ROADMAP FOR THE FUTURE

William J. and John F. Kennedy
College of Sciences
Strategic Plan
2015-2020

vita et spiritu explorationem
(Keep alive the spirit of exploration)

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Kennedy College of Sciences
University of Massachusetts Lowell
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I. Executive Summary

The Kennedy College of Sciences at the University of Massachusetts Lowell has been contributing to the growth and vitality of the Merrimack Valley since the late 19th century when textile chemistry became an important element of manufacturing in Lowell. Since then, the College has established itself as the premier research unit on campus with over $16M of externally-funded expenditures annually and the production of graduates who form the workforce for the myriad of high technology and life sciences firms in New England. The College has a robust international reputation as a leader in areas such as material science, robotics, polymers, photonics, imaging, nuclear physics, big data, and biotechnology, and is poised over the next few years to reach new heights.

Rapidly expanding technology is demanding graduates with training that is multidisciplinary, team oriented, and experiential. Creating the academic environment that will make our graduates truly "work and world ready" requires a rapidly expanding and diversifying College that embraces innovation in research and teaching and strives for excellence and success among students, faculty and staff. The plan laid out in this document is the result of a collaborative process among faculty, staff, students, and alumni. This planning process has generated a clearly defined College vision, mission, and strategic goals with the goals divided into five thematic areas.

1. Expand Research, Scholarship, and Creative Activity

Research to advance human understanding and materially improve man's condition in the world is central to the mission of the Kennedy College of Sciences. To establish itself as one of the premiere public research institutions in the nation, the College must not only continue investing in its traditional strengths such as nuclear science, robotics, visualization, and materials, but we must also expand our research into new and emerging areas that leverage our strengths and address germane problems. We identified three major areas for focus: 1) life sciences; 2) data sciences, and; 3) space sciences and astrophysics. Life sciences encompasses the bulk of our future with expansions into multi-modal imaging, robot-assisted health care, biological and biochemical research translating molecular and cellular findings into organism development, drug creation, and micro-scale solutions to sensing and point-of care devices. Data science development will address problems in big data, cloud computing, and cybersecurity, areas that are at the forefront of mankind's rush into the age of pervasive computing. We also envision a rapid increase in space science research and education on campus that will merge interdisciplinary research with innovative education programs and private sector collaborations to create a space science and technology cluster. Expanding our research capacity naturally leads to improved education programs including new degree tracks. Implementation of these plans will enhance the vitality of the College research mission, provide experiential opportunities for students, further broaden our industrial partnerships, improve our standing among research universities nationwide, and allow us attract higher quality faculty and students.

Relevant Metrics: Research expenditures, numbers of faculty conducting research, research expenditures per faculty, research proposals submitted, peer-reviewed journal publications,

publications per faculty, publication citations, citations per faculty, doctoral students, doctoral students per faculty, research assistantships, fellowships.

2. Improve the Student Experience

The Kennedy College of Sciences seeks to promote student success through excellence and innovation in teaching, new and expanded experiential opportunities, new degree programs, and comprehensive and dynamic student support structures. Achieving these goals will require decreasing time to degree by infusing degree flexibility, offering courses year round, identifying key gateway courses, utilizing interactive degree planning, and actively identifying and intervening with at-risk students. We will create a centralized, comprehensive and proactive advising and mentoring program to connect with students as soon as they arrive and provide comprehensive support throughout their time at UML. We will improve student recruitment, expand experiential learning using enhanced research and co-op opportunities and a more formal capstone experience, create new degrees, grow and reward active learning practices, and expand and formalize freshmen seminars. Educational, student, and faculty interactive spaces will be expanded and modernized. This will be important in helping achieve our goal to create a stronger sense of community by facilitating cross-disciplinary work, incentivizing club formation and expansion, and developing and implementing programs that increase and celebrate diversity.

Relevant Metrics: Student qualifications (HS GPA, SAT Score, etc.); retention and graduation rates; time to graduation; students who have completed undergraduate research experiences, internships, and study aboard; participation in extracurricular activities and community service; student leadership; quality of teaching, mentoring, and advising; student satisfaction; and diversity with relative performance measured across all metrics.

3. Increase Entrepreneurial Activity & Economic Impact

UMass Lowell is known for applied science and technology development and has been working with industry for over 120 years. The Kennedy College of Sciences is committed to this tradition and seeks to further expand the scope and pace of knowledge and technology transfer to the private sector in a way that reaffirms and supports current University initiatives. With the addition of a new Associate Dean for Research and Graduate Education, the College will continue to work towards identifying new funding sources through enhanced relationships with industry, targeted events, and improved alumni relations. The College will create a culture that allows researchers to realize the benefits of IP and innovation. We will also remove barriers that dissuade its creation. Curricula will be modified to underscore the importance of entrepreneurship and innovation, and experiential and capstone activities will be improved and expanded.

Relevant Metrics: Total faculty industrial research expenditures and expenditures per faculty; number of patent disclosures; increased royalties paid to the University/College; number of new start-up companies by faculty staff, and students; and number of jobs created and revenues generated by College IP transfers and business start-ups; number of faculty serving as outside consultants; participation by industry representatives in College events, number of companies participating in the Industrial Affiliates program; increase in monetary and equipment donation

4. Engage the General Public, Our Peers, and the College Community

The Kennedy College of Sciences has an obligation to serve the public through community engagement that draws on strengths in research, scholarship, and education. Providing this superior service involves proactive engagement of the faculty, staff, and students in making meaningful contributions on issues of environmental stewardship and sustainability, health, education, and societal change that impact local, regional, national, and global communities. The College can and will facilitate science literacy by expanding service learning, participating in external events, and training teachers. We will include topics in our curricula having societal significance such as climate change and sustainability, and we will conduct research on energy and green technology. We will also improve and enhance our engagement with alumni who represent the continuing lifeblood of the institution. Finally, we will expand our use of marketing and the media to more effectively communicate our vision, opportunities, and successes.

Relevant Metrics: Nationally/Internationally recognized faculty (society fellows, members of the National Academy of Sciences, etc.), Nationally/Internationally ranked undergraduate and graduate programs, degrees award (BS/BA and MS/Ph.D.), number of alumni and industry donors, gifts received from alumni and industry, and size of the College endowment.

5. Cultivate Faculty & Staff Excellence

The strength of any organization ultimately resides with its people. Consequently, supporting excellence among the faculty and staff is essential for fulfilling the mission of the College. By maintaining a supportive work environment that provides opportunities for professional growth, fairness, and recognition of achievement, faculty and staff are more likely to remain motivated and committed to the institution and the College. Achieving this goal requires expanding mentoring programs and recognizing the achievements of faculty and staff. We must cultivate leaders for our future by defining service roles, educating personnel about leadership paths, and improving workload distribution. Diversity in faculty and staff needs to increase and we must continue educating personnel about the benefits of diversity. Finally, we should strive to maximize efficiency in all that we do so our resources can be used to achieve excellence.

Relevant Metrics: Faculty/Staff receiving and serving as mentors; instances of demonstrated leadership by faculty and staff; and measures of Faculty/Staff dedication, collaboration, recognition, initiative, and volunteerism.

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II. Introduction

The Kennedy College of Sciences at UMass Lowell came into existence in Fall 2010 when the College of Arts and Sciences dissolved. The College has ~120 full-time tenure-track and non-tenure-track faculty members divided into six departments: Biological Sciences, Chemistry, Computer Science, Environmental, Earth and Atmospheric Sciences, Mathematical Sciences and, Physics and Applied Physics. Collectively, these departments offer seven undergraduate degrees with 23 different concentrations/specializations, six master's degrees with over 17 concentrations/specializations, and four doctoral degrees with many different options for specialization. In addition to over 1300 undergraduate and 550 graduate day-school majors, the Kennedy College of Sciences has an extremely heavy service teaching load that benefits students from all parts of the campus. Enrollment in the Sciences has increased an average of approximately 10% per year over the last seven years. Furthermore, the Kennedy College of Sciences is the premier research unit on campus with approximately $16M in annual expenditures of external research funds which amounts to ~40% of University expenditures.

The education of scientists and growth of a scientifically literate populace are important societal goals central to the mission of the Kennedy College of Sciences. College programs aspire to boost student success and to prepare graduates for prosperous careers and life-long-learning. Research in the College is focused on finding solutions to regional, national and global problems, and offers experiential learning so students are "Work Ready, Life Ready and World Ready". The College aims to grow its research enterprise by building on its strengths and expanding into interdisciplinary areas that are germane to societal needs and will prepare students for the future workforce.

If the plan described below is implemented as intended, in five years the Kennedy College of Sciences will house 60% more students and over 50% more full-time faculty members. The quality of the students will increase significantly with incoming freshmen GPAs of 3.75 or better, freshmen retention of over 85% and 6-year graduation approaching 70%. Education programs will be more diverse, interdisciplinary, experiential, and active learning will be pervasive. Students, faculty and staff will be more diverse with more international experience. Research programs will be world renowned and more interdisciplinary with collaboration across all UML colleges in addition to a myriad of external partners. External funding will increase to over $30M annually. Alumni will be prouder than ever of their alma mater and alumni giving and College endowments will increase several fold. College facilities will be modernized and more conducive to learning and teamwork. Faculty and staff development will be expanded and College resources will be used more wisely.

III. Kennedy College of Sciences Vision, Mission, and Core Values

<u>Mission Statement for the University of Massachusetts Lowell</u>

The University of Massachusetts System's mission is to provide an affordable and accessible education of high quality and to conduct programs of research and public service that advance knowledge and improve the lives of the people of the Commonwealth, the nation and the world.

In accordance with the UMass System's mission, the University of Massachusetts Lowell is a public research university committed to excellence in teaching, research and community engagement. The University is dedicated to transformational education that fosters student success, lifelong learning and global awareness. UMass Lowell offers affordable, experience-based undergraduate and graduate academic programs taught by internationally recognized faculty who conduct research to expand the horizons of knowledge. The programs span and interconnect the disciplines of business, education, engineering, fine arts, health, humanities, sciences and social sciences. The University continues to build on its founding tradition of innovation, entrepreneurship and partnerships with industry and the community to address challenges facing the region and the world.

A. Vision for the Kennedy College of Sciences

To provide regional, national, and world leadership in producing, disseminating, and applying scientific knowledge for human prosperity, social progress, and sustainability.

B. Mission Statement for the Kennedy College of Sciences

The Kennedy College of Sciences at the University of Massachusetts Lowell provides comprehensive programs that produce future scientists and science educators who are informed citizens committed to the well-being of our region, nation, and planet. The College is engaged in basic and applied research to advance scientific and technical knowledge that will improve the health, economic, and environmental welfare of citizens of the Commonwealth of Massachusetts and the world. The College aims to advance scientific literacy through excellence in research, education, outreach, and broad partnerships while fostering respect, openness and a sense of community.

C. Core Values

- Integrity
- Intellectual Freedom
- Collegiality
- Inclusiveness
- Commitment to the Public Good

IV. Strategic Themes

Five major strategic themes were identified and strategic goals within these themes were developed. The University's "Pillars of Excellence" was used to guide the process and Pillars associated with each theme are denoted. In addition, metrics for measuring progress for each strategic theme are defined.

1. Expand Research, Scholarship, and Creative Activity

(Pillars: Innovative Research and Entrepreneurship; Entrepreneurial Stewardship)

Research to advance human understanding and materially improve man's condition in the world is central to our mission in the Kennedy College of Sciences. Moreover, the College is already the research powerhouse at UMass Lowell with its $16M in annual expenditures from **external** sources, accounting for >40% of all external research funding across campus. However, to establish itself as one of the premiere public research institutions in the nation, the College must not only continue investing in its traditional strengths, it must also expand its research activities into new and emerging areas. This expansion will require new faculty and resources to ensure success. Since only about 60% of the College tenure track faculty members engage in significant research activity, there is a real opportunity to increase these numbers, especially in light of upcoming retirements. However, new faculty hires and internal resource allocation must be conducted judiciously. In particular, by building upon and leveraging current strengths and existing opportunities for collaboration within and across campus, optimal results can be achieved. Effective implementation will help enhance the vitality of the College research mission, improve our standing among research universities nationwide, and help us attract higher quality faculty and students.

Relevant Metrics: Research expenditures, research faculty, expenditures per faculty, faculty, grants per faculty member, research proposals submitted, peer-reviewed journal publications (PRJP), PRJP per faculty, faculty with PRJP, RRJP citations, citations per faculty, doctoral students, doctoral students per faculty, research assistantships, GRAs per faculty member, fellowships.

1.1 Invest in Existing Strengths that Underlie Interdisciplinary Collaborations

The Kennedy College of Sciences is a strong research unit that surpasses all others in acquiring external funds to support research. College faculties have become well known in various disciplines, and the College has access to sophisticated assets on campus. Maintaining and growing these strengths requires future investments in infrastructure, human resources and equipment. The following are most notable:

- *Radiation Physics and Nuclear Reactor*
- *Robotics*
- *Submillimeter-Wave Technology Laboratory and Photonics*
- *Materials Science/Polymers*
- *Climate Action Plan and Climate Change Initiative*
- *Neuroscience*

- *Informatics and Visualization*

The College also has access to a variety of other assets such as:

- *UMass Medical School*
- *The Massachusetts Green High Performance Computing Center (MGHPCC)*
- *Saab ETIC and its associated clean room facilities and instrumentation*
- *New Pharmaceutical Sciences Department in the College of Health Sciences*
- *The Materials Characterization Laboratory*

1.2 Promote New Areas of Research Synergy

A goal of the planning process was to identify high impact research synergies for the College. These areas will (i) capitalize on strengths in the College and other units across and beyond campus; (ii) possess highly interdisciplinary capacities; (iii) satisfy regional and national needs; (iv) enhance opportunities for cooperation with regional corporations; (v) stimulate international collaborations, and; (vi) provide for state-of-the-art educational opportunities for students. Growth in these areas naturally leads to new and evolving degree opportunities for students, which are outlined in the next main section under Strategic Theme 2: "Improve the Student Experience."

Based on faculty feedback, several areas were identified and common themes were grouped to maximize our collective investment and to enhance the development of three novel, cutting edge themes: *Life Sciences; Data Sciences; Astrophysics and Space Science*s. Although these areas are ripe for expansion, the College will continue to highly value and support the many productive and cutting edge activities and research conducted by individual faculty members, groups and centers that contribute so much to the vitality of the College.

Of the three new research synergisms identified, the bulk of the work falls into the "Life Sciences" category, which underscores the importance of the life sciences in eastern Massachusetts and beyond. Indeed, the life sciences industry in Massachusetts is growing more rapidly than any other sector and is a national leader in this area. These research focus areas encompass a wide breadth of faculty expertise and interest and offer enumerable opportunities for interdisciplinary investigation and productivity throughout the college and beyond.

1.2.1 Life Sciences. The Kennedy College of Sciences comprises a wide-ranging diversity of researchers involved in a myriad of life science-related undertakings. The UMass Donahue Institute's Technical Report *Growing Talent* stated that, "Massachusetts needs to increase the pipeline of residents entering both higher education and careers in the life sciences" and that this must occur by "strengthening the interdisciplinary curriculum and experiential learning programs…and by being collaborative". Hence, besides the significant contributions to the basic life sciences, the Kennedy College of Sciences has an obligation to provide a strong educational platform to support the vitality of the life science sector in the Commonwealth. Kennedy College of Sciences' faculty members found strong connections within the College departments as well as with faculties in the Colleges of Engineering and Health Sciences. We agreed that these connections should grow and could be vastly improved.

The life sciences industry — incorporating bio-pharmaceuticals, medical devices, therapeutics, diagnostics, and the research and development functions of universities and teaching hospitals — is growing nearly 45 percent more rapidly than other industry sectors in the state. Consequently, it will continue to create many high-quality employment opportunities in the Commonwealth. Clearly, the state has the potential for greater than business-as-usual growth, but meeting the demand for talent will be critical to realizing this potential. The following subsections focus on areas identified as "ripe" for collaboration and that can build on our strengths.

1.2.1.a Imaging. Significant advances have been made in individual imaging technologies, but there is even greater promise in coupling multiple methods to achieve coordinated spatial-temporal imaging. Such multi-modalities may offer combined functional imaging of PET, spectroscopic capabilities of terahertz imaging, and superior cell resolution of optical imaging, to better understand dynamically the measurement and tracking of biomarkers and imaging agents. Such multi-modal imaging capabilities would bring together UMass researchers working on imaging controls, metrology, and signal processing for the benefit of life science researchers across the University System working on areas such as pharmacokinetics, imaging agents, diagnostics, and cancer research. For example, ongoing collaborations in breast cancer research, colorectal and skin cancer, and brain tumors are showing promise for innovative multi-modal imaging techniques. Enhanced imaging research would leverage our expertise in the physics of ionizing and non-ionizing radiation across orders of magnitude of wavelengths, our extensive abilities in technology development, and our capacity to apply results from molecular biology to organisms. We must invest in research animal care, infrastructure ensuring the juxtaposition of equipment, testing laboratories and animal models, and interdisciplinary faculty resources.

1.2.1.b Robot-Assisted Home and Rehabilitation Care. Robot-assisted living and therapy represents a rapidly growing field due to the increase in numbers of aging adults who wish to remain in their homes longer, and of people with physical and/or cognitive disabilities. A key remaining challenge is to improve human-robot interaction in everyday environments. By leveraging and expanding the recently opened New England Robotics Validation and Experimentation (NERVE) Center, researchers will have access to mock-ups of home settings and beyond to test the use of robotic systems in different ambulatory conditions or for assessing coupled human-robot motion in support of daily activities.

The facility will benefit researchers across the system in complementary areas including robotics, machine learning, wireless health sensing, physical therapy and kinesiology, gerontology, and disability studies. Many of the more than 80 robotics companies in the region (employing 2500 people and generating roughly $1B in sales) will also benefit from access to the facility.

1.2.1.c Molecules to Organisms. A major focus of life sciences research is understanding the translation of molecular and cellular processes into the differentiation of cells into tissues, organs, and organisms. At the molecular and cellular level, focus on the structure and function of biomolecules is crucial for the analysis of protein structure, folding and misfolding, molecular and cellular biomechanics, molecular modeling, receptor signal transduction, apoptosis, etc. Combining these studies with developmental biology leads to a continuum that is crucial to the study of vertebrate and invertebrate development, stem cell biology, wound healing, cell and

tissue response to injury regenerative medicine, and more. There are several faculty members actively engaged in molecular biology/cell biology research and developmental biology. By leveraging UML expertise in biophysics, imaging, biochemistry, photonics, biomaterials, computational geometry and pharmaceutical sciences, and our core facilities, we have the foundation for a comprehensive research group poised to provide solutions to a myriad of health related problems. We must invest in faculty, state of the art instrumentation, modernized teaching and research laboratories, and a world-class vivarium.

1.2.1.d Biophysics and Biomedical Physics. Even though biophysics began in the late 19th century, it is still relatively new and is an emerging field that encompasses many areas of the life sciences such as molecular biology, biochemistry, computer science, mathematics, medicine, pharmacology, physiology, physics, and neuroscience. UML has been expanding its capabilities in biophysics primarily through new faculty hires in Physics and their connection to imaging studies and medical physics. However, the inherent multidisciplinary nature of the field lends itself to bridging several topical areas within the Sciences, Engineering and Health, and therefore the field is ripe for expansion.

Our goal is to grow biophysics by taking advantage of our expertise in imaging, and by expanding collaborative work between biophysics faculty members in physics and other departments in the college and other colleges, especially Biology and Chemistry, but also Engineering and Pharmaceutical Sciences. To achieve this goal, we plan to engage biophysics faculty members in the planning process for a "Life Sciences Center" in Olsen Hall. This especially applies to researchers with strong interests in imaging and the use of small animal models for their work. In addition, to ensure the vitality of biophysics, we will enhance interactions between Physics and Biology faculty as well as faculty members in Mathematics who can assist with simulations of probabilistic solutions by deterministic processes. We also need to co-list courses on topics like Monte Carlo methods.

The Medical Physics graduate program was recently nationally accredited and is the only accredited program of its kind in New England. This achievement has led to a significant increase in student applications. This raises the opportunity for co-listing courses among Physics, Biology and Chemistry and the creation of an interdisciplinary Biophysics degree program.

1.2.1.e Drug Development. The Kennedy College of Sciences has existing strengths in the area of drug development within the departments of Chemistry, Biology, and Computer Science. In addition, the individuals working in this area have connections with industrial entities. Indeed, some came to the university from private sector companies that specialize in drug discovery and development. Kennedy College of Sciences faculty members have close-working relationships with biomanufacturing faculty members in the College of Engineering, and some Kennedy College of Sciences alumni have tremendous experience and expertise in the drug development process. Some of these alumni are members of the College Advisory Board. In addition, the Department of Chemistry is seeking new faculty members with strong molecular biology backgrounds to enhance the area of biological chemistry. These individuals will interface with our existing strengths in protein characterization and modeling and will have the potential to generate valuable intellectual property by synthesizing and testing new molecules related to drug

discovery. In addition, Math is currently hiring applied mathematicians and statisticians who could potentially contribute to these efforts. Therefore, the College is poised to expand its research in drug development. If realized, this will be an asset to the newly established Department of Pharmaceutical Sciences in the College of Health Sciences.

Drug development activities in the College offer the opportunity for extensive growth in interdisciplinary research with the potential for computer-aided drug design, expanded medicinal chemistry, drug delivery research, bioavailability work, and studies of efficacy, potency, metabolic stability, optimization, and manufacturing. We need to invest in enhancements of our interdisciplinary research space, improved in-vitro and in-vivo drug testing capabilities that would require state-of-the-art cell culture and animal care facilities, and continued growth in the numbers of suitable research faculty. Much of these needs can be met through careful planning of the Olsen Hall renovation.

1.2.1.f Biomaterials. Biomaterials science is an important part of the local economy, with many biotechnology companies in Massachusetts supporting a biomaterials division. Research and development into new technologies will drive investment in local enterprises and also preclinical test facilities, research hospitals, and area universities. In addition, the revenues to the Commonwealth of Massachusetts from next generation products will be significant, and successful product launches will enable the continued employment of thousands of high tech workers. Key areas of research are the synthesis and characterization of new materials (e.g., polymers) and biocompatibility related to implants and artificial organs, regenerative medicine, and stimuli-responsive "smart polymers." Our vision is to hire faculty in the area of polymer synthesis and characterization to support this ongoing effort. Other departments who will be involved in this area of growth include Biology, Plastics Engineering, and Chemical Engineering with a growing connection to Pharmaceutical Sciences.

1.2.1.g Micro-instrumentation. The Chemistry Department is currently searching for faculty in the area of micro-instrumentation. This involves analytical and materials chemists (including polymer scientists) interested in miniaturized analytical equipment such as chemical and biological sensors, miniaturized mass spectrometers for explosives detection, lab-on-a-chip type devices, and point-of-care detectors and drug dispensers for medical applications. New faculty expertise will be sought in microfluidics, miniaturized electrochemical devices, and nanofunctional materials, including "smart" materials and polymers. This area will interface well with other departments at the University, including Biology, Computer Science, and Electrical Engineering.

1.2.2 Data Sciences. The Association for Computing Machinery defines "Data Science" as "the study of the generalizable extraction of knowledge from data, with the key word being science." As such, it is a perfect fit in our College. Data Sciences include techniques and approaches from many fields, including mathematics, machine learning, statistical learning, computer vision, "Big Data" (see below), and high performance computing.

The Computer Science department will coordinate work in this area, beginning with the creation of a new degree program in Data Sciences. The department will focus research, education and outreach in the primary areas of Big Data, Cloud Computing, and Cyber Security.

Computer Science will collaborate with the other departments in implementing relevant research in this area including Chemistry on computational biology and biogeochemistry; Mathematical Sciences on multivariable statistics, mathematical modeling, and deep neural networks; and Physics and Applied Physics on image processing.

Sciences faculty will also collaborate with departments and programs in other colleges, including Biomedical Engineering, Business Analytics, Electrical and Computer Engineering, Economics, Health and Environmental Sciences, Linguistics, Political Science, and Social Sciences.

1.2.2.a. Big Data. The term "big data" has infiltrated almost all aspects of science, technology, commerce, and manufacturing since its inception in 2001 when there was an astronomical increase in data volume and the need to deal with data handling speeds and the variety, variability and complexity of data arose. Challenges include capture and storage, searching and sharing, and analysis of data including visualization methods. The need for big data solutions crosses all boundaries within the University of Massachusetts Lowell. By leveraging our expertise in the Departments of Computer Science and Electrical and Computer Engineering as well as the Massachusetts Green High Performance Computing Center, we can solve societal and corporate problems in areas such as social and communication networks, transportation, drug discovery, genomics, visualization, optimization, robotics, and sensor development.

Current research and teaching in the Department of Computer Science involves big data system designs, computer vision, databases, information retrieval, machine learning, multimedia computing, mathematical modeling and analysis of big data, natural language processing, online social network and media analysis, visualization, and visual analytics. Hence, with this foundation and improved collaborations with other departments, colleges, and the private sector, we are poised for growth. In particular, we plan to expand our expertise in areas such as machine learning, network science, statistics, computational models of human behaviors, image processing, and spoken language recognition.

1.2.2.b. Cloud Computing. Cloud computing, or the use of shared computer resources to achieve economies of scale, has soared in recent years and is now coming of age for full exploitation. In the Department of Computer Science, current cloud-computing research and teaching involves cloud system infrastructure, cloud storage, cloud queries with noisy data, cloud security, and cloud applications. In the future, we will focus on enhancing our expertise in cloud architecture and cloud management research.

1.2.2.c. Cyber Security. The Department of Computer Science has considerable expertise in cyber security research including differential privacy, cyber forensics, cryptography, and mobile computing security and privacy. With a relatively small investment, the program could become a leader in the field. In particular, we propose to expand in the areas of security and privacy of cyber physical systems and software security, an area that naturally connects to the Center for Terrorism and Security Studies in the College of Fine Arts, Humanities, and Social Sciences.

1.2.3. Space Science and Technology. The landscape of space exploration is changing at a rapid pace. With the success of several privately funded programs, space exploration is no longer

limited to NASA and other governmental organizations. Furthermore, with its resurgence and extension into private industry, the already limited pool of well-trained workforce members will need creative solutions. The nascent Space Science and Astrophysics program at the University of Massachusetts Lowell will build on the tradition of innovation, entrepreneurship and partnerships with industry. The breadth and indeed the depth of these activities demand a concerted effort to develop strong graduate and undergraduate experiential learning programs to train the next generation of leaders in this field. We plan to leverage existing institutional strengths in experimental and observational aspects of Space Science and Astrophysics. UML has a strong history in Space Weather research, which needs strengthening. We also have programs in particle physics, nuclear physics and optics with ties to astrophysics. At the outset, we will establish partnerships within the university community beyond the Department of Physics and Applied Physics such as with the Department of Computer Science, and most importantly, with the Francis College of Engineering.

1.2.3.a. Lowell Center for Space Science and Technology (LoCSST). LoCSST represents a partnership between UMass Lowell, industry and government entities. Space Science and Astrophysics cover a broad field of multi-disciplinary study and offer extraordinary opportunities for education. This multi-disciplinary entity will bridge the Kennedy College of Sciences and the College of Engineering to train the next generation of space scientists, technologists and teachers. However, with the recent growth of Private Space industry, it is possible that members of the School of Business and some of the policy scholars of the College of Fine Arts Humanities and Social Sciences might be interested in becoming a part of this new cluster. It is expected that industry partners will actively participate in the development of new curricula that will be tailored to theirs and the nation's needs. Already we have had very productive discussions with and received enthusiastic support from key members of Northrop Grumman, Raytheon, and Draper Laboratories. To ensure LoCCST's success, two areas have been identified as key foci – Space Science and Astrophysics, and Space Technology.

1.2.3.b. Space Science and Astrophysics. Humanity is increasingly dependent on the products of astronomy and space science. We routinely communicate using geosynchronous relay satellites, travelers in the remotest parts of the Earth communicate using satellite phones, and GPS navigation is routinely built into almost any new car and cell phone. This increasing dependence comes with increasing vulnerability, especially from space weather that can damage modern systems and lead to disruptions in electric power supply, transportation and communications, information technology, and government services. Hence, it is vital to produce a steady stream of well-educated space scientists and engineers who can address these and related problems. With a modest expansion, UMass Lowell will be well positioned to help meet this need and become an international leader. To take advantage of the diversification of space science, its funding sources, and opportunities, we must invest in additional faculty to strengthen our course offerings to meet student demand and to round out a comprehensive curriculum that will lead to creation of a MS/Ph.D. degree program in Space Science and Astrophysics.

1.2.3.c. Space Technology. The faculty of the Physics department has established a long track record of experimental research programs in space science and technology. Some of these involve design and development of instruments deployed in remote locations with others collecting data aboard balloons, rockets, satellites and the *International Space Station*. The

continuation and expansion of the space activities need a larger support infrastructure than we presently have at the university. To provide the necessary research leadership as well as administrative infrastructure requires the creation of LoCSST.

1.3 Increase Research Capital

The previous two sections focused on promising areas of research to be pursued by leveraging existing strengths and promoting interdisciplinary collaborations within the College and across the campus. Here we describe the human, physical, and financial resources necessary to make this happen. This includes strategic replacement of retiring faculty, increasing the number of tenure-track faculty, recruiting graduate students, reducing the technical and administrative burden on faculty through appropriate staff appointments, updating existing facilities and creating new research labs and equipment, and diversifying sources of research funding.

1.3.1 Increase Numbers of Research-Active Faculty. In order to make significant progress on many of the absolute research metrics e.g., total research expenditures, externally funded proposals, publications, etc., the number of faculty members engaged in research must be increased. There is a real opportunity to increase these numbers through strategic replacement of retiring faculty not currently engaged in any significant research activity. These replacement hires need to be carefully managed to ensure the College builds upon its current strengths while also expanding opportunities for interdisciplinary collaborations. However, additional faculty lines will be needed in key areas to promote growth of existing programs and new initiatives. Specific expertise of new faculty members are listed in the specific department plans in Appendix B. In addition, we have created a seed-funding program entitled SPARK to provide support for ideas showing promise for future funding. We will create an additional seed-funding source focused on interdisciplinary projects by junior faculty to encourage collaborations between departments and colleges.

1.3.2 Increase Numbers of Doctoral Students. If the Kennedy College of Sciences is to significantly expand its research footprint then it must also increase the size and quality of its graduate programs. Currently, only Computer Science, Physics, and Chemistry offer Ph.D. programs. As faculty research expands in those departments over time, there will be more support for additional Ph.D. students and we envision adding new graduate programs. However, a goal of the College is to create new doctoral training opportunities for students in the departments of Biology, Mathematics, and Environmental, Earth and Atmospheric Sciences. We believe this goal can be attained best by creating interdisciplinary degree programs that utilize the graduate group model and synergies available through tapping expertise across departments and colleges. These new degree programs are tied directly to needs for new and expanding research programs. The faculty and infrastructure required to support these programs are described in sections 2.1, 2.3 and 2.4. Faculty workloads and Graduate Teaching Assistant allocations will closely adhere to the number of doctoral students, their graduation rates, and the number of Graduate Research Assistants funded externally. Additionally, we will establish a College working group devoted to graduate student recruitment. We also plan to expand our recruiting efforts by creating partnerships with regional institutions that generate quality B.S. graduates, developing conduits with foreign institutions including dual Ph.D. programs, and by working with other colleges to create a University-wide recruiting effort.

1.3.3. Modernize research labs and equipment. Research facilities in the Sciences are grossly outdated and inadequate. We must invest in modernizing existing facilities and creating additional state-of-the-art research spaces including flexible research bays and specialized facilities that are in juxtaposition to required equipment, e.g., imaging units near animal care facilities. We envisage research spaces that bring together personnel from a variety of departments and colleges with similar needs. For example, we plan to convert Olsen Hall into a "Life Sciences Research Center" to house scientists from Biology, Chemistry, Physics, Pharmaceutical Sciences, Clinical and Nutritional Sciences, and Engineering departments. This arrangement will greatly facilitate research interactions as well as holding great potential for partnering with biotechnology firms. Creating these facilities will require subventions from the State and fundraising activities targeting alumni and private sector firms with matching commitments. We continue to lobby for State funds to renovate Olsen Hall followed by Olney Science Center. These renovations are crucial if we are to be a competitive research university. Our ultimate goal is a new science center. We envisage a strong and growing nuclear program at UML, and one that takes advantage of our nuclear reactor in Pinanski Hall. Efforts should be made to consolidate all nuclear programs in the Sciences and Engineering into Pinanski including all faculty offices and research space, and should include spaces to bring students together.

1.3.4. Broaden Funding Resources. The Kennedy College of Sciences has a strong record of federally funded research from the National Science Foundation (NSF), National Institutes of Health (NIH), Department of Defense (DoD), Department of Energy (DoE), and National Aeronautics and Space Administration (NASA). The College procures nearly $16M per year of external support. Certainly, efforts directed at securing grants from these agencies must continue. However, there are many additional federal, state and private funding resources available to College researchers. Our interdisciplinary initiatives show real potential for helping achieve this growth, and our faculty hiring will contribute greatly. However, the College needs to find ways to help faculty take advantage of new opportunities. The College has had some success attracting industry partners and our plans for expanding these relationships can be found in section 3.1.

1.4 Create Climate Conducive to Creative Engagement and Change

All research is conducted within a social context that is defined by practices endemic to the scientific enterprise itself, discipline specific norms, and institutional/organizational rules and traditions. If the Kennedy College of Sciences is to move to the next level of research excellence, it must transform itself to promote a more vibrant intellectual environment capable of sustaining a more robust culture of research, scholarship, and creative activity. Hence, our motto: *vita et spiritu explorationem* (Keep alive the spirit of exploration). This will require creating adequate opportunities and venues for faculty to engage with each other as well as developing a nurturing framework that frees individuals from encumbrances that might prevent their participation in such exchanges.

1.4.1 Provide and promote opportunities for vibrant intellectual exchanges. Inquiry is impotent without the creative spark, and the engine that drives creativity is the sharing of ideas.

Thus, it is critical for the College to foster more collegiality and collaboration between faculty, departments, and the broader academic community. There should be more support and resources for efforts aimed at promoting productive dialogue among faculty, staff, and students within and across academic disciplines. A first step is re-arranging departmental colloquia to avoid conflicts so a College-wide colloquium series on interdisciplinary research can be created. We will also create a mentoring program for all junior faculty members (see section 5.1) and a concerted effort will be made to bring young tenure-track faculty together. In particular, the college will provide regular seed money for collaborative research proposals by younger faculty. We already initiated a seed program for all faculties (SPARK). In addition, the College will host faculty and staff social events semiannually and an annual event for all faculty, staff and students.

1.4.2 Improve administrative and logistical efficiency. The college is actively engaged in centralizing functions to alleviate departmental burdens including student services (advising, degree planning, students at risk program) (section 2.4), selected research-related tasks (e.g., fiscal and procurement), and aspects of public relations (web and print media).

1.4.3 Reformulate faculty tenure and workload requirements. The College and individual departments need to reconsider what activities are most critical to enable faculty to achieve academic distinction. To this end, a committee will continually improve the faculty workload agreement to formulate criteria and weighting schema that promote and reward diverse and interdisciplinary creative activity.

2. Improve the Student Experience

(Pillars: Transformational Education; Global Engagement and Inclusive Culture)

The Kennedy College of Sciences seeks to promote student success through excellence and innovation in teaching, new and expanded experiential opportunities, new degree programs, and comprehensive and dynamic student support structures. The goal is to ensure that all our undergraduate and graduate students enjoy a richly rewarding educational experience that prepares them for successful professional careers devoted to making a difference in the world. It is our duty to prepare students for the dynamic working environment that awaits them and to provide the workforce for growing technical industries. In addition, we must work to improve retention and graduation rates, and ensure students find meaningful employment.

Relevant Metrics: Student qualifications (HS GPA, SAT Score, etc.); retention and graduation rates; time to graduation; students who have completed undergraduate research experiences, internships, and study abroad; participation in extracurricular activities and community service; student leadership; quality of teaching, mentoring, and advising; student satisfaction; and diversity with relative performance measured across all metrics.

2.1 Attract, Retain, & Reward an Academically Excellent and Diverse Student Body

The Kennedy College of Sciences has been very successful at producing graduates ready for the workforce and who find jobs quickly. However, improvements can be made to attract more and higher quality students and to retain and graduate them.

2.1.1 Improve recruiting efforts. The College and individual departments need to enhance their recruiting efforts beyond those conducted by Admissions. We must reach out to high schools and community colleges, and we need to create an efficient system to reach as many schools as possible. This will include school visits and events to bring students, parents and counselors to the campus, and will require expanding our student "Ambassador" group so our best and brightest can meet applicants. Our community college transfer agreements need to be updated and we need to continue to add new scholarships. Our college and department web sites also need to be modernized and kept current to highlight research, scholarship, and other creative activities of students and faculty in the Sciences.

2.1.2 Enhance degree flexibility. We are working to modify degree programs to infuse as much flexibility as possible so time-to-degree can be reduced. Course requirements that do not adhere well to timely pathways to the degree completion are being eliminated so additional free electives can be inserted. Learning outcomes are being examined and kept up to date, and repetitive information eliminated when not needed. Gateway courses are being identified (with help of Educational Advisory Board software) to help develop strategies to enhance student success and retention, and to quickly identify and intervene with at-risk students. More courses will be offered during both the fall and spring as well as during the summer, which will help promote more timely progress toward degree completion.

2.1.3 Expand experiential learning. The Sciences prides itself on the quality and depth of hands-on activities for students, including original research in faculty labs, industrial co-op experiences, freshmen co-ops, service learning, and high-quality teaching laboratory exercises. However, with high student-to-faculty ratios in some departments, such opportunities for students have grown increasingly inadequate. For example, industrial co-ops are abundant for Computer Science students, but difficult to find for Biology students. Increasing faculty, and hence, decreasing the student to faculty ratio, will improve the College capacity to meet this demand for experiential opportunities. With more research faculty we can expand freshmen co-ops and more advanced undergraduate research opportunities. We plan to explore a quasi capstone requirement for majors across the College that requires completion of a "laboratory" course that will be an individual or team research or service-learning project. Some such projects might even be done in conjunction with engineering capstone design courses. We will still encourage and support projects in faculty labs, project-based courses that already exist, and co-ops of all types, but we expand our efforts in securing industrial sponsorships and international experiences. The College has not adequately supported nor participated thoroughly in student clubs, but will do so through the Dean's Office and a College-wide student council.

2.1.4 Further develop active learning. Today's generation learns differently from the past and responds best to active learning that entails peer-to-peer approaches, group discussions and "flipped" courses. Many advances in modern higher education were made in response to poor performance in math and science. The College has made strides in this direction, but we can do better by expanding our Service and Active Learning Committee, rewarding faculty members who embrace new approaches and pass those ideas and results to colleagues, creating learning spaces that foster these approaches, and further educating our instructors.

2.1.5 Strengthen freshmen seminars. We recognize the importance of connecting to new students quickly, and this is a central pillar in the mission of our new College advising office (section 2.4). Five of the six departments in the College offer formal freshmen seminars and the sixth is currently creating one. These are excellent venues for getting students on the right path and for infusing excitement about the sciences, which can help improve retention. A College goal, through leadership of our College advising office, is to standardize a portion of these seminars to ensure that students are quickly familiarized with advising protocols and opportunities, social events and clubs, pertinent University offices and events, study skills, etc. We also plan to use these seminars for presenting selected modules on topics such as climate change and sustainability.

2.1.6 Train Graduate Teaching Assistants (GTAs). Much of the initial hands-on undergraduate training in the Sciences is guided by Graduate Teaching Assistants and adjuncts in teaching laboratories. These personnel need to be trained to provide a consistent and uniform experience for undergraduates and to give the Graduate Teaching Assistants useful teacher training that can aid their future careers. To this end, the College will establish a Graduate Teaching Assistant mentoring and training program.

2.1.7 Recognize student achievement. The College currently has dozens of scholarships and awards to honor achievement and promote continued student excellence. Most of these are explicitly, and often solely, tied to academic performance. We plan to greatly expand the breadth of activities and accomplishments identified and recognized by the College. Many of these areas are the focus of this strategic plan. For example, to promote entrepreneurship, we will investigate the feasibility of instituting a yearly business plan competition. As another example, we want to highlight the importance of, and participation in, internships and co-op experiences through employer-sponsored awards for best interns. To highlight the importance of community building and broader public engagement we will establish specific prizes for service and volunteerism. Many of these awards will be disbursed through the departments while others will be College-wide. In addition, a Dean's Medal will be established for truly outstanding achievement in any of the above-mentioned areas. By expanding the palate of what is recognized and rewarded, we intend to not only nurture the creative drive and passion of our students, but we also want to harness these pillars of success to advance and shape the mission of the College.

2.1.8 Modernize educational and student space. Lecture and laboratory spaces in the Sciences are incredibly outdated, worn and grossly inadequate for today's student learning needs. There are also few spaces near learning areas for students to congregate. Furthermore, the spaces for formal clubs are sorely inadequate or simply non-existent. We must invest in flexible teaching spaces with sufficient technology to allow for a variety of active learning methodologies. We need teaching laboratories located near to preparation spaces to more adequately facilitate group work. We also need spaces that can be used for individual and group projects outside of scheduled teaching times. There is a need for areas to promote social interaction and intellectual exchange. In general, the Sciences desperately requires space that can connect personnel to encourage interaction and help develop the team mentality that drives success in the high technology world. One possibility to help meet this need can be found in the "inverse pyramid" shape of Olsen. This space is conducive to adding open glass-enclosed interactive areas on the

lower floors. Another possibility is the green space between Olney and Pinanski, which is currently underutilized. Properly developed, this plan can provide premier spaces for dynamic student and faculty interaction that cannot be achieved in the current "silos" structure. This is also true for other areas around Pinanski, including the Facilities' garages, that can be more effectively utilized.

2.2 Create More High-Impact Educational Opportunities

2.2.1 Undergraduate. The Kennedy College of Sciences offers undergraduate degrees in **Biological Sciences** (B.S, with options in Biotechnology, Ecology, and Bioinformatics), **Chemistry** (B.S. with an option in Forensic Science), **Computer Science** (B.S.), **Environmental Science** (B.S. with concentrations in Environmental Studies (formerly the B.A.), Atmospheric Science (Meteorology), and Geoscience (Geology), **Mathematics** (B.A. and B.S. with options through Continuing Studies of Applied Mathematics, Mathematics/Statistics, and Mathematics/Teacher Concentration), **Physics and Applied Physics** (B.S. with options in Optics and Radiological Health Physics; a new Astrophysics option has been approved by the UPC). Several minors are also available. These offering serve the regional economy and the need for STEM-educated graduates nationwide. Although quite comprehensive, our undergraduate programs can be improved with additional options and new cross-cutting degrees including:

- Joint B.S. in Biophysics: In section 1.2.1.d we describe our plans for growing biophysics research, which naturally leads to a degree in Biophysics. The life science industry has moved well beyond disciplinary boundaries. With the advent of imaging and detector technologies and their applications from cells to organisms, the life sciences could benefit greatly from expertise in biophysics. This is especially true in biomedical companies. A degree that is joint between Biology and Physics with a common core and specialized electives could serve a wide range of industries in the Commonwealth. We are already conducting biophysics projects with investigators from two or more departments and a Biophysics degree would facilitate this ever expanding collaborative work.
- Joint B.S. in Biochemistry: Biochemistry courses are offered in both Chemistry and Biology and faculty hiring in this area has attracted candidates for both departments that are very similar in background and expertise underscoring an intellectual amalgamation. Students, the industries that hire them, and our faculty would benefit from a synergistic degree program that takes advantage of the broad strengths in biochemistry; strengths that are growing.
- B.S. in Data Science: A strong focus of our Computer Science Department is the expansion of efforts in data sciences including big data, cloud computing and cyber security research programs. We have already assembled a core faculty group in CS who are investigating a data science degree. With additional hires focused in these areas, we will have an experienced cluster to conduct cutting edge research and train students. This program has natural connections to Engineering plans, especially in the big data arena. There are also connections to ongoing efforts in Math, Chemistry, Physics, Biology and Health Science programs such as Pharmacy and Clinical Sciences.
- B.S in General Science: We are investigating the idea of offering a General Sciences degree that will span the Kennedy College of Sciences. This option will give students the ability to obtain a science degree that is less constrained by discipline, but will provide a

broad background in science suitable for careers in areas such as government, policy, consulting, logistics, design and management. This program also offers a pipeline for life-long learning in the sciences for industry employees to enhance their skills, improve their promotion opportunities, and to learn new technologies.

2.2.2 Graduate. The Kennedy College of Sciences offers graduate degrees in **Biological Sciences** (M.S, with options in Biotechnology, and Ecology); **Chemistry** (M.S. and Ph.D. degrees in Chemistry; the Ph.D. degree has options, in collaboration with other departments and colleges, in Polymer Science/Plastics Engineering, Biochemistry, Environmental Studies, and Green Chemistry); **Computer Science** (M.S. with options in Bioinformatics and Entrepreneurship; Ph.D. with options in Computational Mathematics or Bioinformatics); **Environmental Science** (M.S. in Environmental Studies/Atmospheric Sciences concentration; Ph.D. in Atmospheric Physics that is administered by Physics); **Mathematics** (M.S. with options in Applied Mathematics, Mathematics/Statistics and a Teachers option); **Physics and Applied Physics** (M.S. degrees in Physics, Radiological Sciences and Protection, Medical Physics, Applied Physics with an Optical Science option; Ph.D. with options in Radiological Sciences and Medical Physics). We plan to create new programs in the following:

- Joint M.S. and Ph.D. in Life Sciences: It is clear that a major strength in the Sciences and the University of Massachusetts Lowell in general is our interdisciplinary emphasis on everything "life sciences," from molecular biology to whole organism imaging, and everything in between such as drug development, cancer biology, biomolecules, evolutionary biology, and technology development. Our Biomedical Engineering and Biotechnology (BMEBT) Program is very successful and has the full support of the Kennedy College of Sciences including acting as home to the majority of the BMEBT students. However, BMEBT is missing a swath of students (and faculty advisors) who want to focus more on basic aspects of cell and evolutionary biology, genomics and bioinformatics, biochemistry, genetics, and environmental biology, biophysics, and developmental biology and biochemistry, but not the bioengineering side of these topics. We envision a core curriculum that ties together several departments using the group model, with advanced electives from individual departments. Graduates would be work ready for biomedical industries, environmental firms using genetic approaches for remediation, and companies involved in large genomic projects. This program would benefit from collaborations with BMEBT, Math, Business (analytics) and Pharmaceutical Science.
- M.S. and Ph.D. in Data Science: The logical extension of our data science thrust is the creation of a graduate track in this area.
- Joint M.S. and Ph.D. in Environmental Science/Engineering: Using the group model and leveraging assets in EEAS and Environmental Engineering, we can create the critical mass to train students for environmental careers that will be increasingly germane in a rapidly changing world.
- M.S. and Ph.D. in Space Science and Astrophysics: Space Science research in the College is expanding rapidly with annual research expenditures of nearly $1.5M, the creation of the space UML/industrial cluster, and proposals being prepared that could bring $60-$90M to campus. Space science is rapidly moving more fully into the private sector and our science and technology expertise can provide the associated workforce.

2.3 Strengthen Support for Pedagogical Excellence and Innovation

Besides needed efforts to increase experiential learning and active learning in the classroom, the College must strengthen assessment, provide sufficient opportunities for faculty development, and create a culture that embraces teaching excellence. To this end, the College will create a committee to oversee pedagogy. Departments must conduct strenuous student learning outcome assessments that generate data useful for continuous improvement. The College will work diligently with the Faculty Development Committee to support workshops and seminars to ensure effective transmission/access to effective and innovative teaching pedagogies. We will establish junior and senior-level faculty awards for excellence and innovation in teaching and we will increase opportunities and support for faculty seeking to engage in science education research or the development of innovative teaching tools. We will provide summer funds to support faculty with proposals for innovative courses that meet important educational needs and encourage cross-disciplinary work.

2.4 Establish Robust Advising Practices and Student Services

Advising practices are uneven across the College and many students university-wide are dissatisfied with advising. In addition, comprehensive support for at-risk student populations has been poor. Student concerns in this area are supported by data from National Survey of Student Education (NSSE) and the Kennedy College of Sciences student focus groups. Consequently, the College has worked actively to provide more consistent and comprehensive service in this area by creating a centralized College advising office called OAS^{2}iS (Office for Advising and Student Success in the Sciences) and developing more robust policies and procedures to ensure student success. We recently hired two professional advisors for OAS^{2}iS and the Assistant Dean, Stephen Norton, has been creating an advising program for several months. We will roll out this program in September 2014 for incoming students, but full implementation will be an evolving process throughout the year. We believe this program will be the most comprehensive of its kind on campus.

The goals of this effort will be to (i) ensure students complete their coursework in a timely manner; (ii) promote an enhanced undergraduate experience for students by connecting them with resources and supplemental educational opportunities that, in turn, will broaden their horizons; (iii) engage students with career development activities throughout their undergraduate years to facilitate their understanding of career options and pathways for making a difference in the world; and (iv) foster a stronger sense of social and intellectual community that will contribute to the campus culture of inclusion and support student success. Ensuring these goals are met will require radically transforming the delivery mode, content, and range of advising activities and professional mentoring within the Kennedy College of Sciences. It will also require expanding student activities and services that promote social integration and community building beyond anything currently provided by the College.

2.4.1 OAS^{2}iS (Office for Advising and Student Success in the Sciences)

The mission of OAS^{2}iS is to improve the educational experience of undergraduates in the sciences and promote student success through more structured and comprehensive advising requirements. Student efforts to fulfill these requirements will be supported by expanded access to more consistent and high quality advising provided by the OAS^{2}iS staff of professional advisors and dedicated Lecturers. The centerpiece of the College vision is an integrated advising process to help students build comprehensive plans incorporating academic, career, financial, leadership, and personal goals. This integrated planning will involve more face-to-face advising time for students, as well as more time by advisors on the back-end monitoring and benchmarking of student progress relative to their plans. This integrated advising model will be initiated with First Year and new Transfer Students in the Biological and Computer Sciences. OAS^{2}iS will also provide general academic advising and support to all undergraduates in the College as well as organizing and running college-wide events and community building activities. In addition, OAS^{2}iS will provide specialized intensive advising through the Program for Retention and Academic eXcellence in the Sciences (PRAXiS).

2.4.2 PRAXiS (Program for Retention and Academic eXcellence in the Sciences)

PRAXiS was initiated in Fall 2013 to empower the Kennedy College of Sciences undergraduates to succeed academically and achieve their full potential. The program assists students in developing reasonable academic goals, and effective strategies for achieving those goals, by ensuring they are connected to appropriate resources and support structures. The ultimate aim is to have PRAXiS students take full responsibility for their education by placing them in a position to succeed on their own. Though open to any student who wishes to improve their academic performance, PRAXiS focuses primarily on students in academic jeopardy. This latter group is of particular concern for the Kennedy College of Sciences given the high number of students at academic risk. At the end of Fall 2013, there were 150 undergraduates in the College with GPAs below 2.00, which is just over 13% of the College enrollment. One third of these students were first semester freshmen. In addition, there were another 150 students with GPAs above 2.00 exhibiting serious signs of academic distress. Though not all students in this latter group require assistance, intervention and academic support is highly desirable for many. Through targeted and customized advising, PRAXiS seeks to significantly reduce the number of warning and at-risk students in the College and thereby increase first and second year retention rates and graduation rates.

2.5 Create a Stronger and More Inclusive Sense of Community

The scientific community is a diverse network of interacting scientists with many sub-communities each having their own discipline specific knowledge, techniques, and social activities. The ability of students to succeed in the sciences greatly depends on their ability to successfully integrate into this rich intellectual and social environment. Thus, to help encourage student success and retention in the sciences, the College seeks to strengthen the various modalities by which students begin to identify with the College and their discipline of choice.

To achieve this goal we must:

- Create a set of core competencies across the different majors in the College to help guide teaching and programming, as well as facilitating more cross-disciplinary work by students.
- Assist departments and programs with the formation and support of science and technology clubs and organizations.
- Provide and publicize incentives for students to get involved in science and technology clubs.
- Create and support social events and activities to promote esprit de corps among the undergraduate and graduate students, e.g., college spirit day, first-year student retreat, college international day, t-shirt competition, etc.

It is also essential that we create a diverse intellectual and social community composed of faculty, staff, and students with different perspectives reflective of race, ethnicity, socioeconomic background, gender, sexual orientation, and disability, among others. Divergent perspectives and opinions are essential for the pursuit and application of knowledge for the betterment of the human condition. As such, diversity and inclusion are valued by the Kennedy College of Sciences as much for their intrinsic worth as they are for their impact on the mission of the College. To this end, the following objectives will be pursued:

- Require departmental plans to address efforts to recruit and retain women and underrepresented minorities for faculty positions as well as recruitment of students.
- Develop specific goals for gender, racial, and ethnic diversity of students, staff, and faculty as well as support for the disabled.
- Create an external advisory committee to assess and provide feedback to the College on diversity issues and the general climate of inclusiveness.
- Support cultural competency in the learning environment.
- Provide learning opportunities to increase awareness of issues relevant to the global community.
- Promote expanded opportunities for international experiences for faculty and students in their disciplines.
- Create a link on the College webpage promoting culturally diverse activities across campus and in the local community.

3. Increase Entrepreneurial Activity & Economic Impacts

(Pillars: Innovate Research and Entrepreneurship; Leverage Our Legacy and Our Place)

UMass Lowell is known for applied science and technology development and has been working with industry for over 120 years. The Kennedy College of Sciences is committed to this tradition and seeks to further expand the scope and pace of knowledge and technology transfer to the private sector in a way that reaffirms and supports current University initiatives. These efforts will facilitate the development of practical solutions to many of the challenges confronting mankind as well as generate salutary economic impacts both in the local economy and for the University. Creating an environment that recognizes and rewards innovation and generation of intellectual property (IP) is absolutely critical for making progress.

Relevant Metrics: Total faculty industrial research expenditures and expenditures per faculty; number of patent disclosures; increased royalties paid to the University/College; number of new start-up companies by faculty staff, and students; and number of jobs created and revenues generated by College IP transfers and business start-ups; number of faculty serving as outside consultants; participation by industry representatives in College events, number of companies participating in the Industrial Affiliates program, increase in monetary and equipment donation.

3.1 Increase Outreach to Industry

Strong long-lasting connections with industry are necessary for effectively exploiting intellectual property, but these bonds can lead to a variety of benefits including funded research projects, co-op opportunities, equipment donations, and most importantly, an employment pipeline for our graduates. However, with federal research funds shrinking, these connections will become more important for sustaining our future.

As mentioned in section 1.3.4, the College has a long history of success with industrial partners and we plan to work diligently to identify new ones. The College has had many successes attracting industry relationships including Millipore, E-Ink, I-Robot, Pfizer, Mercury Systems, Thermo Fisher, IBM, Novita, Symantec, EMC^2, Sage Science, Boston Scientific, Biogen Idec, Applied Nanofemto Technologies, Mide Technology Corporation, Entegris Inc., Triton Biosystems, and many others. However, this can be improved. With the addition of a new Associate Dean for Research and Graduate Education, the College will continue to work towards identifying new funding sources. This will entail an escalation of visits with decision makers at companies, enhanced relationships with our alumni pool, boards of advisors, and our Advancement office. We propose to create a yearly research day where the College hosts key industrial partners, an Industrial Affiliates Program, and we will facilitate and support departmental events to connect faculty and students with industrial partners. We also plan to recruit adjuncts from industry to teach special courses in leadership skills valued by companies. We need to do a better job tracking and keeping in touch with our graduates and leveraging their successes to teach our students and to better connect with employers.

3.2 Generate and More Effectively Exploit Intellectual Property and Technology

Research and creative work are meant to improve the quality of life and the human condition. To help realize this goal, the College needs to more acutely focus its efforts on applications-orientated activities that will more swiftly address various challenges in society as well as spurring local and regional job creation and economic activity. We have not taken full advantage of our efforts in areas such as polymer design, sensor technology, genetic approaches to material creation, and drug development and delivery. To enhance the exploitation of our work we need to improve our relationship with the Commercial Ventures and Intellectual Property (CVIP) Office, especially the UMass Innovation Institute (UMII), to help us foster relationships with industry and to identify and promote potential products and licensure agreements. Through our efforts to connect faculty to industry, we must create a culture that allows researchers to realize the benefits of IP and innovation and we must remove barriers that dissuade its creation such as negative impacts on promotion and tenure. An extremely important enabling mechanism in

achieving increased development and transfer of IP and technology is a workload policy with appropriate incentives.

Our curriculum needs to be modified to underscore the importance of entrepreneurship and innovation. This should begin within freshmen seminars, emphasized in hands-on courses, and culminate in senior project (capstone) courses and in participation in the DifferenceMakers Program and service-learning activities. It may be possible to create an undergraduate innovation program that builds on relationships with Engineering and Business to foster more formal interdisciplinary projects.

To more fully promote the importance of intellectual property generation we will create a College entrepreneurship colloquium series with talks by faculty and outside experts who have knowledge of ,and experience with, technology transfers. We will better highlight, in campus and College publications, the entrepreneurial activities of faculty, staff, students, and alumni. We will also sponsor workshops on entrepreneurship, which will become a significant component of College retreats.

4. Engage the General Public, Our Peers, and the College Community

(Pillars: Leverage Our Legacy and Our Place; Entrepreneurial Stewardship)

A major goal of the Kennedy College of Sciences is to serve the public through community engagement that draws on strengths in research, scholarship, and education. Providing this superior service involves the proactive engagement of the faculty, staff, and students in making meaningful contributions on issues of environmental stewardship and sustainability, health, education, and societal changes that impact local, regional, national, and global communities. This engagement ranges from participation in various public forums and outreach programs to applied research and civic partnerships. Local, national, and international recognition of our faculty, programs, and achievements speaks to the issue of our engagement and impact. To this end, the College will do a better job of communicating our successes and plans for future action with the general public and our peers.

Relevant Metrics: Nationally/Internationally recognized faculty (society fellows, members of the National Academy of Sciences, etc.), nationally/internationally ranked undergraduate and graduate programs, degrees awarded (BS/BA and MS/Ph.D.), number of alumni and industry donors, gifts received from alumni and industry, and size of the College endowment.

4.1 Promote Greater Scientific Literacy in the General Public

The American Association for the Advancement of Science defines the science-literate person as: "one who is aware that science, mathematics, and technology are interdependent human enterprises with strengths and limitations; understands key concepts and principles of science; is familiar with the natural world and recognizes both its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individual and social purposes." Promoting scientific literacy requires changing public attitudes about science and effecting peoples' actions. This can occur directly through innovative education, including educating teachers (e.g., UTeach), and interacting with the public on and off campus, either in person or through media.

In some sense, when the public can realize the usefulness of science in their daily lives, they are more prone to having positive attitudes about science.

Besides direct teaching, the College can facilitate science literacy by expanding service learning, participating more fully in science fairs, especially large events like the USA Science and Engineering Fair, and offering a "Kennedy College of Sciences Day" or a "Science and Society" lecture series. We can also develop "exhibits" for open houses and other recruiting events, and if created in a modular form, these exhibits can be used for a variety of events including at public schools and Admissions events across New England. Some Sciences' departments at UML use hands-on activities to excite potential students and their parents during Open Houses and Welcome Days. These are ripe for a science road show. In addition, besides newsletters and marketing brochures designed for potential students and donors, publications can be created that highlight activities we do that would be of interest to all, such as robotics, space science, climate change, marine biology. Finally, we have the expertise and the connections through the School of Education to provide workshops for public-school teachers that help them focus on teaching science literacy to a general population

4.2 Encourage Stewardship and Conservation of Natural Resources

An institution that serves the general public has an obligation to act as a role model regarding sustainability and attitudes toward conserving natural resources. This must span the research and education mission as well as the day-to-day activities of students, faculty and staff including recycling efforts, use of paper, energy usage, and building standards. As a signatory of the Climate Action Plan (CAP), we must adhere to high standards in our education mission as well, which includes assuring climate change and sustainability topics are important components of our curricula – beginning with new students in our freshmen seminars. We will work closely with the CAP committees to ensure these goals are met. Kennedy College of Sciences faculty members are engaged in energy-related research and green technology, but we need to make sustainability an everyday priority.

4.3 Involve Alumni More Fully in the Life of the College

Alumni represent the continuing lifeblood and ambassadors of the institution and are a remarkable resource for mentoring current students in life lessons and careers, advising faculty and administrators, creating connections with industry decision makers, and providing financial resources. We will improve and enhance our engagement with alumni through: (1) increased faculty participation at events on campus, such as Homecoming and sporting events; (2) creation of workshops and panel discussions regarding career opportunities and choices, and tips to landing a job; (3) creation of an alumni mentoring program that connects alumni interested in mentoring young professionals with interested students, and; (4) engaging alumni in teaching courses or presenting topical lectures and colloquia. We will "capture" graduating student information so we can keep track of alumni, preferably through social media like LinkedIn. We will also improve communication through media such as College and Department newsletters and magazines with articles about alumni achievements. Finally, we will develop strategies to more effectively use our advisory boards as links to alumni.

4.4 Increase Marketing and Media Participation

The College will improve its relationship with UML Public Relations and will increase and improve its online and print publications. We currently produce an e-newsletter and we are working on a printed magazine for annual release. Both publications focus on the achievements of students, faculty, and alumni as well as their effects on the region and nation. We have already identified a group of faculty "reporters" to provide material for publication pieces, and we are working with University media personnel to produce the final copy. However, this process could be streamlined and expanded greatly by hiring a person to centralize these efforts in the Dean's office and work with departments to expedite information gathering. This person would also be responsible for web site content and maintenance, supervising events for the public and the media, and working directly with media outlets for targeted press releases.

5. Cultivate Faculty & Staff Excellence

(Pillars: Global Engagement & Inclusive Culture; Entrepreneurial Stewardship)

The strength of any organization ultimately resides with its people. Consequently, supporting excellence among the faculty and staff is essential for fulfilling the mission of the College. By maintaining a supportive work environment that provides opportunities for professional growth, fairness, and recognition of achievement faculty and staff are more likely to remain motivated and committed to the institution and the College. In addition, the expertise of such a motivated workforce can be creatively engaged on a continual basis to address challenges and problems confronting the College. This not only gives them a deeper sense of commitment and stake in the College activities but it also ultimately generates the best results.

Relevant Metrics: Faculty/Staff receiving and serving as mentors; instances of demonstrated leadership by faculty and staff, and measures of Faculty/Staff dedication, collaboration, recognition, initiative, and volunteerism.

5.1 Improve the Quality of and Opportunities for Mentoring

Mentoring in an academic setting can be difficult since faculty members are essentially peers who may have to judge one another during promotion. However, surveys underscore the desire of faculty members to be mentored. Furthermore, though studies have shown informal mentoring is most successful, ensuring it occurs requires a more formal mentoring program in which mentors are identified and assigned. Guidelines need to be developed laying out expectations for both mentors and mentees, and programs will be continually assessed. Workshops and luncheon groups for junior faculty members also will be regularly convened to facilitate camaraderie and idea sharing.

A similar program of mentoring will also be implemented for staff. Seasoned staff members have incredible institutional knowledge and insights necessary for the smooth functioning of the College. Rather than leaving the dissemination of this knowledge and insight to happenstance, a more structured approach is called for. As with new faculty, this can partially be achieved through mentoring activities, which will facilitate the growth and integration of staff into the intellectual, administrative, and social culture of the College.

5.2 Recognize and Reward Faculty and Staff Achievements

Recognizing and celebrating faculty and staff achievements demonstrates their efforts are valued, and it communicates what behaviors and attitudes are valued across the College. Award celebrations also serve to boost morale and give members of the College community the opportunity to socialize and get to know their peers better. Campus-wide award ceremonies have been increasing and the College of Science has begun recognizing faculty and staff for extraordinary efforts using what we call "Going Beyond" awards. We must expand these efforts to ensure achievements are truly noticed and come to mean more than simply merit raises. We need to expand the breadth of awards to include sub-categories such as supporting a respectful and healthy work environment, commitment to the College, and role models. We need to recognize superior performance by Lecturers and TT faculty, technical and administrative staff as well as senior and junior personnel. These recognitions should be part of the College climate and part of all gatherings where appropriate. Criteria will also be set for monetary rewards for outstanding achievements.

5.3 Cultivate Leaders

With an aging faculty that is retiring rapidly comes a dearth of academic leaders. Grooming leaders often occurs through service activities and many leaders began as committee members, coordinators, chairs or associate chairs, senators, or dean's office staff. However, the barriers to expanding one's leadership roles are immense with a loss of research time, decreased time spent teaching and mentoring students, and redefined relationships with colleagues. Some potential leaders are dissuaded by the notion that there is no way back and their efforts will not be appreciated. We need to create an environment in which all faculty members appreciate the importance of service, have a willingness to serve, and realize all must lead to some degree. This might include:

- Engaging in College-wide discussions that highlight the benefits of service, create mechanisms to sharpen leadership skills, and determine ways to protect junior faculty from repercussions that may occur from dedication to service. We must strive to involve all faculty members in service, not just the few who are most willing or the chair.
- Defining service roles and their worth more thoroughly. What activities deserve remuneration or course releases and how should these be counted toward workload?
- Identifying potential leaders and mentoring them through targeted service tasks.
- Providing literature that describes leadership paths, how skills are honed, and how skills can be aligned with other aspects of ones workload.
- Educating faculty about norms for leadership pathways in their discipline.
- Supporting personnel from under-represented groups.
- Negotiating leadership roles to ensure teaching and research can continue, and to ensure that faculty have an opportunity to "test the waters" without jeopardizing other interests.
- Supporting participation in leadership workshops and symposia.
- Reorganizing department and college administrative structures to allow chairs to focus on leadership and moving the department forward rather than day-to-day minutiae. This will entail centralizing activities; a task that is already underway in the Dean's office.

5.4 Increase Faculty and Staff Diversity

Increasing diversity on campus is an important mission of the institution, but we still have a long way to go, especially within the faculty ranks. The administration and faculty members must strive to seek out diversity in applicant pools and use our vast collegial network to recruit. The recently declined NSF ADVANCE proposal laid out a suite of measures to promote equity and diversity and underscored subtle actions that dissuade women from continuing their careers. Although not funded yet, many aspects of the program should be supported and the campus must tackle gender bias head on. We also need to continue educating personnel about the benefits of diversity.

Recent faculty hiring in the Sciences has focused on recruiting mid-career candidates to boost our research portfolio. Although successful to some degree, this practice hinders diversity since senior faculty ranks nationwide are not diverse. We recommend that future hiring begin to focus more on junior hires to enhance diversity and to provide better balance and mentoring capabilities. A scarcity of junior faculty is not a sufficient rationale to hire more faculty members, but it is a compelling rationale to hire junior faculty members who often are more approachable by students and can be groomed as future leaders with useful institutional knowledge.

5.5 Improve Efficiency to Maximize Faculty and Staff Productivity

The distribution of tasks within the College can be optimized to improve efficiency and to ensure assignments are distributed equitably and conducted by the appropriate personnel. As we have grown and enrolled more students, the burden on departments has intensified. This has negatively affected morale and buried leaders in minutia. To alleviate some of the burdens of growth, we have begun to centralize some activities in the Dean's office such as advising and student success. There still remain opportunities to make significant differences in aspects of research management, recruitment, graduation approvals, public relations, enrollment management, etc. The acquisition of an Assistant Dean and an Associate Dean for Research and Graduate Studies has been a big a step in moving the College ahead. However, opportunities for maximum efficiency also reside in our ability to better shape department structures and to define positions therein.

Chairs must focus more on managing the department; providing a strategic vision; and integrating the department with the College, campus, alumni and industry. To this end, they require well-defined assistance by Associate Chairs who can concentrate on internal matters. The faculty union contract recognizes Associate Chairs, but has yet to define their compensation and role. The College and departments must define the roles of Chairs and associate staff and need to share best practices to create a department and College structure that best serves our needs and can effectively evolve over time as we grow and diversify.

V. Next Steps

The current document, "Roadmap for the Future: Kennedy College of Sciences Strategic Plan 2015-2020, is the result of the initial phase of the College strategic planning process. As part of this on-going process, the plan will be continually revised and updated as circumstances evolve and goals are refined. To ensure this happens in an effective and timely manner, well-defined procedures for evaluating and assessing progress are being developed and will be implemented over the course of the coming academic year.

The next step going forward is creating a standing Strategic Planning Oversight Committee (SPOC) to guide the overall process as we move forward. This committee will align sub-committee and individual efforts with the overall College vision. A college assessment committee will also be formed. This committee will refine the metrics and create new ones if necessary, develop benchmarking data, set and adjust indicator values for success, and collect and process assessment data necessary for evaluating our progress. This committee – the College Assessment and Accreditation Working Group (CA^2WG) – will also assist student learning outcomes assessment and accreditation matters across the College.

In addition to SPOC and CA^2WG, separate sub-committees devoted to each of the five main strategic areas will also be formed in Fall 2014. These committees will begin refining specific objectives and developing detailed action plans for implementing specific program goals, and proposing new policies and procedures to ensure timely progress on the objectives specific to their thematic areas.

Finally, all of this work will continue to be informed by the various constituencies of the College. This includes the faculty, students, staff, alumni, members of relevant industries, and the public. Input from these various constituencies will be evaluated and integrated into strategic improvement processes to continually re-align and adjust our efforts in order to make the vision of the Kennedy College of Sciences a reality.

Appendix A
Strategic Planning Process

The strategic plan laid out in this document is the product of a collaborative process among faculty, staff, students, and alumni. This planning process has generated a clearly defined College vision, mission, and strategic goals with the goals divided into five thematic areas.

An Executive Team was established in September 2013 to lead this strategic planning process. The team consisted of Mark Hines, Acting Dean; Supriya Chakrabarti, Associate Dean for Research and Graduate Studies; Fred Martin, Director of Student Success; and Stephen Norton, Assistant Dean. The department chairs and their faculties created department one-page business plans that outlined department goals and strategies for achieving these goals. These plans were reviewed by the College Advisory Board and discussed at the Fall Advisory Board meeting. The Executive Team and the chairs became a Strategic Planning Committee, which used department input to create a tentative list of strategic themes. At a faculty retreat, these themes were modified and subcommittees met and provided lists of specific goals for each theme, which included action items to achieve these goals and metrics used to assess progress. The Executive Team then organized this information into a working list of action items for the plan. This outline was discussed with a staff focus group, an undergraduate student group, and a graduate student group.

The Strategic Planning Committee, using input from departments, created a list of research foci that best built on College and University strengths, and that represented interdisciplinary efforts and would best move College research forward while addressing regional and national needs. The resulting foci were discussed with faculty at a second retreat where subcommittees created revised lists that included 1) strengths and weaknesses; 2) potential internal and external partners; 2) necessary resources such as new faculty, equipment, and infrastructure; 4) educational implications such as new degree programs or tracks. The Executive Team used these results to organize research foci into three primary focus areas. A draft that incorporated the strategic themes and the research foci was discussed with the College Advisory Board during the spring meeting. Feedback from the Board and other College constituencies was incorporated and helped shape the draft of the final report.

Appendix B
College Scorecard

Throughout the strategic plan various metrics have been identified as necessary for measuring the College's progress towards achieving its various goals and related objectives. This appendix collects these metrics and organizes them under their primary thematic foci for each of the five main strategic goals. In addition, baseline numbers are, or will be, identified for each metric and indicator values for success are projected over the course of the next six years. This will enable the College to calibrate its efforts so as to ensure steady progress and the most effective use of available resources. The list of metrics outlined below is an abridged version for the whole College, but an extended version has been created that delineates details for each department.

Some data exist for making comparisons and guiding projections for College target outcomes. However, most of these data are only available for departments. The diverse nature of science colleges in American higher education makes is nearly impossible to create any sort of meaningful database for comparing science colleges holistically. Without such a database, selecting aspirational peers at the College level is not instructive. Thus, no peer aspirants have been selected.

Kennedy College of Sciences Scorecard	Source	FY2014	FY2015	FY2016	2017	2018	2019	Related Goals & Objectives
Strategic Goal 1: Expand Research, Scholarship, and Creative Activity (Actual Data in Blue, Target Goals in [Brackets] in Red)								
Tenure Track Faculty (TTF) – Increase Total Faculty 150%	**Factbook**	**91**					**140**	
Diversity: Female / Underrepresented								
Total Research Expenditures – Increase 180%								
External Research Expenditures – Increase 150%	**Summit**	**$15.5M**					**$30M**	
Research Expenditures / TTF – Increase Average 150%		**$170,000**					**$200,000**	
Federal Research Expenditures / TTF								
Federal Research Expenditures / TTF								
Industry Research Expenditures / TTF								
Industry Research Expenditures / TTF								
% of Research Center Budgets Supported Externally								
Peer-reviewed Journal Publications (PRJP)		**260**					**500**	
Citations								
PRJP / TTF		**2.9**					**3.6**	
Citations in PRJP / TTF								
Graduate Students Supported / TTF								
Ph.D. Students / TTF								
R.A.s / TTF								
Strategic Goal 2: Improve the Undergraduate and Graduate Experience (Actual Data in Blue, Target Goals in [Brackets] in Red)								
Total Experiential Learning Opportunities (by students served)								
Laboratory Experiences								
Research								
Internships								
Service Learning Opportunities								
Other Experiential or Professional Learning Experiences								
Undergraduate Students - Total	**Factbook**	**1,287**					**2,000**	
Diversity: Female / Underrepresented								
Avg. GPA Frist Year Student /Transfers								
1st Year / 2nd Year Retention Rate								
4-year / 6-year Graduation Rate								
Average Time to Graduation								
Graduate Students - Total	**Factbook**	**550**					**750**	
Diversity: Female / Underrepresented								
Total Doctoral Students								
Total Masters Students								
Applicants / Acceptance Rate								

Kennedy College of Sciences Scorecard	Source	2014	2015	2016	2017	2018	2019	Related Goals & Objectives
Strategic Goal 3: Increase Entrepreneurial Activity & Economic Impacts (Actual Data in Blue, Target Goals in [Brackets] in Red)								
Total Industry Research Expenditures (External Only)	**Summit**							
Industry R&D Expenditures / TTF								
Patent Disclosures / Applications								
Patent Royalties paid to UML								
Commercial Ventures / Start-up / IP Transfers								
Faculty / Students Involved								
Revenues Generated								
Jobs created in Massachusetts								
Strategic Goal 4: Engage the General Public, Our Peers, and the College Community (Actual Data in Blue, Target Goals in [Brackets] in Red)								
Nationally / Internationally Recognized Faculty								
Society Fellows								
National Academy of Sciences								
Undergraduate / Graduate Programs Ranked Nationally	**USNWR**	**0 / 2**						
Degrees Awarded B.S.		**344**					**520**	
M.S.		**89**					**150**	
Ph.D.		**18**					**50**	
Total Donors								
Alumni								
Industry								
Total College Endowment								
Endowed Scholarships								
Endowed Chairs / Professorships								
Total Gifts Received								
Alumni Gifts								
Industry Gifts								
Strategic Goal 5: Cultivate Faculty & Staff Excellence (Actual Data in Blue, Target Goals in [Brackets] in Red)								
Faculty & Staff Mentoring								
Faculty / Staff Receiving Mentoring								
Faculty / Staff Serving as Mentors								
Faculty & Staff Engagement	**Surveys**							
Dedication								
Collaboration								
Recognition								
Initiative								
Volunteerism								

Appendix C
Department Strategic Plans

Biological Sciences

The Department of Biological Sciences consists of a vibrant community of scientists and students engaged in the discovery, dissemination, and application of knowledge of biological sciences. It is clear that biological sciences are at the forefront of research that will affect all of mankind for decades to come. The 20th century was the century of physics, while the 21st is certainly the century of biology. A Biological Sciences goal is to become the regional hub of life science research. Student enrollment in Biological Sciences continues to grow to meet the needs of the region's burgeoning life sciences industry. Biological Sciences currently consists of 17 full-time faculty members (12 TT) with over 500 undergraduate majors and 60 graduate students. We envision that the coming years will represent a significant growth period in Biological Sciences at the University, and this is completely justified when the rapid rise in the life sciences worldwide is considered. The College strategic planning exercise identified the life sciences as the area most conducive to expansion since it spans many areas of expertise throughout the College and the University, is growing rapidly in the private sector, offers diverse avenues for federal and private support, is a focus area of State Government, and encompasses a myriad of opportunities for interdisciplinary scholarship and education. Biology's research plan is delineated in the College research plan under the "Innovation in Life Sciences" section (1.2.1).

Curricula. Biological Sciences has been offering a popular general B.S. degree for many years that enrolls over 80% of the undergraduate majors. However, Biological Sciences also offers a Biotechnology option that is quite popular, as well as an Ecology and Bioinformatics options. Although the Biotechnology option prepares students well for jobs in the biotech industry, students graduating from the general degree also easily find positions in the life-sciences sector. Biological Sciences also prepares students well for professional degrees (the bulk of the pre-med students receive a Biol. Sci. degree), and many graduates go on for M.S. and Ph.D. degrees. The Bioinformatics option is poorly enrolled and is undergoing modification to increase flexibility with additional free electives. The M.S. program has been growing; especially the number of applications. However, the yield is still disappointing, so the Department must improve recruiting and marketing. Removing the application deadline should improve enrollments now that the student quality has improved.

Degree Programs. To facilitate the growth of the research, Biology is in the late stages of developing an Integrated Life Sciences option for the existing inter-campus Biomedical Engineering and Biotechnology (BMEBT) graduate program. This improvement will provide students with a broad knowledge of the interrelationship of biological systems from the molecular to the organism and ecosystem scale. Since there are significant areas of Biology research that do not fit within the BMEBT framework, Biological Sciences has begun discussing the development of a new **Biosciences or Life Sciences Ph.D.** program that leverages the Kennedy College of Sciences inter-disciplinary strengths. We envision that this PhD program will encompass the group model approach and provide a single entry point for students into all departments within the Kennedy College of Sciences. This will enable them to conduct Bioscience research in any laboratory in the College with the curriculum being customized to

match each student's particular research interests. In addition to these new PhD programs, we have also begun to consider establishing new Biology-discipline specific B.S. programs so students can earn undergraduate degrees in, for example, **Biochemistry, Biophysics, and improvements in Biotechnology and Bioinformatics.** We see these programs being designed across departments without being constrained by the need to meet the core requirements of any existing departmental program. These new undergraduate programs would also provide the University with the ability to attract outstanding high school students who possess a mature interest in a specific sub-discipline of Biological Science or life sciences in general. These new programs can be easily adapted to fit our research plans articulated in the College strategic plan (section 1.2.1) e.g., imaging research, biophysics, big data, drug development, biomaterials, molecules to organisms, and even aspects of space sciences.

Enrollments. The importance of the biological sciences and its role in regional industry have led to a 14% annual increase in enrollments between AY08 and AY13. As of August 29 2014, enrollments for Fall 2014 are 23% above 2013 levels, so growth is escalating. We anticipate that undergraduate enrollments will reach 700 or more by 2019 and M.S. enrollments will reach over 75. We also expect to see a tripling of Ph.D. enrollments to 30 as faculty ranks increase and new Ph.D. degrees and options (BMEBT) are developed.

Faculty. The faculty of Biological Sciences is grossly too small to meet the student and research demand of the Commonwealth. Consequently, two new tenure-track faculty members and one additional Lecturer will join the faculty by January 2015. In addition, we plan to hire two new tenure-track faculty members per year over the next several years, with an ultimate target of 29 full-time faculty members by FY 2019. Despite such growth, the student-faculty ratio in Biological Sciences will still be too high at 24. The selection of new faculty expertise is based on interdisciplinary College research directions (Section 1.2.1) and the requirement that research and workforce needs of the future will entail the translation of macromolecules to organisms and interdisciplinary teamwork. To that end, we will search for faculty members with expertise in molecular and cellular dynamics, developmental biology, regenerative medicine, biophysics, computational biology/informatics, and evolutionary biology.

Infrastructure. To foster the growth of research in biosciences at the University, we have begun expanding the core research facilities both within Biological Sciences and at the University. For instance, over the past year we have added state-of-the-art real-time quantitative PCR and gel imaging systems. We are also currently establishing a new Biomolecular Characterization Laboratory to provide researchers with access to new tools for molecular analysis such as a surface plasmon resonance. A long-term goal of Biological Sciences is to spearhead a capital project to upgrade the physical state of our teaching and research laboratories, with a vision toward establishing bioscience "nodes" that bring researchers with overlapping interests and related technical cores together in close proximity within a Life Sciences research center without regard to departmental or college affiliation. This expansion must include a state-of-the-art vivarium to allow for the use of small animal models in research, especially mice and rats. This vivarium is a requirement for the creation of an imaging and biophysics program and is needed for improvements in Bioengineering and Pharmaceutical Sciences. Biological Sciences has no spaces for students, clubs, nor any space for faculty to socialize at all – including eating. Moreover, the conference room is too small for a full faculty meeting.

Chemistry

The Department of Chemistry has the overall goal of becoming an attractive destination for outstanding undergraduate and graduate students, while expanding its research activities and industrial connections. This will result in greater research and collaborative opportunities for undergraduate senior thesis research (or co-ops) and increased ability of Chemistry to participate in cutting edge, interdisciplinary research grants. Chemistry is strong in interfacial and surface science, and historically in polymer science. It is proposed that these strengths be leveraged to participate in College-wide interdisciplinary research growth as articulated in the College plan. In particular, Chemistry intends to be a significant partner in College efforts to strengthen life sciences research and education and to contribute to materials science initiatives at the University. It is also anticipated that Chemistry will expand its research base in pharmaceutical science due to the large number of regional companies in the field, and to match the University's planned new programs in this area.

Curricula. Chemistry offers a B.S. degree in Chemistry with an option in Forensic Science, and both are approved by the Committee on Professional Training of the American Chemical Society. Although attractive to incoming students, graduation rates in the Forensics option have been relatively low. The best students often switch to the traditional chemistry degree, while the poorer ones tend to change to majors outside of the Kennedy College of Sciences. Efforts are underway to examine and possibly modify the Forensics option. Chemistry offers M.S. and Ph.D. degrees in Chemistry, and the Ph.D. degree has options, in collaboration with other departments and colleges, in Polymer Science/Plastics Engineering, Biochemistry, Environmental Studies, and Green Chemistry. To date, Chemistry has graduated more than 400 Ph.D. students.

New Degree Programs. The Chemistry Department offers a well-rounded program at the undergraduate and graduate levels, and the Ph.D. degree is quite diverse with several options available. With the growth in interdisciplinary research programs throughout the College, there are expanding opportunities for students in Chemistry that would help prepare them for the rapidly changing biotechnology/biopharmaceutical industry. The possibility of a **joint B.S. degree in Biochemistry** with Biological Sciences will be explored, and it is anticipated that Chemistry may participate in a Biosciences or Life Sciences graduate degree program with other departments in the College. Chemistry will also contribute to a new Biophysics degree with Physics and Biology since their expertise in biomaterials, drug development, and aspirations in micro-instrumentation will be a natural fit for imaging science and medical physics. The Department's strengths in surface chemistry, polymer science, pharmaceutical science, and materials chemistry will also benefit the University's efforts in printable and flexible electronics, nanotechnology, and chemical and biological sensors.

Enrollments. The undergraduate enrollment in Chemistry is relatively small compared to Biology and Computer Science. However, the average rate of growth of majors in Chemistry has been more than double the annual rate of the University as a whole at nearly 14% per year for the last seven years. We expect over 150 majors by 2019, which is a healthy program for a chemistry department. In addition, Chemistry teaches a significant service load, at well over

8,000 credits per year. The M.S. program has not been growing because Chemistry focuses on Ph.D. student training. The number of PhD. students is large for the size of the department with 50-60 in FY14 and projections of over 80 in 2019. With the rapid retirements occurring in Chemistry and their replacement by active research faculty, Ph.D. student enrollment is expected to increase.

Faculty. Increasing the number of research-active faculty by seven in the next five years is proposed. Targeted hires will include those working in micro-instrumentation involving lab-on-a-chip or printable electronic and microfluidic devices, biomaterials, and organic synthesis for drug development. These are all areas that will contribute to College plans for interdisciplinary research programs. In addition to hiring strong researchers and excellent teachers, it is desirable that future Chemistry faculty hires interface with regional companies and participate in interdisciplinary research proposals.

Infrastructure. To succeed, Chemistry requires access to continually improving research and teaching facilities, such as modular and flexible research labs and upgraded and new analytical instrumentation. Core facilities also need to be strengthened, and would benefit from creation of a Life Sciences Center.

Computer Science

The field of computer science is a drastically changing and important field; and with "pervasive computing" just around the corner and the interdisciplinary nature it embodies, the department must continue to make alliances within the College and beyond. The field in general attracts many students, and Computer Science has been very successful at graduating students who acquire meaningful jobs in regional industry. In fact the Computer Science undergraduate program is the fastest growing in the College over the last few years. Its programs in robotics, cybersecurity, visualization, machine language, computer education, and others are world class and will be leveraged to move Computer Science to the next level. This expertise creates underpinnings useful for innovations across campus from genomics and pharmaceutical research to imaging and climate change. It is recommended that Computer Science pursue even deeper connections with other disciplines on campus. We anticipate there will be significant growth in big data, cybersecurity, and cloud computing, which will move Computer Science forward rapidly. Consequently, Data Science was a clear choice as one of the three major research thrusts of the College over the next five years.

Curricula. Computer Science offers a B.S. in Computer Science with an option in Bioinformatics. The general degree is overarching and allows students to become proficient in software and hardware aspects of computing, as well as the mathematics and science underlying the discipline. The M.S. in Computer Science is also a general degree and has options in Bioinformatics and Entrepreneurship. The Ph.D. in Computer Science provides students with a challenging research environment and the opportunity to tackle theoretical or applied projects. Ph.D. options are available in Computational Mathematics and Bioinformatics.

New Degree Programs. Computer Science has prided itself on offering a popular and well-rounded curriculum general enough to satisfy the needs of diverse student interests and industry

workforce. However, with the rise in data science, or the generalizable extraction of knowledge from data, and the broad expertise in this area already present, Computer Science will benefit greatly by creating **Data Science undergraduate and graduate programs.** These programs will focus on the needs of the rapidly growing areas of big data, cybersecurity, and cloud computing. As such, they will be ideally positioned to satisfy regional workforce needs in topics such as signal processing, pattern recognition and learning, visualization, uncertainty modeling, data warehousing, and high performance computing among others. Computer Science is also creating a "day school" **Information Technology B.S**. degree. This degree option will be an on-campus program to satisfy the demands of incoming freshmen aspiring to work in the information technology area but not interested in acquiring high end computer science skills.

Enrollments. Since 2008, the number of new undergraduate students in Computer Science has increased each year by a remarkable average annual rate of nearly 19%. With the importance of Computer Science growing worldwide and its pervasiveness in all aspects of life and other science and technological disciplines, we expect undergraduate enrollments to climb to ~700 students by 2019. Graduate student enrollments in Computer Science surpass any other department in the College with 140 M.S. and 94 Ph.D. students enrolled in 2014. The Computer Science graduate student enrollments over at least the last seven years have exceeded those of any other department at UML. We anticipate the M.S. and Ph.D. enrollments in 2019 will be 230 and 175, respectively.

Faculty. The field of computer science will continue to grow at phenomenal rates as technology becomes pervasive. Unlike the bench-science departments in the College, CS can grow substantially at minimal costs and Computer Science has a track record that underscores the benefit to the institution if it does. It maintains large enrollments at all levels, supports more GRAs than any department with a relatively low GTA need, is adept at acquiring external funds, has strong industry ties, offers more industrial co-oops than the rest of the College combined, and provides much needed expertise for many other departments, a need that will only increase in the future. We anticipate that Computer Science will require 28 faculty members (seven more) by 2019 to stay competitive in a rapidly growing field. These hires will be dedicated primarily to the data sciences, especially big data, cybersecurity and cloud computing as delineated in the College plan.

Infrastructure. Construction needs in Computer Science are rather minimal compared to the bench sciences. However, like the other departments, Computer Science needs modernized laboratories and student spaces. Much of the research is conducted in joint spaces with two or more PIs. Although this arrangement is often satisfactory and adds flexibility, there are several types of work in Computer Science less efficient when conducted in multi-PI labs – such as work with machine learning and video understanding. Hence, Computer Science is assessing how to best arrange spaces.

Environmental, Earth & Atmospheric Sciences

Climate variability and the resulting environmental impacts are a major societal concern. The Department of Environmental, Earth and Atmospheric Sciences (EEAS) is uniquely positioned to not only deal with these concerns, but also other issues involving environmental degradation,

energy and sustainability. EEAS is small (only six faculty members), but covers all aspects (atmosphere, geosphere, hydrosphere) of the physical environment. It is well positioned to engage others on campus in a comprehensive study of these areas. EEAS is currently collaborating with the College of Engineering (particularly Civil Engineering) and sees further collaborative opportunities with the College of Health Sciences dealing with the impact of the physical environment on human health. We also note that the National Bureau of Labor Statistics predicts above average growth for the Environmental Sciences and Geosciences. In addition, we expect the escalation of the space sciences and technology areas at UML will necessitate increased collaboration with EEAS researchers. EEAS has a very strong Advisory Board; and the department is exploring increasing opportunities for external co-ops, endowed scholarships (which have already been increasing rapidly), and service learning projects.

Curricula. Restructuring of the Environmental Studies and Environmental Geoscience options in the BS Environmental Science degree occurred in the 2011-2012 academic year. Students began entering these new options in Fall 2012 and from then until Fall 2014 EEAS has seen a 50% increase in the number of students in these options. Both options share a common science core, which maximizes the efficiency of course delivery. The Environmental Studies option is a reworked version of the old BA degree, but it is more desirable to students because they receive a BS degree to be more marketable. The Environmental Studies option comprises six non-science foci (Economics, English, Foreign Languages, Legal Studies, Management, Political Science) developed in consultation with the appropriate UML departments and colleges. These options provide value added to the Environmental Studies program. The Environmental Geoscience option has additional course work shared with the new MS/PSM degree options in Environmental Geoscience (MS/PSM Environmental Studies, a shared degree with Civil Engineering). EEAS is in the early stages of developing the MS/PSM options, and the first students enrolled in Fall 2013. There are currently five students in the program, and an aggressive marketing campaign is planned for Fall 2014 with the intent of at least doubling the number of students by Fall 2015. Because a significant number of undergraduate students in EEAS are transfer students, beginning Fall 2014 EEAS will be aggressively recruiting at area Community Colleges via personal site visits.

New Degree Programs. Because of its close working relationship with the Civil Engineering Department, EEAS hopes to establish **joint graduate degree programs.** An example of the collaboration between the Civil Engineering Department and EEAS is the new Geology for Engineers course. The courses is designed specifically for Civil Engineering juniors and is being offered for the first time by EEAS in Fall 2014. Discussions are also underway to leverage resources to enhance environmental science and environmental engineering at the undergraduate level. Additionally, we hope to create a joint Ph.D. program with Engineering, which we will include an Environmental Geoscience option. EEAS anticipates developing a second option in Atmospheric Science involving both Civil Engineering (air pollution and related topics) and Chemical Engineering and Mechanical Engineering (solar and wind energy). There are a number of potential collaborations with the College of Health Sciences we plan to explore/develop over the next two to three years. EEAS plans to develop Graduate Certificates in Atmospheric Science and Environmental Geoscience. EEAS will also house the new interdisciplinary minor **Climate Change and Sustainability**.

Enrollments. Undergraduate enrollments in EEAS have been rather stagnant over the last few years but have still increased to over 100. However, much of this apparent lack of growth was due to a decrease in enrollments in the Atmospheric/Meteorology option. However, enrollments have recently begun increasing in this area as well. The Environmental Studies and the Geosciences options have grown fairly steadily. We attribute much of this to increased recruiting, but it is also due to the revamped curricula in both options that make them more current and better aligned with similar options nationwide, which has eased the transfer process. The Environmental Studies option accounts for about 40% of all enrollees and underscores the utility of creating a broad set of tracks that are superior to the previous B.A. degree. Given that EEAS growth is occurring in the Environmental Studies and Environmental Geoscience options, which are areas predicted to grow nationwide, we plan to build our expertise in this area. There are presently over 100 undergraduate majors in EEAS. Considering the growth in Environmental Studies and Geoscience, we expect 130 or more within the next few years, even if the Atmospheric Program declines. We also anticipate a 30% increase in M.S. enrollments over the next few years as research and our intercollegiate programs grow.

Faculty. Given the demands of our curriculum and the programmatic and collaborative research areas we wish to explore, EEAS needs to add three geoscience faculty members over the next five years. Ideally one of these hires (a hydrogeologist who would support curriculum and research needs in both CE and EEAS) should be in place in Fall 2015. The second hire, for Fall 2016, would be a geochemist who would support a broad range of activities in the department and replace the expertise of the current department chair who plans to retire relatively soon. The third hire has not been defined, but the exact specialty depends on the research direction of EEAS. If plans to develop cooperative activities with the College of Health Sciences come to fruition, a logical third hire would be in the area of human health and the environment. As the teaching service load increases, EEAS will also require another Lecturer within the next few years. Finally, if EEAS becomes more involved with the space sciences, faculty positions in the more distant future (2018 and beyond) will be required.

Mathematical Sciences

The Department of Mathematical Sciences is equipped to substantially expand its contribution to the teaching, research, and service missions of the university. Mathematical Sciences research expertise centers on probability and statistics, analysis and mathematical modeling, and optimization. They also plan to expand their strength in applied and applicable mathematics through further collaboration with Engineering and Science departments. There exist several promising areas, such as the modeling and optimization of traffic flow (in conjunction with the Transportation Research group of the Civil Engineering department), computational chemistry (in conjunction with chemistry and nanotechnology), and computational geometry, including image processing (in conjunction with Computer Science). Through new hires, Mathematical Sciences proposes to add expertise in numerical methods and algorithms. Scientific computing, including parallel computing and "big data" methods, forms natural complements to many research efforts at the University; and their importance is expected to grow in the Sciences, Engineering, Business, and Health. Hence, over the next few years, we expect math to be a key player in many of the premier growth areas.

Curricula. Mathematical Sciences offers both a B.S. and a B.A. in Mathematics. Both require the same math and computing core courses, but the B.S. has more stringent science requirements similar to other B.S. degrees in the College. The B.S. is more popular than the B.A., and the B.S. allows for a variety of concentrations from Applied/Computational, Business Applications, to Probability/Statistics; so the B.S. track is useful for the variety of math applications seen in the workforce and the kinds of research conducted on campus. Mathematical Sciences also offers an M.S. with options in Applied Mathematics, Mathematics/Statistics and a Teachers option. There is a PSM in Industrial Mathematics. Students can obtain a Ph.D in Computational Mathematics through the Computer Science Department.

New Degree Programs. With the proposed expansion in faculty members with research expertise in a variety of applied disciplines, Mathematical Sciences will be poised to create a new **Ph.D program** to support this research and the pedagogy required to satisfy workforce needs. In addition, Mathematical Sciences plans to expand its successful Professional Science Masters (PSM) program in Industrial Mathematics. A key component of the PSM program has been a science cluster approach that graduates students with a strong mathematics background and an expertise in areas such as epidemiology, data science, or pharmaceutical sciences. We have already graduated students in the first two areas and are exploring ways to develop a cluster corresponding to the growth in the Pharmaceutical Sciences Department.

A significant percentage of Mathematical Sciences undergraduate majors are interested in industrial co-ops or UTeach. We plan to expand co-op participation by adding an **epidemiology option to the B. S.**, eventually leading to a five-year BS/MPH program. Within three years of launching UTeach, we already have two mathematics majors who have simultaneously earned a bachelor's degree and professional teaching certification, and they are now teaching in local high schools. By maintaining contact with UTeach graduates of the program, we expect to have an increasingly influential role in the professional development of mathematics teachers in the Merrimack Valley.

Enrollments. Once widely thought of as primarily a service department, Mathematical Sciences has proven to be a consistent source of strong graduates that serve the workforce needs of the region. Mathematical Sciences' graduates are often UML valedictorians, and they find jobs quickly. Since 2007, undergraduate enrollments in Mathematical Sciences have increased by 12.5% per year and are currently over 140 majors. We predict enrollments will approach 200 by 2019. The M.S. Program is also growing, especially over the last two years with a growth rate of 36% and enrollments near 70 are expected by 2019.

Faculty. Mathematical Sciences has embarked on a five-year plan to hire new faculty members to satisfy the needs of the College plan. The Department is losing several faculty members to retirement. Four are retiring this year alone. The first two additions, a statistician and applied mathematician, will join Mathematical Sciences in AY 2015. Engineering has plans to launch an industrial engineering (IE) program, and the applied mathematician we have recently hired could teach courses to strengthen that program and also help us design a PSM science cluster in IE. In the future, Mathematical Sciences proposes to hire faculty members with expertise in the following areas: statistics, statistics/combinatorics, number theory, geometry, applied math, algebraic geometry, and graph theory. The hires in these disciplines are designed to collaborate

with a variety of research and education programs at the University including data mining, imaging and image processing, optimization, security studies, manufacturing systems (nanomanufacturing, biomanufacturing, manufacturing enterprise, modeling and simulation, design optimization, etc.), biomolecule modeling, drug design, environmental systems, and various areas in Physics.

Infrastructure. Like Computer Science, space needs for Mathematical Sciences are rather modest, but currently insufficient to handle any growth. Offices are smaller than the University norm, their conference room is inadequate, and there are no spaces for student clubs.

Physics & Applied Physics

The Department of Physics and Applied Physics at UMass Lowell has an internationally recognized record of excellence in academic research and teaching. The standards of excellence, such as its externally sponsored research expenditures of over $10M annually, its service teaching of over 2,500 students per year, its undergraduate majors and graduate student enrollment of ~200, and the acceptance of its seniors into elite physics Ph.D. institutions, speak for themselves. Physics is integrally committed to the mission and advancement of the University. As reviewed in the College plan, Physics plays a vital role in the future of research and education in the Sciences with its thirteen research centers and laboratories. We plan to build on the legacy of the nuclear programs, the Submillimeter Wave Technology Lab, the Photonics Lab, and the successes in Advanced Materials. Physics is also a key player in critical interdisciplinary initiatives outlined in the College plan, such as imaging, biophysics, medical physics, data sciences, and space science and technology.

Curricula. Physics offers a B.S. degree in Physics and Applied Physics as well as a nationally recognized degree in Radiological Health Physics. Physics also offers four M.S. degrees in Physics, Radiological Sciences and Protection, Medical Physics, and Applied Physics with an Optical Science option. Physics offers a Ph.D. degree in Physics and Applied Physics, with nationally accredited options in Radiological Sciences and Medical Physics.

New degree programs. Physics will be an important contributor to a Life Sciences joint M.S. and Ph.D. This program will provide a pipeline for graduate work in biophysics and imaging research. It will create a framework of interdisciplinary investigative research for Physics students with career aspirations in the biotech industry. Physics also plans to explore an **M.S. and Ph.D. degree in Space Science and Astrophysics,** which would be a natural accessory to our proposed Cluster in Space Science (LoCSST) and planned expansion of the space sciences in the College. This graduate degree will be a significant pipeline for students entering the aerospace industry, which is rapidly becoming dominated by private section innovation.

Enrollments. Physics' undergraduate enrollment is not huge, but has grown at a rate of over 10% per year for the last seven years. We predict it will reach 140 majors by 2019. Physics has always maintained a well-organized and well-enrolled service component that is also growing rapidly with ~2500 students in 2014. Thus, it is a moneymaker for the University in the classroom as well as the research labs. The graduate program in Physics is well established; and in some years, the department has conferred more graduate than undergraduate degrees. Physics

takes pride in its Ph.D. program, but it has roughly 40 M.S. students currently enrolled in addition to about 70 Ph.D. students. We anticipate Physics will have at least 100 total graduate students in 2019.

Faculty. The hiring plan for Physics is based on two premises: (1) maintain and further develop current signature programs where we have strength and future promise, and (2) provide support for new initiatives that allow growth in interdisciplinary research and academics identified by the College that serve the University, region, and nation. Ultimately the department is building programs ripe for branding the College.

Commensurate with this plan, we recently hired a nuclear physicist to join our established team in experimental nuclear physics and have proposed to hire another in 2016. The reactor/ accelerator complex at our Radiation Laboratory is unique and offers us the opportunity to leverage the facilities toward developing collaborations with national laboratories and industrial partners. Also within this plan, we intend to hire a materials scientist in 2015 whom would be a computational physicist with broad expertise in condensed matter and could strengthen our expertise in the area of "soft" or "low-dimensional materials" (carbon nanotubes, graphene, bio-materials and semiconducting polymers). This individual would be synergistic with current research programs in sub-millimeter wave technology, photonics, nano-manufacturing, and medical physics. The individual would interact well with our aspirations for expanding our biomaterials focus in chemistry and the life sciences in Biology.

Our nationally recognized ABET accredited Health Physics program is undergoing attrition and needs faculty resources to maintain its preeminence. Therefore, in 2016 we propose hiring a mid-career professional in radiological sciences to lead the program since one of our senior faculty members will retire. An emphasis on significant research will drive the selection process.

The College has identified astrophysics and space science as major focus areas for growth in support of academics at the University. As outlined in the College plan, these areas are ripe for funding (currently over $1.5M annually), are moving rapidly from the public to the private domain (we have significant industrial connections already), offer a multitude of international opportunities, are very popular with students, and will raise the international profile of the department and University. We are proposing to hire three junior faculty members between the years of 2015 to 2019 that would create a critical mass toward establishing a world-class space program. These hires would include: (1) a theorist/modeler, who could work with current departmental interests in either observational space physics, cosmology, exoplanet studies, or nuclear/particle astrophysics; (2) an observer/modeler, who would be synergistic with the existing experimental program and would open new funding opportunities; and (3) a new hire in ionosphere physics to preserve our expertise in this area.

Infrastructure. Our large government-sponsored research programs in physics have survived due to the access of flexible laboratory space in Wannalancit. We foresee expanding our operations there, especially in photonics and space science. However, our aspirations to expand interdisciplinary programs in the life sciences, such as multi-modal imaging, biophysics, and medical physics, as well as the expansion of our nuclear programs, requires modernization of north campus facilities in Pinanski, Olney and Olsen.

Physics' nuclear scientists need space in Pinanski. Our Health, Medical, and Nuclear Physicists do not have adequate research space, and most do not have offices in Pinanski. They need the close proximity with each other and the nuclear engineers to create vibrant programs to meet our long-term investment demands. UML has significant, un-tapped grant opportunities in the nuclear field and resources are required in both the Sciences and Engineering to realize this potential. The growth in imaging and biophysics requires investment in life-sciences facilities that will allow us to reach the next level of research activity. Academic research space that includes flexible bay labs, a world-class vivarium, and imaging equipment in juxtaposition to biology, bioengineering, and pharmaceutical faculty will move these programs at Lowell. This also requires modern student spaces and teaching facilities. Complete renovations of Olsen and Olney are absolutely essential for achieving these goals.