A. Executive summary

A.1 Current status

The most central academic unit on campus

The School of Mathematics is arguably *the most central academic unit* on campus. Like many Math departments, we provide a large number of enabling courses—in fact, every year nearly half of all Georgia Tech students take a course in the School!

What is even more striking at Georgia Tech is the amount of high level teaching provided to non-majors. Advanced courses such as real analysis, abstract algebra, probability, and dynamical systems attract large numbers of non-majors. Indeed, at the 3000 level, non-majors outnumber majors more than 10 to 1, and at the 4000 level, undergraduate Mathematics majors are only 1/3 of the total student population. Even advanced graduate courses have large enrollments from other departments.

It is fair to say that a Georgia Tech education would simply not be possible without the courses offered by the School of Mathematics. Continuing to offer all the necessary courses and meet the needs of our majors and graduate students will require a highly qualified staff of research-active mathematicians.

A highly successful research unit

The School of Mathematics is *a highly successful research unit*. Faculty in the School carry out world-class research in a variety of core and applied areas of mathematics. Our group in Discrete Mathematics is routinely ranked in the top 10 nationally, and our group in Applied and Computational Mathematics is in the top 15. Interdisciplinary projects abound. Plenary lectures at international conferences by School faculty are commonplace. About 78% of the faculty have external research support and new awards are coming in at an average rate of over $3M per year. Over half of the faculty serve on editorial boards, several of them in editor-in-chief roles.

Rapidly increasing quality and reputation

During the last two decades we have experienced *rapidly increasing quality and reputation*. As one measure, we consider NRC research ratings. In the 1982 rankings, Georgia Tech Mathematics was 71st of 102. A decade later, the 1995 ratings placed us 44th of 140. Using the middle of the research activity range, the most recent NRC study places the Georgia Tech School of Mathematics at 33rd of 127, i.e., in the 26th percentile. R-ranking and S-ranking numbers are similarly high.

As another measure, we consider awards to junior faculty. Since the last external review, School faculty have received five CAREER awards, three Sloan Research Fellowships, and one PECASE award, in addition to numerous NSF, NSA, and NIH grants.

The quality of our recruiting since the last external evaluation has been excellent and we have every reason to hope that, with adequate support, we will be able to continue our rise in quality and national rankings.

A.2 Ingredients for continued success

Budget to fill available lines

The School holds 59 tenure/tenure-track faculty lines. In recent years several of these lines have been held open to meet budget cuts. (With anticipated retirements and hiring, we expect to have four open lines in 2012-13.) A good-faith estimate of the gap between our current budget and what would be needed to fill all lines and carry out current operations leads to a "structural deficit" of approximately $450K. A sum of similar magnitude was discussed in negotiations between the current chair and the dean in 2008, but the financial crisis has so far precluded action on this point.

The School has pressing research needs and an ever-increasing load of classroom teaching, research and mentoring duties supporting undergraduates and graduates, and outreach. Long-term there is a strong case for additional faculty. In the immediate future, we are requesting an increase in budget to bring our faculty back up to full strength.

A post-doctoral program

The career path in mathematics leading to a tenured position at Research I institution often passes through a named post-doctoral position. ("Named" because the positions are often named after a distinguished former faculty

member of the institution in question—for example, CLE Moore at MIT, Hedrick at UCLA, or Golomb at Purdue.) These positions are pursued by the brightest and most ambitious fresh PhDs.

This is a stream of talent that Georgia Tech has so far not availed itself of. Doing so would have major positive impacts on several aspects of our mission. In particular, a significant post-doctoral program as proposed below would:

- increase quality and availability of courses, thereby improving the educational experience of virtually every undergraduate on campus
- magnify the research impact and influence of our senior faculty
- increase the reputation of the School of Mathematics and Georgia Tech as a whole.

The workings and impact of such a program are explained in Sections C.1 and C.2 below, and in more detail in a separate document available on the APR web site (`http://www.math.gatech.edu/APR2012`).

We are proposing a significant investment phased in over three years. The initial cost would be $433K and at steady state the program would cost $1.36M per year. Clearly this is a large investment but we argue that it is excellent value when its very large impact is taken into account. Smaller investments would also have a positive impact.

A significant post-doctoral program is *the single most important step for the future of the School of Mathematics* that is possible right now.

Better faculty support

The School of Mathematics endeavors to compete for the best faculty talent available world-wide. Increasingly we find ourselves at a significant disadvantage when recruiting and retaining top faculty due to a lack of certain faculty support mechanisms. There are several specific needs: endowed chairs or other "beyond-full-professor" positions to retain top senior faculty; a more competitive salary structure, especially to alleviate salary compression in the mid-career ranks; continued support for our excellent computing environment; more support staff; and a larger graduate program. These needs are elaborated on in Sections C.3 and E.2 below.

B. Overview

B.1 Our role, status, and ambitions

Role

The School of Mathematics plays a central role in the Institute's mission. Our contributions range from service teaching and undergraduate degree programs, through graduate education, disciplinary and interdisciplinary research, and on to service and outreach.

Our enabling courses form the foundation of most degrees at Tech. Every major on campus requires mastery of at least second-semester calculus; most require three or four semesters of mathematics, and many require significant amounts of higher-level math. Even our most advanced undergraduate and graduate courses often have large enrollments from other departments in science and engineering. In any given year, fully 47% of the Tech undergraduate population takes at least one course taught by the School of Mathematics.

Another important aspect of our role is the formation of mathematical professionals through our degree programs. The School is sole proprietor of bachelor's degrees in Applied Mathematics and Discrete Mathematics, and Master's of Science and PhD degrees in Mathematics. These degrees are the nominal focus of this review. We also collaborate with several other units on campus to offer Master's degrees in Computational Science and Engineering (CSE), Quantitative and Computational Finance (QCF), and Statistics, as well as doctoral degrees in Algorithms, Combinatorics, and Optimization (ACO), Bioinformatics, and Computational Science and Engineering.

Our status in the mathematical community is based on our disciplinary and interdisciplinary research. We have strong groups in about a dozen areas of mathematics and its applications, ranging from fundamental areas such as analysis, geometry-topology, and algebra, through interdisciplinary and applicable areas such as discrete mathematics, dynamical systems, PDEs, numerical analysis, probability and statistics, mathematical physics, and mathematical biology. These are not rigid divisions and there

is a great deal of cross-fertilization between areas. We are also deeply involved in interdisciplinary research with collaborations involving the Schools of Physics, Biology, Computer Science, Industrial Engineering, Biomedical Engineering, and others.

The School of Mathematics also contributes to the larger community through several outreach and service efforts. We inspire future scientists and engineers through the High School Mathematics Competition and through Distance Calculus. We participate in the formation and reinvigoration of teachers through the Georgia Tech's Center for Education Integrating Science, Mathematics, and Computing (CEISMC). We offer continuing education through video courses and we offer foundational courses at Tech's campuses in Lorraine and Shanghai. And we engage our alumni and friends through quality publications and periodic social, mentoring, and scientific events.

Status

We have achieved a certain level of national prominence. National Research Council ratings have placed us in the Research I group of Math departments since 1995. The most recent NRC study ranks the School's research activities at about #33 of 127. (This is the average of the 5th percentile and 95th percentile rankings of 16 and 50 respectively.) There is a clear increasing trend: in 1982, we were 71st of 102 and in 1995, we were 44th of 140.

The latest US News ranking of mathematics graduate programs places us at #30, up from #36 two years ago. Also, two subspecialties are highly ranked by US News—Discrete Mathematics at #8 and Applied Mathematics at #12. Georgia Tech as a whole is a highly regarded educational institution, consistently ranking in the top 10 among public universities in the US.

Shanghai Jiao Tong University's "Academic Ranking of World Universities" placed Mathematics at Georgia Tech #20 *world-wide*. (This is an entirely data-based ranking of the Institute as a whole, about which we will say more in Section C.2 below.)

A large proportion (currently 78%) of our faculty receives research support from external agencies such as NSF, NSA, NIH, DoD, DARPA, etc. Since the last review, five of our junior faculty members have been awarded CAREER grants, three have received Sloan Research Fellowships, and one has received the PECASE award. Several senior faculty have led Focussed Research Group projects, and several have five-year, "high-impact" awards

from NSF.

The School has competed effectively for prestigious training grants—we had a VIGRE project from 2002 to 2007, and we currently hold MCTP and S-STEM awards to support our undergraduate and graduate programs respectively.

External rankings and awards support the contention that the research and education efforts of the School of Mathematics place it among the top 30 programs in the US. More importantly, we have been rapidly increasing in quality and status.

Ambitions

The first goal in Georgia Tech's recently completed strategic plan is to "be among the most highly respected technology-focused learning institutions in the world." In support of this, the ambition of the School of Mathematics is to be among the most highly regarded programs in mathematics at public institutions in the US.

The Institute as a whole is consistently ranked as a top-10 public institution, and all of the engineering programs at the Institute are ranked in the top 10 of their respective peer groups. To maintain the Institute's ranking, the College of Science must also be in the top 10. Mathematics has this as our long-term ambition. As reported above, we can currently claim to be in the top 30. Near term, and with concerted effort, we can realistically hope to compete with the top 20 in the next decade.

A major initiative in this direction is a proposed new post-doctoral program. It would propel our research reputation and make a major difference in our teaching effectiveness. This is discussed in detail in Section C below.

Important secondary initiatives include improved faculty support (nationally competitive salaries; endowed chairs and other "super-professor" positions; a larger support staff), a larger graduate program, and improved space (both more and better). Relatively modest investments in Mathematics will pay substantial dividends.

B.2 People

Students

Every Georgia Tech student is a School of Mathematics student! Last year we taught almost 45,000 undergraduate credit hours to over 7,000

distinct students. This is more than 10% of the total credit hours taught at the Institute and more than 1/3 of the total in the College of Sciences. Each year almost half of the undergraduate population takes a course from Mathematics!

At the graduate level, last year we taught about 4350 credit hours with about 27% of them taken by students whose home school is Mathematics.

We have about 200 undergraduate students in the two majors and about 140 graduate students divided among several MS and PhD programs.

We also serve a large number of students through various outreach programs. Almost 300 Georgia high school students take calculus at Tech through the distance calculus program. About 500 middle school and high school students participated in the last High School Mathematics Competition. In 2011, over 100 students took courses taught by Mathematics faculty in Lorraine and Shanghai. And during this last summer we hosted 13 students doing undergraduate research projects.

Faculty

The school currently has 59 faculty lines. At the end of 2011-2012, 53 of these will be occupied (55 will be occupied if expected hires occur this spring). Four faculty members (one assistant, two associates, and one full professor) are on leave exploring other opportunities.

There are four adjunct professors associated with the School (Cook and Nemirovski from Industrial Engineering, Randall from the College of Computing, and Tannenbaum from Electrical Engineering). Two more are under consideration. (At Georgia Tech, "adjunct" means "prestigious associated faculty" not "temporary teaching faculty.") There is one Professor of the Practice associated with the School, Richard Milman, the Director of CEISMC.

We have three academic professionals (all with PhDs in Math or Physics) and two instructors, all on long-term contracts. The academic professionals handle computing infrastructure, advising for our majors, and scheduling and evaluation of transfer credit. The permanent instructors play a key role in mentoring our undergraduate and graduate teaching assistants. (One of them is a full-time English as a second language expert dedicated to supporting our graduate students. We may be the only program in the country with such a position.) We have one additional temporary instructor (a former tenured faculty member) teaching specialized courses related to the QCF graduate program.

Staff

The School operates with a very small staff: two in finance/accounting, two full-time and one half-time in academic support, three (one being hired) in faculty support, an office manager, and a receptionist.

We also have a small computing staff including one academic professional, two full-time staff members, and several student workers.

The overall level of staff professionalism and efficiency is remarkable.

B.3 Academic and administrative structures

Faculty committees

Roughly a dozen faculty committees set policy for the school. In total there are about 50 positions on these committees and the vast majority of faculty members not on leave serve on at least one School committee.

Academic policy is set by the Undergraduate and Graduate committees; these are entirely elected and have administrators as ex-officio members.

Appointment, promotion and tenure, and salary recommendations are made by four committees: Hiring, Junior P&T, Senior P&T, and Salary & Awards. These committees have both elected and appointed members. In response to a previous review, the size of the hiring committee was increased in 2008 in order to have greater faculty input.

An entirely elected Faculty Advisory Committee receives input from faculty members on all matters of concern and advises the chair on appropriate courses of action. It has representation from all ranks of the faculty. This committee calls faculty meetings and sets the agenda for these meetings. An entirely elected Elections and Nominations committee organizes elections for all School committees.

Appointed committees for the Colloquium, Computing, and the Library orchestrate the School's activities in these domains.

The School currently has three members elected to the General Faculty Assembly.

Administration

The School's administrative team consists of the chair, an associate chair, undergraduate and graduate coordinators, and a director of teaching effectiveness (DOTE). It also includes a team of administrators and academic professionals who handle scheduling, and permits and overloads.

Major duties of the chair include: (i) making recommendations to the Dean and Provost on faculty appointments; (ii) mentoring junior faculty; (iii) making recommendations on promotion and tenure cases; (iv) leading faculty discussions on the scientific and educational direction of the School; (v) allocating and managing the budget; (vi) and representing the School within the Institute and to external constituencies.

The associate chair assists the chairs on these matters and is specifically tasked with handling student complaints and managing the flow of research visitors and temporary faculty. This person also assists with faculty reviews (P&T, annual, periodic peer review) by drafting letters and apprising all parties of procedures and deadlines.

The graduate coordinator administers our graduate programs and in particular makes decisions about admissions and financial support.

The undergraduate coordinator leads discussions about undergraduate curricular policy and makes decisions about prizes and awards.

The director of teaching effectiveness (DOTE) coordinates the School's mentoring and evaluation of teaching. This person is a resource for faculty on all matters related to teaching and he or she plays a role in promotion and tenure considerations—each P&T case includes a letter from the DOTE discussing and evaluating student CIOS reviews as well as peer visits to the classroom. These reports are a very important part of our P&T process.

The scheduling team consists of the undergraduate and graduate coordinators, the DOTE, and three other faculty members (instructors or academic professionals responsible for matters related to undergraduate and graduate TAs, majors, and scheduling). This team carries out the herculean task of arranging the schedule of all Math courses and assigning faculty and teaching assistants to each course. More details of the workings of this team appear near the end of Section E.1.

B.4 Resources

Faculty lines

We are currently authorized to fill 59 lines. This number is not likely to increase in the immediate future, but we do expect to keep them all filled insofar as is possible. As will be discussed below, over the last few years several faculty lines have been left unfilled in order to close budget gaps. Closing this "structural gap" in our budget was a commitment made by the

College at the start of the current chair's appointment, and it will effectively give us several new positions. This should help alleviate the strains associated with increasing student populations and increasing commitments to the rest of the Institute (such as joint degrees and interdisciplinary research programs).

Budget

Our main state budget is currently approximately $8.8M. The major categories of spending are as follows:

Tenure/tenure-track faculty:	68%
Contract faculty and staff:	11%
Graduate program:	15%
Visitors and research support:	6%

Over the last five years, our main budget was cut by approximately $800,000, or roughly 10%. About half of this cut has been met by holding open faculty lines. The majority of the rest was met by drastically reducing our program of matched post-docs and visitors. Smaller sums were saved by eliminating a staff position and reducing the number of teaching assistants and graders. Additionally, all faculty and staff suffered furloughs in 2009-10 on a sliding scale of up to six days (which amounted to a pay cut of about 3%).

There are two other important streams of revenue to the School. The first comes from start-up commitments made with new faculty appointments. Funds are allocated to new faculty members for travel, equipment, students, etc., as at most other universities. These funds are controlled by the faculty member, not by the School. However, and in the background, a second commitment of funds is made to the School to be used for computing equipment. As discussed on the following page, our computing environment is managed centrally and this stream of start-up commitments is the critical resource that allows us to build and maintain a quality environment. Last year there was some resistance from the Provost's office to this model and we view this as a significant threat to the long-term health of our computing environment.

The second stream of revenue mentioned above consists of funds from the Georgia Tech Research Corporation (GTRC), the Georgia Tech Foundation (GTF), and our friends and alumni. These are the only funds that can be

used for entertainment, faculty and graduate student recruiting meals, and other purposes not allowed with state funds. Our GTRC allocation in the last two years has been $17,000, which is roughly half of what it was in earlier years. Our Foundation accounts are small—currently slightly less than $100,000, and most of these accounts have restricted uses. We are working diligently to build relationships with friends and donors with a view toward future donations. See "Alumni and Friends" below for more on these efforts.

Computing environment

The School's computing environment is managed centrally so that all computing resources are shared and form a coherent system. The environment and support thereof are often commented on positively by visitors and faculty candidates. It is our main laboratory and is becoming increasingly important both directly for our faculty and students, and as we deepen our collaborations with other Schools, notably the School of Computational Science and Engineering.

Here are more details of this resource: The School's computing environment consists of a high-speed, Gigabit switched network connecting several hundred workstations, printers, servers, and other network devices.

We support a variety of desktop and laptop hardware. We have over 175 computers in offices and computing labs. The PCs mostly run Linux and are typically at least 2.4-GHz, quad core CPUs with 8 Gb of RAM. All of them have 64-bit processors and most have a reasonable quality discrete video card.

All user data, including large research datasets, are stored on a secure central file server. The storage capacity is several terabytes of hot-swappable disks in a RAID configuration. All user data (files, email, etc.) and critical system configuration data is backed up nightly.

We support two computer labs for graduate and undergraduate students with a total of 26 seats. Note that, since 2009, all Georgia Tech students are required to have a laptop. The lab systems mostly run Linux, but we also have Windows 7 and Mac OS X systems available there, as well as scanners and printers.

The School of Math has a small cluster of servers for high performance code that can take advantage of a parallel and/or distributed computing architecture. This includes a server with NVIDIA TESLA C2070 video card for GPU processing. In addition, our faculty and students have access to a

1000+ node cluster which includes Infiniband connected computing nodes funded by the Institute.

We also support several other services internally including a web server, mail server, database server, print server, backups, secure remote access, etc.

Finally, we have several network printers and copiers which are available from anywhere on our network. They include standard features such as scan to PDF emails, duplex printing, etc.

Alumni and friends

We view the friends and alumni of the School as an important resource, both for their potential as future donors and as a source of mentoring and career development for our students. As a result, significant effort has been devoted to cultivating relationships with them.

Working with the College of Sciences development office, the chair identified several likely leaders among this group and engaged them. In April 2010 a meeting was held with about a dozen potential friends of the School and several administrators, faculty members, and students. The group was given an overview of the School's mission and ambitions, as well as some indication of research directions and student activities. There was also a discussion of ways in which friends and alumni would like to be involved with the School. As a result, a group called the Friends of the School of Mathematics (FoSoM) was formed.

Since then, we have been organizing events for this group at a pace of about one per semester. In Fall 2010, we held an undergraduate research poster session. In Spring 2011, we had a panel discussion (with panelists from FoSoM) on non-academic careers. This was very popular with both undergraduate and graduate students in the School. It turns out that two members of FoSoM are serious barbecue enthusiasts, and so in Fall 2011 we will have an all-School barbecue hosted by FoSoM.

Clearly efforts to engage our friends are in early stages, but we have seen significant commitments and donations as a result of efforts so far. Two alumni have pledged $1,000 each per year for five years to support School activities, and another has committed an additional $25,000 over five years, above and beyond previous generous donations. Also, several students have established mentor-mentee relationships with members of FoSoM.

B.5 Notable achievements

Faculty milestones

Faculty in the School have received significant awards of several types since the last departmental review in 2007.

In 2010 Robin Thomas was appointed Regents' Professor, bringing to two the number of Regents' Professors in the School.

Maria Westdickenberg received a PECASE award (the Presidential Early Career Award in Science and Engineering, "the highest honor bestowed by the United States government on science and engineering professionals in the early stages of their independent research careers") in 2011.

Sloan Research fellowships were awarded to Silas Alben in 2011, Maria Westdickenberg in 2010, and to Dan Margalit in 2009.

NSF CAREER awards were made to Maria Westdickenberg in 2010, Dan Margalit in 2010, Brett Wick in 2009, Yuri Bakhtin in 2008, and Haomin Zhou in 2007.

Rafael de la Llave was appointed a fellow of the Institute of Physics in 2011. Klara Grodzinsky received the Institute-wide CETL Undergraduate Educator award in 2011. Jeff Geronimo was appointed to a Cátedra de Excelencia chair in Madrid in 2011. Matt Baker won the University System of Georgia Regents' Teaching award in 2010. Robin Thomas was a co-recipient of the Fulkerson Prize, for the second time, in 2009. Liang Peng was appointed fellow of the IMS in 2009. Prasad Tetali was appointed a fellow of SIAM in 2009. Tom Trotter won the College of Sciences' Gretzinger Award for his efforts toward faculty diversity in 2009. Brett Wick received a Humboldt Research fellowship in 2009. Michael Lacey received a Fulbright fellowship in 2008.

Several faculty members (Professors Alben, Bunimovich, Loss, Peng, Yu, and Zhou) have collaborative, multi-institutional projects with NSF support. Christine Heitsch was PI (with co-PIs in Biology and Computer Science) on an NIH R01 grant of $1.3M awarded in 2007.

Major training grants

Both our undergraduate and our graduate programs are currently supported by major training grants. PI Michael Lacey made a Mentoring through Critical Transition Points (MCTP) proposal to NSF which was awarded $730,000 in 2008. This grant supports our undergraduates through scholarships for high performing majors, the High School Mathematics Compe-

tition, a teaching seminar to train Undergraduate Teaching Assistants, and the distance learning program to teach Calculus 2 and 3 in high schools.

PI Luca Dieci made a proposal to the Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) program at NSF which was funded with $600,000. The grant supports graduate students, mostly through fellowships.

Staff awards

Staff awards: Justin Filoseta received an Institute-wide Outstanding Staff award in 2010. Sharon McDowell received the same award in 2009.

School advancement

During the academic year 2009-10, the School discussed, wrote and voted in a strategic hiring plan. The process, which was arguably at least as valuable as the final product, included vigorous debate about future directions for the school and tactics to achieve our goals. Further discussion and revision, to take into account progress in the preceding two years, took place in Fall 2011. The 2009 document and its revisions are available on the APR web site.

Since the academic year 2008-09, a team led by Michael Loss has produced a very high-quality glossy annual newsletter called *ProofReader*. This publication has made a remarkable impression on our alumni and friends and is a great ambassador for the School. (The review team is highly encouraged to have a look.) Publication has continued at a pace of once per year. Making sure that this effort continues in the long-term should be a priority for the School.

As discussed in B.4 above, the School has formalized the group "Friends of the School of Mathematics" (FoSoM) for friends and alumni of the School. We are working to develop this group into a significant resource for the School and its students.

C. Vision and strategic direction

We reiterate that the long-term ambition of the School of Mathematics is to be ranked among the best in the nation and that our near-term goal is to compete with the top 20. This section spells out some details about what we will do in the next few years to achieve this ambition.

C.1 Educational vision

Research-active teaching faculty

Georgia Tech students need and deserve instruction in the most sophisticated mathematics available. They drive demand for a large number of high-level courses, research experiences, and one-to-one faculty contact. These needs can only be met with research-active faculty. Our tradition has been to have few (if any) non-PhD temporary faculty and to have faculty of all ranks teaching students of all levels. This must continue.

It is therefore imperative that we be able to fill and keep filled all our lines. Budget cuts in recent years have been met partly by leaving open lines unfilled and this has led to strain on class sizes and availability of courses.

In the near term, we need to fill the "structural gap" in our budget and fill all authorized lines. In future years, increased enrollments may bring the need for additional permanent faculty.

A post-doctoral program

In a separate document we make a case for a large program of terminal post-doctoral positions. These positions would be populated by top-tier fresh PhDs whose long-term ambitions include tenure-track appointments at the main research universities such as Georgia Tech.

One of the principal motivations for such a program is the impact it would have on our lower-division teaching mission. Namely, it would provide a *flexible* source of *high-quality* teaching labor. Appointees will be energetic, highly motivated, and, as products of other top universities, likely

to be acquainted with the latest thinking in science education. At the proposed scale, the program would allow us to reduce average class size in lower division (1000- and 2000-level) courses from the current 120 students to 80 students. Given the large fraction of Tech students who take Math courses every year, the impact on the undergraduate experience would be huge.

Secondary but still very important effects would occur at the upper-division level. Under the proposed conditions and scale, we would be able to offer eight additional advanced undergraduate courses and eight additional graduate courses per year. It is also very likely that many of the post-doctoral appointees would become involved in undergraduate research and other one-to-one mentoring activities. They would also be an excellent resource for graduate students. These additional resources will have a large positive impact on our undergraduate and graduate degree programs.

Technology and a scientific approach to teaching

As detailed in Section E.1, we are just beginning to explore new technologies and learning strategies: personal response systems ("clickers"), on-line homework, and on-line learning platforms such as MUMIE have all been the subject of experiments in the School over the last few years. These experiments have generally been positive and there is interest in spreading some of these innovations more widely in the curriculum. Our vision is that the School will be open to experimentation, that we will take a scientific approach to evaluating the results, and that we will be serious about implementing innovations with potential positive impact more widely in the curriculum.

It is worth pointing out here that resource constraints may be a limiting factor in some of these efforts. For example, there is interest in programs such as SCALE-UP, but lack of enough suitable spaces is an obstacle to widespread implementation.

C.2 Research directions

Excellence in a limited number of areas

The School's strategy has been to focus on a limited number of areas where real excellence can be achieved. This strategy has served us well and we plan to continue it. That said, the set of areas we strive to excel in is not static and will evolve over time. Significant energy was put into developing a

strategic hiring plan that names specific areas where we will build strength. These are discussed in the sections that follow.

Renewal in applied and computational mathematics

Applied and computational mathematics, in various guises, has been a strength in the School for as long as it has had research ambitions. Clearly this makes sense in our institutional context and is a tradition that should be built upon. The strategic hiring plan makes a case that the School could profit from exploiting developments on campus in this area (strategic initiatives, hiring in other units, new degrees), and it calls for targeting faculty in applied and computational mathematics more aggressively.

Algebra, broadly construed

The strategic hiring plan calls for aggressive efforts to build strength in algebra, here defined to include algebra, number theory, algebraic geometry, and algebraic combinatorics, as well as their applications. Partly this is due to the large place this area has in contemporary mathematics, partly it is because strength in the area will support interactions with Industrial Engineering, Electrical Engineering, Computer Science, Biology, Statistics, and other areas. There is also a need for staff to teach advanced courses in this area. Significant progress has been made in the two years since the plan was written (with the hires of Josephine Yu and Greg Blekherman), but there is more to be done and possible departures may increase needs in this area.

Mathematical biology

Biology is the focus of a major strategic thrust at Georgia Tech and mathematical biology is an area where the School has a small but excellent core group. The strategic hiring plan notes that we are well-positioned to become leaders in the field. For example, a recent $16M proposal for a center ranked second in the nation, and proximity to CDC and Emory gives us resources not available to others. The plan's recommendation is to hire faculty in mathematical biology with a particular focus on systems biology/dynamical systems on networks, mathematical immunology, and computational methods in biology.

Probability and Statistics

This is another area where we currently have a small but strong group with an excellent record in training graduate students. There is large demand

for statistics instruction on campus and discussions are under way about a potential PhD in statistics. This would almost certainly be offered in conjunction with the School of Industrial and Systems Engineering, and there is need to coordinate statistics instruction and research with that School. One excellent hire (Karim Lounici) has been made in the area since the strategic hiring plan was put in place, but further reinforcements are needed.

The unity of mathematics

The discussion of specific subfields of mathematics above should not obscure the unity of the field and our commitment to cross-cutting research. History has shown repeatedly that core and applicable mathematics are synergistic and feed each other in unpredictable ways. We emphasize recruiting faculty who can bridge areas, especially across a perceived applied/core divide. Examples from the last few years include: Rafael de la Llave (math physics and computation), Greg Blekherman (algebraic and convex geometry and their applications), Howie Weiss (dynamics and biology), Christine Heitsch (discrete math and biology).

The utility of mathematics

We view the School's existing connections with other units on campus as a great strength. These include research and teaching collaborations with units as diverse as Industrial Engineering, Computer Science, Computational Science and Engineering, Electrical Engineering, Physics, Biology, and Management.

We will continue to build these existing collaborations and we are open to others. To be specific, for example, our recent proposal for a Simons Math+X chair brought out possibilities for collaboration with the Schools of Mechanical and Aerospace Engineering.

Research benefits of a post-doctoral program

The post-doctoral program mentioned above would also have major positive benefits for our research program. It would bring a steady flow of the most ambitious young people to Georgia Tech, allowing us to learn in depth about the latest developments and magnifying the research influence of our senior faculty. To quote from a recent book of advice to young people in mathematics:[1] "one thing that makes the elite ... math departments special

[1] S. G. Krantz, "A Mathematician's Survival Guide," p. 204

is that most of them have" a program of instructors. After explaining how these positions work, he notes: "From my own point of view, one of the most important perks of being a member of one of the elite departments is this never-ending supply of young mathematicians."

The Georgia Tech Mathematics brand

We mentioned above that Georgia Tech is rated number 20 in mathematics *world-wide* by Shanghai Jiao Tong's "Academic Ranking of World Universities." This ranking is based entirely on objective data (publications, citations, prizes) and has no reputational component. It places Georgia Tech substantially higher than the NRC or US News ratings. We believe that this is because the Shanghai rankings take into account the mathematical output *of the Institute as a whole*. Clearly there is a great deal of mathematics produced on campus outside the School of Mathematics (e.g., in Industrial Engineering, Computer Science, Electrical Engineering, ...) and this very rich mathematical environment is an advantage for the School. It is worth exploring whether there are structures or modes of cooperation that could further take advantage of this resource.

C.3 Challenges

Budget cuts

As noted above, the School's budget has been cut by about $800,000 over the last five years. These cuts have been met with (i) drastic reductions in the number of visitors and post-docs; (ii) elimination of staff positions; (iii) faculty lines being left open. It is imperative to eliminate (iii) and reduce the effects in (ii) and (i).

Quality space

As mentioned is Section B.4, the Skiles building is ill-suited to its current uses. In the long run, a total renovation or even a new building will be required. In the short run, continued infrastructure issues are certain to arise.

Beyond Skiles, there is a lack of certain kinds of classroom space, for example very large lecture halls. Moreover, we have little access to small classrooms outfitted for non-traditional teaching, e.g., in the SCALE-UP model. Also, the technology available in classroom is of very uneven quality

and the number of rooms suitable for distance learning and video courses is quite limited.

Lack of suitable classroom space spills over into scheduling—with not enough rooms available at popular times, courses are pushed into more marginal slots and there is strong competition for seats in prime-time sections.

Retention

Excellent recruitment has brought strong retention challenges. One cause is that there is marked salary inversion in the ranks of associate professors (where there is a *negative* correlation between time since PhD and salary, even after removing outliers).

At the senior levels, salaries are beginning to lag. Also, the lack of endowed chairs or other positions higher than full professor has been a challenge both for recruitment and retention.

Diversity

The School has made significant progress in recruiting and promoting excellent female faculty. Indeed, after last year's promotions, we quadrupled the number of tenured female faculty, from one to four. We also have one excellent female assistant professor.

Unfortunately, as with all excellent faculty, retention is a challenge and we may lose one of the four tenured female professors. Moreover, there is definitely room for more progress. Given that some critical mass has been achieved, we are hopeful for the future, but attention must be paid to this issue.

Recruitment of minority faculty has been extremely challenging.

Leave policies

A substantial fraction of NSF resources for research in mathematics is devoted to supporting research institutes (IPAM, MSRI, IAS, IMA, etc.). This underscores the importance of this type of activity for research in mathematics.

On the other hand, the University System of Georgia has quite restrictive policies regarding absence from campus. So far we have been able to organize research visits and semesters away for junior faculty while staying within the letter (and spirit) of the law, but this has relied on the cooperation and understanding of the upper administration.

We encourage the administration to pay attention to the travel needs of faculty in all fields (especially non-lab-based faculty) when formulating leave policy.

A related challenge is the absence of a true sabbatical program for Georgia Tech faculty. We have a system of "faculty development leaves" under which the School pays the faculty member full or half salary (for leaves of a semester or year respectively) and receives a fairly nominal sum ($16,000) to be used to make up the teaching effort. Recent and very short-sighted changes to policy on benefits and part-time employment—specifically, the plan not to offer benefits to employees working less than 75% time—promise to make an already weak sabbatical program impractical for many faculty members.