

**Kate Gleason College of Engineering**  
**Concept Paper: Proposal for a Ph.D. in Engineering**

***Program Goals***

The primary goal of the proposed Ph.D. in Engineering program is to expand the research enterprise at RIT by focusing on the creation of new technologies and engineering innovations to address grand societal challenges. Expanding the engineering research enterprise at RIT will significantly enhance RIT's ability to attract and retain talented faculty and students, to produce world-class leaders in the global society for the 21<sup>st</sup> century, to extend educational pathways for students in existing undergraduate and graduate programs, and to stimulate economical growth both regionally and nationally. The proposed program will achieve these goals by focusing on four industry-themed application domains: ***Healthcare, Energy, Telecommunications*** and ***Transportation***. These four application domains are selected because of their prominence as economic and societal drivers, and also because research thrusts in these areas will engage the largest possible percentage of faculty in the KGCOE along with many others from across RIT.

The technological challenges that exist in these application domains, both now and in the foreseeable future, do not respect disciplinary boundaries. Therefore, to achieve the stated goals, the proposed Ph.D. program is structured to inspire collaboration across disciplines within engineering and across colleges, and to instigate students to work in cross-disciplinary teams to formulate solution strategies and advance technologies in the spirit of President Destler's concept of "team Ph.D." (a bold idea that he proposed when he accepted the presidency of RIT). With a focus on healthcare, energy, telecommunications, and transportation, the proposed Ph.D. in Engineering will also complement existing RIT Ph.D. programs in Imaging Science, Computing and Information Sciences, Sustainability and Microsystems Engineering to provide a full complement of technology-rich research threads that can both engage RIT faculty in the research enterprise and create a robust platform for inspiring solutions to society's most challenging issues. Because of their strategic importance, both nationally and globally, these four application domains are closely aligned with the priorities of industrial, state and federal research sponsors, creating excellent opportunities for RIT to grow its base of external funding for research.

*Healthcare* is second only to food as the largest expense in the U.S. economy (measured as a fraction of gross domestic product) and the costs continue to escalate at hyper-CPI rates. On the other hand, advances in healthcare offer the promise of a healthier life and prolonged vitality for every member of our society. Students in the *Healthcare* track will apply the fundamental knowledge of their respective engineering disciplines to advance the technological boundaries essential to developing enhanced imaging systems, assistive devices systems, and methodologies to diagnose and treat diseases; and to optimize the delivery and quality of healthcare processes and services.

The *Energy* industry is poised for transformational changes over the next several decades as our society transitions from its heavy dependency on carbon-based, fossil fuels to a more diversified portfolio of energy sources, and as consumers increasingly need and desire high-energy-density products for a multitude of devices and applications. Students in the *Energy* track will be engaged in both basic and applied research to realize sustainable solutions to our society's energy needs, including technology challenges in the areas of energy collection, conversion, storage, distribution, control, and consumption.

Innovations in *Telecommunications* will continue to transform our society in the 21st century. The proliferation of cyber and physical sensors in cell phones, smart homes, work environment, traffic monitoring, and other areas highlight the growing importance of efficiently transferring, processing and

interpreting vast amounts and diverse types of data. Emerging initiatives in the telecommunications industry include cyber-physical systems, Internet of Things<sup>1</sup>, and machine-to-machine communications. Students working in the Telecommunications track will leverage and expand the ongoing research of KGCOE faculty in wireless communication, sensor systems and networks, embedded systems and electronics, satellite communications, signal processing and control, high performance and reliable architecture, resilient and secure systems and global networks, and emerging multimedia systems.

The *Transportation* industry encompasses all types of vehicles and materials in motion, relates to a wide variety of applications, and involves multiple disciplines across the College and the Institute. Transportation systems include ground-based vehicle systems; underwater vehicles; flight and space vehicles; robotic systems; micro vehicles; intelligent manned and unmanned vehicles; remotely operated vehicle systems; freight transport systems; transportation data gathering and fusion; sensor systems for estimation of vehicle state information; transportation infrastructure; and systems of vehicles acting cooperatively. Two broad-based societal issues that will be addressed within this area are next-generation personal transportation systems and optimal strategies for vehicle routing and logistics.

### ***Synergy of Proposed Program with RIT's Mission and Strategic Directions***

The proposed Ph.D. in Engineering is well aligned with RIT's Mission and Strategic Directions, and builds upon its historical strengths. The program offers a multidisciplinary approach to prepare students for successful careers in the global society to address prominent needs in healthcare, energy, telecommunications and transportation. The strategic choice of these industry-themed multidisciplinary areas is a key enabler not only for student success but also for providing RIT faculty a competitive edge to secure research funding for scholarly activities. As RIT evolves into a "Category-of-One" university that is more comprehensive in scope, with a significantly stronger emphasis on research as a complement to its teaching mission, its faculty will need to build a strong and productive scholarship agenda through external funding sources.

The impact of the increased emphasis on scholarship is clearly visible in the growth of external funding both for RIT as a whole and for the Kate Gleason College. Indeed, in the years prior to the launch of the Ph.D. in Microsystems Engineering in October 2002, the College typically had less than \$500,000 per year in external grant support, and a significant portion of this support was for curriculum development, not for research. By comparison, in the last four fiscal years (2009-2012), the College has averaged over \$6 million per year in external grant support. In 2001, the external support garnered by KGCOE faculty was less than 4% of that for RIT overall, while today the College is responsible for over 15% of RIT's total external funding. It is no coincidence that this pattern of growth in external funding for the KGCOE coincided with the development and launch of the Microsystems Engineering Ph.D. program in 2002. The establishment of the Ph.D. program in Microsystems Engineering marked a fundamental shift in the mission of the College, to embrace research and knowledge creation as a key component of its academic portfolio. Engaging in research and seeking external funding to support such activities became a recognized component of a faculty member's plan of work, with the Ph.D. program providing the

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<sup>1</sup> The term "Internet of Things" refers to the idea of linking uniquely identifiable objects to their virtual representations in the Internet, which in turn links these objects to additional information such as their identity, status, location, or any other business that might be relevant. (Wikipedia)

mechanism for a limited subset of the faculty to engage students in academically based research at the highest level, while facilitating for these faculty members access to external funding through grants and contracts from governmental agencies such as the NSF, DOD and DOE that have a tradition of supporting Ph.D.-level research and education.

Today, over 37% of the tenured and tenure track faculty members in the Kate Gleason College have grants in excess of \$100,000. While this is encouraging, the ability to access and grow external funding for research, particularly in the engineering disciplines, is strongly linked not only to the number of engineering faculty members but also to the number of Ph.D. programs in engineering at the institution. Ph.D. students are key elements of the “research work force” within engineering departments. This is supported by the fact that for the cumulative period FY08-FY10, research expenditures for the core KGCOE Microsystems Ph.D. faculty accounted for 64% of the total research expenditures for the College, yet these faculty only comprised about 20% of the College faculty. With the proposed Ph.D. in Engineering program, a much broader cross-section of the faculty will be able to engage Ph.D. students in their research activities; which will expand their research agenda, stimulate higher levels of funding, and open up new avenues for external support. The net effect will increase the national reputation of the College and the Institute and help fuel growth in the external funding levels at RIT towards President Destler’s Institute-wide goal of \$85 million.

The Ph.D. in Engineering program is designed in alignment with RIT’s Core Values. The proposed program will contribute to student centeredness by enhancing the quality of the student experience at all levels, including the existing Bachelors and Masters programs in engineering. The Ph.D. in Engineering program will expand the educational opportunities open to students through a richer set of course offerings, enhanced teaching infrastructure and exciting new research opportunities; and it will make RIT and the College even more attractive to new populations of outstanding students who have previously not chosen to attend RIT.

- RIT’s well-established national reputation for experiential learning and partnerships with industry and government will serve as the foundation for a Ph.D. program that provides students with applied research training in a multidisciplinary, collaborative environment that is focused on solving real-world problems of major significance to society.
- The research activities that define the intellectual content of the proposed Ph.D. in Engineering will be integrative across all engineering disciplines, making the program distinctive from the many hundreds of discipline-specific Ph.D. programs in engineering across the nation and dramatically increasing the appeal of graduate study at RIT among students from first tier programs around the world. As a consequence, the caliber of graduate student researchers will increase, as will the quality and quantity of research they conduct.
- The integrative nature of the research will also resonate well with the large scale, multi-program funding initiatives that have characterized federal research funding priorities over the last decade.
- The Ph.D. in Engineering program will make RIT much more attractive and competitive when recruiting top candidates for faculty positions in engineering and applied science, and will eliminate the KGCOE’s single largest impediment to recruiting top-tier faculty over the past decade.
- The Ph.D. in Engineering will maximize efficiency by offering shared courses among disciplines, expand course offerings to Master's students, and enable RIT to become an even more attractive

partner for corporate research, as we continue to advance our state of the art facilities, leading to greater employment opportunities for all students.

Engineering with an *industry focus* has been an RIT tradition for over 125 years. This tradition will be carried forward and amplified with the four industry-inspired research focus areas for the Ph.D. in Engineering.

### ***Linkages with Other Academic Programs***

The proposed Ph.D. in Engineering complements the portfolio of existing RIT Ph.D. programs by providing an engineering systems component for grand societal problems. By adding a broader research focus, complemented by application-specific coursework, RIT will be more attractive to students considering graduate study in related research areas that have an engineering emphasis. The industry partnerships that are sure to grow from the applied research activities in healthcare, energy, telecommunications, and transportation will help to establish linkages with the current Ph.D. programs as well; most especially the Ph.D. programs in Computing, Sustainability, and Imaging Science.

The proposed Ph.D. in Engineering will serve a significant majority of the faculty in the KGCOE, across all disciplines within the college, as well as foster collaborations with faculty members in many of the other colleges, who are engaged in engineering-related projects that address grand societal challenges. The proposed Ph.D. program will tightly connect to the portfolio of existing Masters degree programs in engineering and science, providing opportunities for students in these programs to extend their graduate education at RIT. Likewise, the ability of these Masters programs to attract high quality graduate students will be enhanced by the expanded portfolio of research activities, elective courses, and research infrastructure that will derive from the proposed Ph.D. program. Expedited pathways between these Masters programs (particularly the dual degree programs) and the proposed Ph.D. program are included in the plan to continue to drive the quality of the undergraduate student body through the recruitment of outstanding Bachelors degree students to RIT through the combined BS/Masters programs.

The proposed Ph.D. in Engineering incorporates industry-themed focus areas that promote collaboration between disciplines within engineering and across colleges. Each student, irrespective of their discipline, will be clustered in one of these four industry-themed focus areas and a dimension of their thesis research will be aligned with a grand challenge in the application domain. Thus, in a very real and tangible fashion, students within each of the themed focus areas will be functioning as a team, particularly at the systems level, invoking the spirit of a “team Ph.D.” The synergistic elements of the family of research projects in each focus area will also catalyze meaningful collaborations with faculty from across KGCOE and among other colleges at RIT. These collaborations will enhance each faculty member’s productivity and ability to attract external funding for research, while bringing disciplines closer together and building a strong, vibrant intellectual community.

### ***Marketability & Sustainability***

As stated earlier, the proposed Ph.D. in Engineering will take a multidisciplinary approach to the development of new technologies to advance the state of the art in four key industry sectors: Energy, Healthcare, Telecommunications and Transportation. These industry themes, which collectively represent several thousand trillion dollars of annual expenditures in the U.S., will be a primary driver to attract students who want to innovate, create, and drive economic growth in these industries, for the betterment

of society. This program will be unique among engineering Ph.D. programs in the scope of its efforts to foster research collaborations among students and faculty across disciplines to solve grand societal challenges. These features will enhance the College's ability to market the program, to create a distinctive position for the College's research thrusts within the engineering community, and to grow the brand of RIT as an innovative university. Furthermore, because of the innovative features of the program, there is every reason to expect that this program will attract not only strong students but also meaningful partnerships with companies and government agencies to provide sustained funding for the research thrusts over the long term.

Career opportunities for graduates with a Ph.D. in Engineering from RIT include faculty positions at all the top-tier, research-one engineering schools; research scientist and post-doctorate positions in academia and government laboratories; and research and development positions within the full spectrum of high-tech industries, both nationally and internationally. Currently, the job market for academic positions is extremely competitive, due to the significant budget cuts and cost containment measures being implemented across this market sector. Thus, individuals who aspire to an academic career will need a competitive edge to successfully compete for the limited number of academic positions available. Given these circumstances, the graduates from the proposed Ph.D. program should be in an excellent competitive position, due to the innovative way in which the program develops an individual's research and critical thinking skills within the context of an application domain of special societal importance. Because individuals graduating from this program will have an enhanced understanding of systems-level issues and the business drivers that will shape economic growth within at least one of the four focus areas for the program, one can expect those who pursue a career in industry to advance rapidly through technical management positions within their companies to become industry leaders. It is also reasonable to expect that graduates from the proposed program will be more likely than graduates from traditional Ph.D. programs to participate in new product creation and start-up ventures. In summary, the design of the proposed Ph.D. in Engineering is expected to enable our graduates to be the new breed of doctorates who can seamlessly and effectively bring the industrial perspective to the classroom as well as bring the theoretical foundation to new product development.

### ***Impact to the College***

The proposed Ph.D. in Engineering program will leverage the existing Masters programs as well as expand upon the ongoing research and education activities at the Kate Gleason College. Because of the broad scope of the program, it will engage 46 of the 88 tenured and tenure-track faculty across all departments and programs in the College. These faculty currently are actively engaged in research; working with MS students, dual degree BS/MS students, and/or a limited number of Ph.D. students in RIT's existing Ph.D. programs. The proposed program will make it possible for these faculty to expand the scope of research activities within the College, enhance their research productivity, including publications and annual external research expenditures, and elevate RIT's reputation as a balanced research and teaching university. To accommodate this extra level of effort that faculty will invest in research, proposal preparation and Ph.D. student mentoring, the proposal includes a request for four incremental lecturers, which will be phased in over time.

Over the last ten years, several departments within the College have struggled in their efforts to recruit well-qualified individuals to their faculty because of the absence of Ph.D. programs that incorporate their mainstream research interests and expertise. The proposed Ph.D. program will go a long way towards

resolving this issue. Furthermore, having a Ph.D. program that can engage a broader spectrum of the faculty in the College assures that the intellectual environment within the programs is not only at the cutting edge but also that the faculty are engaged in innovative activities that stimulate multidisciplinary collaborations, which will directly translate to student learning experience with RIT's student-centered focus expanding from BS all the way to the Ph.D. level. Engineering with an industry focus has been an RIT tradition for over 125 years. We look forward to advancing and enhancing this tradition through the implementation of the Ph.D. in Engineering, with its four industry-inspired focus areas of global significance.