Executive Overview of the Pratt School of Engineering Strategic Plan

Executive Summary

The mission of the Pratt School of Engineering is to provide a rigorous engineering education for our students, enabling them to lead productive, rewarding and ethical lives for the betterment of society. It is our vision that Pratt students and faculty will be catalysts for integrating and generating knowledge across the disciplines required to address complex issues facing a global society.

Our objective is to be an integral part and integrative force for industry, government and academic communities. The Pratt goal is to create a culture for interdisciplinary research and translating breakthroughs in engineering design, the basic and applied sciences and medicine into new products, processes, diagnostic techniques and therapies for improving the human condition and the environment. The impact of achieving this goal will be the creation of a highly distinguished school that brings more distinction and value to the Duke University brand name.

In order to carry out our objective and goal, Pratt must increase its faculty and student size to play this basic research and translational role for the University. Our plans call for increasing the faculty size by thirty to forty percent over the next six years, doubling the size of our graduate student population, substantially increasing the undergraduate enrollment starting AY2002/2003, and building a world class engineering infrastructure, such as the proposed Interdisciplinary Engineering and Applied Sciences Center (IEASC) in the University’s Master Plan 2000. Great facilities are necessary to attract outstanding faculty and students.

Our strategy for attracting the very best faculty is to launch three interdisciplinary research initiatives that build on our acknowledged strengths in areas of future strategic national importance: Photonics and Communications; Bioengineering; Materials Engineering and Material Systems. Along with reinvestment positions from anticipated retirees, we will invest approximately two-thirds of new faculty hires in these three research initiatives. Most of the remaining positions will be invested in cross-department/cross-school focus programs such as environmental engineering, fluid/structure interfaces and adaptive structures, high performance computation and modeling and entrepreneurship. Finally, we will reserve several positions for targets of opportunity to attract the highest quality faculty in areas that are related to strengths within Pratt and Duke University.

The tactics for hiring the best personnel will be to recruit "magnet" faculty through connections with our existing excellent faculty and the reputation of our undergraduate and graduate students. It is anticipated that each magnet position will hold a distinguished chair and receive substantial startup funding in order to establish a world-class program in one of the three strategic research initiatives or focus programs. These programs will attract other colleagues and newly graduated Ph.D.’s to Pratt. Excellent faculty will draw in the best graduate students, thus increasing our quality, visibility, and desirability as a place to study engineering. Furthermore, the planned expansion of the physical plant and
faculty will potentially more than double Pratt research expenditures, thus providing a substantial increase in indirect costs to Pratt and the University.

Key milestones include well establishing three strategic research initiatives, implementing the staffing plan by December 31, 2000, breaking ground on the IEASC during the summer of 2001 (with occupancy in fall 2003), acquiring the resources for nine new-distinguished chairs (for recruitment and for faculty retention) by 2003, revising the engineering curriculum, adding first year focus programs, and upgrading the laboratories and classrooms by 2004, hiring thirty net faculty by at least 2006. Achieving these milestones will require raising our current campaign goal from $50M to $170M. These additional resources are needed to fund our strategic initiatives including the 240,000 ft$^2$ (gross) new, Interdisciplinary Engineering and Applied Sciences Center (IEASC), support endowed professorships, undergraduate scholarships and graduate fellowships and purchase state-of-the-art equipment to upgrade our engineering laboratories.

It will take tremendous focused effort to achieve these milestones. When successful, one outcome will be to greatly enhance the quality of our undergraduate engineering education by providing a world-class intellectual and physical environment for the creation and transfer of knowledge. At the graduate level, this expansion, in targeted areas of future national strategic importance, will allow us to move swiftly to the forefront of engineering research and development in the 21st century. Our ten-year vision is to increase the tenure-track faculty to 120, double again the graduate student size and expand the IEASC by another 120,000 ft$^2$ building. Architects hired to study the site for the IEASC, as part of the master planning process, have stated this site can easily accommodate double the space proposed for our phase I, five year planned expansion.

The outcome of successfully executing our plan will be to increase the brand name of Duke University by building a distinguished school of engineering that provides a mechanism to translate breakthroughs in basic engineering and applied science research into new products and processes, thus creating new industries and a workforce for the betterment of society.

1.0 The Pratt School of Engineering: A Strategic Investment Opportunity for the 21st Century Duke University

1.1 The National Need for Engineering

The trajectory of technology acceleration is illustrated by the astonishing fact that it took about fifty years to connect up the first five million telephone users and only five years to generate the first fifty million Internet users. Such connectivity will result in a very different world as we enter the next century – one that is more open, global and knowledge-based. Knowledge is power, and technology is access.

The growth in Internet connectivity is the "great new development since the start of the Industrial Age" which is "... driving the U.S. economy today". Indeed it is estimated that one-third of the Nation’s wealth generated over the past seven years has been from information technology (IT). This has serious implications for both the engineering profession and our society. The biggest impact and opportunity for solving some of our country’s most insidious problems is addressing the critical shortage of information technology workers.

Our technology-based new economy has created a shortage of over one million IT
workers in the United States alone. At the same time, it should be noted that all schools of engineering and technology in the United States graduate only 65,000 engineers per year. This order in magnitude difference between supply and demand – is an opportunity for Duke University. In addition to the profound demand for technology workers, there is a need to educate the "new engineer" as leaders and innovators in this new economy. Fortunately, this is exactly what Duke Engineering does best – arguably as good or better than any other University!

The new engineer of the 21st century must respond to an era of "disruptive change through technology innovation" She or he will need to think strategically and holistically about complex problems. Engineers must have the ability to integrate knowledge to some purpose – as in the mission of the Pratt School of Engineering graduate research program – to improve the human condition and nurture the environment, while contributing to economic diversity in our society.

Engineers, particularly those educated at Duke University, will be called upon (as in the past) to lead multi-disciplinary teams of individuals with diverse backgrounds involving technology, marketing, sales, finance, human resources, and project management. They will need to have unique expertise and skills in one of these disciplines (in order to bring something to the table) and must also be able to appreciate the views and opinions of those skilled in other areas. To effectively lead, they must possess more than just written and oral skills; she or he will need to be persuasive and logical in their arguments. Finally, the new engineer must have a strong appreciation and commitment to engineering and business ethics. We refer to these attributes of the new engineer as the pyramid of knowledge skills or the "employable quintet".

1.2 The Value of Engineering to Duke University

Pratt sees its purpose and goal to be the translational unit at Duke University – a lightning rod for technical focus programs of interdisciplinary excellence. For example, in the applied sciences, we plan to translate knowledge from the physics and chemistry of nanoscience into new devices and applications ranging from effective drug delivery systems to photonics switching devices. Within the University's strategic initiative for genome science and policy (IGSP), Pratt can play a role in the various centers including genome technology, bioengineering, bioinformatics and in the formation of a new center for imaging.

2.0 Pratt School of Engineering Current Size and Anticipated Growth to Capitalize upon the National Need and University Opportunity

2.1 Demographics

The Pratt School of Engineering currently educates 906 undergraduate students, 262 graduate students, with seventy tenure track faculty and forty research faculty in four departments (Biomedical Engineering, Electrical and Computer Engineering, Mechanical Engineering and Materials Science, Civil and Environmental Engineering) occupying 101,000 ft² of space in the Teer Building, Hudson Hall, Hudson Hall Annex, the Center for Engineering Education and the Levine Science Research Center (LSRC).

The undergraduate class of 2004 is comprised of 26% women, which ranks Duke high among all research universities in the country for percentage of women students in engineering (In 1998, Duke was ranked #1 in this category). African American and
Hispanic students comprise 3% and 2%, respectively of the undergraduate student body. Of the 262 graduate students enrolled in PRATT, Women comprise 26% while 2% are of African American and Hispanic background. The faculty comprise 8.4% Women, and 2.8% African American and Hispanic.

In 2000, *The US News and World Report* ranked the Pratt School of Engineering undergraduate program 22nd and the graduate program 33rd in the country among 219 technical and engineering educational institutions. This represents an improvement from 24th to 22nd in the past year in our undergraduate program. The undergraduate program in Biomedical Engineering is ranked 2nd and the graduate programs for Biomedical Engineering and Environmental Engineering are ranked 4th and 18th, respectively, by the same survey. Since both undergraduate and graduate rankings are influenced by opinion polls, Pratt will send out an annual report (highlighting our excellence) for the first time in 2000. This should increase our visibility and perhaps impact our rankings.

2.2 Faculty and Student Size

Pratt has the smallest faculty and student body size of any top twenty-five engineering school in the country. An increase in Pratt faculty will bring enormous value to the University. More faculty will enable Pratt to play its strategic role as the translational agent at Duke. A larger faculty should be able to accommodate a larger undergraduate and graduate student body size to help support the expansion in faculty and deepen our students intellectual experiences at Duke. A larger faculty means greater research expenditures and indirect costs contributed to Duke. Pratt departments compare favorably on average with other departments at Duke University with regard to research productivity per faculty per square foot.

It is the vision of both the former Provost John Strohbehn, in his thinkpiece, "Duke University at the Millennium", and the current Senior Officers of the University to believe the Pratt School of Engineering should expand its faculty by thirty to forty percent over the next six years. After an extensive comparison with peer institutions in the top twenty-five schools of engineering in the country, we believe this should be a minimum goal. Noting that this goal was set before the magnificent naming gift by Edmund T. Pratt, Jr. and subsequent gifts by Alston Gardner, Jeff Vinik and others, we should be able to support growing to 100 faculty over five years. Within ten years, Pratt aspires to have a faculty size of over 120, with an increased graduate and undergraduate student enrollment. Our challenge will be to improve the high quality of our faculty and students as we grow the undergraduate and graduate student body.

3.0 Pratt School of Engineering Strategic Investments

3.1 Pratt Strategic Research Initiatives

In formulating their recommendations to the planning steering committee of Pratt, the members of the working group (WG) on research trends and priorities identified several strategic initiatives where Duke’s unique location, existing expertise, and/or compelling opportunity for attaining international leadership in research or education could be exploited. After reviewing the comments of this WG, feedback from the Pratt planning steering committee and individual faculty, Pratt proposes to launch major initiatives in:

1). *Bioengineering – Biomedical Engineering* integrating knowledge from molecule-to-human in focus areas of excellence including imaging, applied electrophysiology,
biomaterials, biomechanics and tissue engineering. As part of this initiative we intend to propose a new center for the IGSP initiative. This new Center for Imaging and Pattern Recognition will span the departments of BME, ECE, Radiology, and Oncology in the Medical Center. The topics covered will include data mining, image analysis, and image rendering and visualization. A proposal for this new center will be submitted to the IGSP Planning Steering Committee during Fall 2000. Another tie between this initiative and IGSP is in the development of new tools and instrumentation as part of the IGSP Center for Genome Technology. We anticipate that space within the newly proposed IGSP building will accommodate the integration of these engineering programs into IGSP.

2). Information Technology – Photonics and Communications Interdisciplinary (PCI) Initiative focusing on optical materials, optomechanics and packaging, fiber-based switching devices and broadband, dense wavelength division multiplexed networks designed with these new devices in mind. This will also allow us to attract world class collaborators to Duke in communication and computing including network scalability and ubiquitous computing, high-performance computing and algorithms, imaging and scientific visualization, intelligent systems and computer security and privacy.


Each of these initiatives leverages world-class expertise and cross-departmental and cross-school collaborations at Duke University. The MEMS, PCI and a Center for Neuroengineering (within the Bioengineering initiative) have been identified as high priorities for funding by the Provost’s interdisciplinary planning process. The strategy for supporting the efforts in these three initiatives involves partnerships with Foundations and Funding Agencies (Whitaker and NIH for Biomedical Engineering, DOD and NSF/STC in Materials Engineering and Materials Systems), private donors and industry contacts (Photronics and Communications). There is the potential for several, large (eight figures) external investments made in these initiatives.

In addition to these major cross-school initiatives, Pratt currently has identified four interdisciplinary focus programs of excellence including:

- **High Performance Computation and Modeling** (joint with CEE, BME, ECE and IGSP).
- **Fluid/Structure Interfaces and Adaptive Structures** (MEMS).
- **Environmental Engineering** (joint with CEE and NSOE).
- **Entrepreneurship** (joint with the MEMP and Fuqua).

3.2 Partnerships

3.2.1 Internal

As the translational unit at Duke University, Pratt has established collaborations with the School of Medicine, Nicholas School of the Environment, Trinity Natural Sciences, Fuqua School of Business and the Law School through joint seminars, joint and secondary appointments, team teaching of courses and collaborative research. The focus on future internal partnerships will be to establish the infrastructure for engineering-driven, research
and teaching initiatives in bioengineering, photonics and communications, materials engineering and material systems, and focus programs in high performance computation and modeling, fluid/structure interfaces and adaptive structures, environmental engineering and entrepreneurship. We anticipate an even closer relationship in particular with SOM in the context of joint imaging centers proposed to NCI and the Duke IGSP initiative and NSOE to provide a “tag” for Duke environmental science and engineering.

3.2.2 External

External partnerships involve expanding our relationships with local industry in RTP, national and multinational companies through collaborations on projects in our research initiatives and focus programs. We will continue to encourage a flow of faculty and business professionals to and from Pratt. For example, engineers from Cisco Systems in RTP teach the Introductory to Computer Networking Course in the ECE department in the fall, and supervise undergraduate research students in the spring. Similar relationships exist with IBM-RTP. Cisco also funds graduate students and has hired several of our PhD students upon completion of their degree. Outside RTP, similar relationships with Motorola and Telcordia also exist. To organize and facilitate these relationships, we have hired a new Associate Dean for Industry and Corporate Relations, Mr. Russell Holloway. Our planned expansion of a master’s degree program will deepen our relationships with companies locally, nationally and internationally.

4.0 Implementation Plan

4.1 Education Innovations

The main goal of the implementation plan for the innovations in education is to substantially revise the first and second year curriculum. With the new IEASC, it will be possible to finish the laboratory upgrades and classroom technology enhancements by spring 2003. Detailed plans are in preparation for identifying team leaders incented to completion of the revisions and upgrades.

Plans

In order to meet our goal, Pratt is embarking on a general curriculum revision. The revisions will be phased in over a five year period beginning in 2000/01. The initial focus is on completing a comprehensive review of our curriculum, and developing a set of recommendations that will be presented to the faculty in Spring 2001, for adoption starting in the Fall of 2001. There has been an identified need to engage our students in the first year, and integrate their learning experience over the four-year curriculum. We will start by offering EGR 010 for the first time in the spring of 2001. This course is designed to provide our first year students with an introduction to the study and practice of engineering. A second course, EGR 020, will be developed during the 2001/02 academic year, and a pilot program offered to a limit of thirty students will be offered in the fall of 2002, with full implementation of the first year taking effect in the fall of 2003.

The integrative theme of the second year curriculum will be on core competencies. ABET lists eleven outcomes, or core competencies, that we must demonstrate, and the second year curriculum will be designed with these outcomes in mind. Year three will incorporate PROSE, which will be a logical lead-in to the senior year capstone design experience. Each year’s revisions will be tested in a pilot program a year prior to adoption. The complete four year revised curriculum will graduate its first students in 2006.
Benchmarks

The impact of the curriculum changes on our graduates will be monitored using both self and external assessment methods. Internal assessment methods will include a close monitoring of attrition rates over time, feedback from departmental industrial advisory boards, a senior survey, and both a five year and ten year alumni survey. External monitoring will involve a continuous evaluation of the size and depth of our applicant pool, comparative selectivity, employer feedback and, of course, national ranking. To better serve our constituencies, curriculum changes will be made on a regular basis as needed.

4.2 Graduate Research Programs

Assessment

The major impediment to improving our graduate research program and investing in faculty development is the lack of world-class facilities for housing our three interdisciplinary research initiatives and four focus programs. The establishment of these programs is gated by the availability of space and the timeline for building the proposed IEASC. Associated with each initiative and focus program is a detailed planning document, available upon request.

Plans

The timeline for launching our initiatives and focus programs is tied to space availability. We plan to announce the Photonics and Communications Initiative in the Fall of 2000, so that we can recruit students for academic year 2001/2002. Dr. George Truskey, Interim Chair of the Biomedical Engineering Department submitted a proposal on behalf of the BME faculty to the Whitaker Foundation August 15, 2000. We will find out later this fall if we are awarded a site visit, tentatively planned for the Spring of 2001. This will allow us to announce the Bioengineering Initiative in the Spring of 2001. The Materials Engineering and Material Systems Initiative submitted a proposal for a Science and Technology Center to the National Science Foundation for funding in 2002. We plan to first establish a Center for Biologically Inspired Materials and Material Systems in Fall 2000. The four focus programs will similarly be exploring ways to receive major external funding for centers and collaborative projects across departments and schools.

Benchmarks

We will chart our progress towards achieving the Pratt goal to be a distinguished graduate engineering school and be a translational unit for the University by the following benchmarks:

- Higher GRE scores by our incoming graduate students
- Increased selectivity in our graduate student recruitment
- Accelerated growth of our research expenditures (20% CAGR as a goal).
- Presence of spin-off companies translating breakthroughs in engineering design to new products, processes and therapies for improving public health and safety.
• Evidence of significant breakthroughs in our research collaborations with researchers in Trinity College and the School of Medicine.

• Demonstration that our graduates are sought after by industry, academia and government.

5.0 Faculty Affairs

The working group on faculty affairs considered the appropriateness of our planned expansion, the need for increasing the diversity of our faculty and providing faculty with mentoring and career development opportunities. The assessment, plans and benchmarks in these areas are given in the subsection below.

5.1 Faculty Expansion

Assessment

The Pratt faculty size needs significant expansion to provide real value to Duke University, its local community, and national and international constituents.

Plans

We are modeling the financial and infrastructure implications of expanding the faculty by growth under two scenarios: Case One, where we expand by twenty net positions, and Case Two, where we expand by thirty net faculty over the next six years. Former Provost John Strohbehn's thinkpiece "Duke at the Millennium" called for the University to expand Pratt by twenty net positions in 1998-1999. This was before the magnificent naming gift of $35 Million to the School by Mr. Edmund T. Pratt, Jr. It was also prior to achieving a great deal of success in the Campaign for Duke, and the submission of three major, eight figure proposals to private donors, Foundations and Government institutions for supporting our three strategic research initiatives. Though faculty expansion means infrastructure and facilities must grow in proportion to accommodate our ambition to be a distinguished school of engineering, it is not unreasonable to assume that these good fortunes are a sign of the times not to be ignored. Indeed it is time for Pratt to become a great school of engineering. The financials reflect this growth, and model faculty startup funds, increased revenue from indirect cost recovery and tuition from increasing our graduate and undergraduate student body.

Benchmarks

If we invest wisely, we will expect to measure our progress in faculty development and expansion through many of the same benchmarks we use to evaluate our graduate programs:

• Greater percentage of our faculty as fellows of their respective societies, members of the National Academies, and winners of prizes and best paper competition by our faculty and students.
• Accelerated growth of our research expenditures.

• Presence of spin-off companies translating breakthroughs in engineering design to new products, processes and therapies for improving public health and safety.

• Evidence of significant breakthroughs in our research collaborations with researchers in Trinity College and the School of Medicine.

• Support that our undergraduates and graduates are sought after by industry, academia and government.

• Achieving 20% faculty diversity.

6.0 Anticipated Outcomes

To continue to be a great university, Duke will need the support of a distinguished school of engineering. We have identified five peer institutions to monitor and benchmark our progress in carrying out curriculum reform, building infrastructure and interdisciplinary research strength over the next decade. We believe that with the commitment of the University and the completion of a successful campaign, Pratt will have the necessary resources to carry out its goal to become a distinguished school of engineering.

An anticipated outcome is the Pratt School of Engineering will be the translational unit for the University. Pratt will translate breakthroughs in engineering design, the basic and applied sciences and medicine into new products, processes, diagnostic techniques and therapies for improving public health and safety.

A second outcome will be producing graduates of Pratt that are catalysts for integrating and generating new knowledge across the disciplines required to address the complex issues facing a global society.

A third outcome of this investment by Duke University in engineering will be the creation of certificate programs that, for example, provide non-engineering students and the ability to gain access to technology to improve their lives and better society in the process.

A forth outcome will be that our students, faculty and staff will be sought after by industry, government, the medical, legal and financial professions and academia for their knowledge and judgment.

The impact of achieving our goals, objectives and aspirations will be the creation of a highly distinguished school that greatly enhances the Duke University brand name and provides stability for the institution through the success of its graduates.

7.0 Financial Overview and Model for Expanding Faculty and Infrastructure

7.1 Current Position
The Pratt School of Engineering currently receives a $20 million operating budget from the University. That budget appears to meet our status quo needs adequately. In fact, we have posted moderate surpluses to the budget in recent years. A five-year model of this baseline budget reveals an increase in our surplus to about $1 million if we can maintain 10% annual growth in indirect cost recoveries, consistent with our average growth over the last eight years. Pratt can draw on these surpluses to help reach a targeted level of reserve funds, and to help invest in faculty and facility expansion.

When we include all sources of funding (i.e. endowment income, sponsored research) the total Pratt budget is expected to approach $43 million in fiscal year 2000-01. A breakdown of this budget by revenue source and expense category is shown in Table 7.1

7.2 Faculty and Facility Expansion

The current budget does not begin to reflect our needs as we plan to expand the faculty and facilities, and renovate our existing facilities. From a financial standpoint, these initiatives are interrelated. With the support of the University, private donors, and possibly some loans, we will build a $77 million new facility to accommodate faculty expansion and provide much needed space to our current faculty. This expanded faculty, along with strategic reinvestment in current positions, will dramatically increase our levels of sponsored research activity. But we will need the corresponding increased indirect cost recoveries to help pay for the ongoing maintenance and operation of the new facilities.

Our financial models predict that our 31 new faculty hires will help us more than double our sponsored research levels by 2005-06. We will see a dramatic increase in our non-tenure track faculty, research staff, and graduate student populations who will also contribute to this research activity. As our faculty expands, we propose to increase the undergraduate population by 200 over a four-year time frame. After financial aid, this increase will contribute about $1.5 million (current dollars) in additional revenue to Pratt and $1.5 million to Trinity College. Considering all these factors, we predict the Pratt budget from all sources will grow from $43 million to $91 million by 2005-06. A forward-looking budget of this level by source and expense category is shown in Table 7.2

7.3 Reevaluating Our Campaign Goal

When the campaign began in 1988, the goal for the Pratt School of Engineering was set at $50M. During the strategic planning process, we identified key strategic initiatives, focus programs, and curriculum revision initiatives that will be required to move the Pratt School of Engineering into the forefront of engineering schools in the country. These initiatives will require expanding the tenure-track faculty from its current size of seventy-one to over 120 within ten years, commensurate with an increase in our infrastructure and student body. Hence, we recommend increasing our campaign goal over the next three years to afford these necessary programs and initiatives. In particular, we will need resources above our existing campaign total (@ $105M) to fund:

- $77M Interdisciplinary Engineering and Applied Sciences Center
- $30M for Chaired Professorships (including their start-up funds)
- $11M for Hudson Hall Renovation
- $10M for Graduate Fellowships
- $ 5M for Undergraduate Scholarships
- $ 5M for Annual Fund New Initiatives
Given these real needs we will work with senior officers to re-state our campaign goal.

**Table 7.1 Pratt Fiscal Year 2000-01 Budget (All sources)**

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**Table 7.2 Pratt Fiscal Year 2005-06 Projected Budget (All sources)**

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