given: Ignition Grants (for very 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, the inventors receive an invaluable education on the process of commercialization. The Innovation Centre has drawn together a strong team of catalysts and is developing a network of venture capitalists from both Boston and Singapore.

Outreach

The SMART Centre has established a summer research internship program, the Singapore-MIT Undergraduate Research Fellows (SMURFs) program. Open to all undergraduates at NTU, NUS, and MIT, it gives students in those schools the opportunity to engage in research at the SMART Centre over the summer. The research fellows work in their faculty supervisors' labs, actively participate in research projects, and engage with postdocs, graduate students, and other researchers. SMART hopes these opportunities excite student interest in research and encourage students to consider a career in research. Academic experiences are supplemented with numerous arranged social activities. Based on feedback from the students, the research fellows greatly value their experiences at SMART and the community ties that form out of these experiences.

In order to encourage an open and interactive culture at MIT, SMART organizes career development and social activities for its researchers. The intent is for researchers from different IRGs to cross paths, leading to social or technical conversations. In addition, SMART holds monthly Friday afternoon socials to which all SMART participants are invited. These events are well attended, and they have helped build a sense of community.

SMART has been fortunate 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/supplement/travel to each of 100 incoming doctoral students. The students must be admitted to NUS or NTU, conduct a significant part of their research at the SMART Centre, have co-advisors from their home university and MIT, and have the opportunity 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 recruit postdocs from around the world who are employed and based permanently at the SMART Centre.

Finally, SMART has set up the SMART Fellows program (modeled after the Humboldt Fellows program) to recruit a few extremely talented postdocs each year to work on their own research projects. These projects must connect in some way to an IRG theme. In addition to research funding, SMART Fellows receive an attractive stipend and mentoring from an MIT SMART faculty member.

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