

Framework for Integrating Project-Based Learning, Experience and Practice in Professional Graduate Education for Engineering Leaders in Industry Leading to the Professional Engineering Doctorate and Fellow Levels

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Abstract

This is the third of four papers prepared for a special panel session of the National Collaborative Task Force on Engineering Graduate Education Reform. The paper formulates a very creative approach and framework for postgraduate professional education that fosters the continuous development of the U.S. engineering workforce in industry concurrently with engineering practice for technological innovation. The framework integrates innovative project-based learning, progressive experience, self-directed learning, and graduate studies concurrently with engineering practice. The framework is specifically designed to foster growth beyond the professional master's level, leading to the professional Doctor of Engineering and Engineering Fellow for senior career development of engineering leaders. The intent is to build clusters of postgraduate professional education across the country in partnership with industry that strengthens U.S. innovative capability for continuous technology development and competitiveness.

1. Introduction

This paper reports on the progress of the National Collaborative Task Force on Engineering Graduate Education Reform in designing practice-oriented, postgraduate professional engineering education to enhance the U.S. engineering workforce for competitiveness. The National Collaborative Task Force is embarking on an ambitious effort to create centers for postgraduate professional education across the country that better serve the needs of the U.S. engineering workforce in industry for leadership of creative technology development and innovation to strengthen the nation's innovative capacity for competitiveness. The National Collaborative is a joint initiative of the ASEE-Graduate Studies Division, College Industry Partnership Division, Continuing Professional Development Division, and Corporate Members Council. The intent of this stage of work is to set the educational framework for high-quality postgraduate education for the professional Doctor of Engineering and Engineering Fellow for career development of senior engineering leaders in industry.

1.1 Promoting U.S. Technological Innovation by Investing in the Professional Education of the U.S. Engineering Workforce in Industry

In the innovation-driven economy, the U.S. engineering workforce is the primary driver for technological innovation for U.S. competitiveness. Technology is primarily created, developed, and innovated in industry by industry's engineers. But this workforce must be re-strengthened if we want engineering innovation to flourish in industry. This requires redesigning U.S. engineering graduate education.

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1.2 The New Paradigm for Technology Development: Engineering Drives Technological Innovation for U.S. Competitiveness

As America competes in the 21st century, the innovative capability of its engineering workforce in industry directly influences the advancement of U.S. technological progress, which directly influences America's economic development and national security. The advancement of this innovative capability is directly influenced by use of modern engineering leadership models for systematic technological innovation in industry and the supportive role that the U.S. engineering education system plays in fostering the professional development of the engineering workforce in employing this model effectively for technology development for competitive advantage.

Whereas 1945 Science Policy focused on the linear basic research-driven model as the forerunner for the development of technology,¹ the 1945 linear research-driven policy for the nation's technological thrust is now recognized as erroneous and needs to be modified. A new paradigm and method of needs-driven engineering for the deliberate, creation, development, and innovation of new technology has evolved for the nation's economic prosperity and national security.²

The modern paradigm of engineering practice for systematic, technology development and innovation has changed substantially since U.S. science policy of 1945. But the U.S. system of engineering graduate education has not kept pace with this new paradigm. As the Council on Competitiveness pointed out, the perspective that technology is a linear process like a "relay race" where basic scientific research passes the baton to engineering for later development is outmoded.³ Technology development *does not* occur that way. The stakes for U.S. competitiveness are too high for this error to continue without modification.

There is a meaningful distinction between scientific research and development. As Martino, formerly of the U.S. Air Force Office of Scientific Research, pointed out:⁴

- "Research and development are two entirely different categories of activity, and there is no neat linear progression from one into the other."
- "The term *research* is defined here as an attempt to acquire new knowledge about some phenomenon in the universe."
- "Development is an attempt to construct, assemble, or prepare for the first time, a device, material, technique, or procedure, meeting a prescribed set of specifications or desired characteristics and intended to solve a specific problem. This definition includes not only other materials. The essence of this definition is that development is intended to meet some set of specifications in order to solve a specific problem."

1.3 Technology Development: The Primary Realm of Engineering

As Fred Gary, former vice president of corporate engineering and manufacturing at General Electric Company, pointed out to ASEE: "Development is the primary task of engineers" ... and ... "Great engineering is measured by the proper gauging of people's needs and the delivery of affordable, high-grade products and services."⁵

The development of new/improved/breakthrough technology is a very creative process of engineering. But, the process of technology development is quite different from the process of scientific discovery. Development must no longer be misconstrued as the "translation of research findings" by engineering into technology as perceived 1945 Science Policy. It isn't. Development involves needs-finding, program-making, creative problem-solving, creative design, hard work, innovation, and responsible leadership. The essence of engineering is creative design, development, and leadership to meet real needs.

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1.4 The Pace of U.S. Innovation: The Spectrum of Development

The pace of U.S. technological innovations is reflected by U.S. competitiveness in global markets and our national security posture. This in turn is directly dependent upon the continued professional development of the creative and innovative capability of our high-caliber domestic engineering leaders in industry. Development of technology-based systems is a deliberately planned process requiring expertise in defining the need, defining the specifications, planning the technical project/program/system, through conceptual design and development for feasibility, through advanced development and program management to get the job done.

The resulting outcomes of development programs are new technologies in the form of new/improved products, processes, systems or operations: all purposefully created, designed, and developed to meet real-world needs of people and industry. The spectrum of engineering development includes: ⁶

(1) Exploratory conceptual development:

Exploratory engineering development includes needs-finding and the deliberate invention, conceptual design, and conceptualization of new/improved/original “ideas” and “concepts” to meet real-world needs through the stages of initial testing and modification of concept to demonstrate proof of technological feasibility

(2) Advanced development:

Advanced engineering development includes the development of hardware for experimental test purposes or for operational demonstrations. The resultant products are not intended to be used commercially nor for any other end use without further development.

(3) Systems and operational development:

Systems or operational engineering development includes the further advanced development of hardware for commercial or other end use into production/service capability and improvement

1.5 The New Paradigm: Engineering Driving Technology Development

The system of U.S. engineering practice in industry and the corresponding system of U.S. engineering education at the universities are in transition. The practice of engineering has changed substantially from that perceived by 1945 Science Policy. Subsequently, the terms engineering and technology have been redefined for the 21st century per the National Academy of Engineering report *Technically Speaking*.⁷

Engineering and technology are no longer misinterpreted as “applied science.” As William Wulf, president of the National Academy of Engineering, pointed out in his plenary address to ASEE: “Engineering is design under constraint.”⁸ Some of those constraints are socio, economic, legal, ethical, and the natural laws of science. Accordingly, the National Collaborative Task Force believes that the modern paradigm and process for needs-driven engineering can be reflected as shown below:⁹

Engineering → Technology



Directed Scientific Research
to gain better understanding
of phenomena when needed

2. Professional Education for Engineers in Industry: The New Challenge

For America to compete in the innovation-driven economy, it must rebuild its capacity for leadership of systematic technology development and innovation as a core corporate competence in American industry. Advancement in U.S. engineering graduate education that is specifically designed to foster the creative, innovative and leadership capacity of the U.S. engineering workforce in industry is a key ingredient in an effective technology policy for America to regain its competitive edge.

2.1 A Call for Change in Graduate Education of Engineers

As noted in a recent ASEE report, “America’s progress has been synonymous with innovation. Corporate growth and economic development, coupled with a higher standard of living, are inextricably tied to technological advancement.”¹⁰ Accordingly, if America is to be more competitive in the 21st century then it must redesign its system of engineering graduate education to be supportive of the new paradigm for engineering innovation while maintaining an equally complementary focus on basic scientific research.

Enhancing U.S. competitiveness requires that the pipeline for creative engineering must be strengthened not only in K-12 education but in engineering graduate education as well. We have been teaching with an almost singular emphasis toward scientific research when all along we should have been teaching with an equal emphasis toward creative engineering practice. Broad sweeping changes are required to create a new type of practice-oriented graduate education, which focuses on creative engineering and innovation, to support the postgraduate needs of the U.S. engineering workforce in industry for leadership of technology development and innovation as a complement to research-based graduate education.

Today, continual technological innovation in industry is primarily the result of, and the deliberate use of, the purposeful systematic needs-driven method of engineering for the creative design, development and innovation of technology. As such, the lion’s share of new/improved/breakthrough technological innovation results from the deliberate use of the systematic method of engineering in the development of technology — from exploratory engineering development through advanced development and systems engineering development for operational use and commercialization.

However, as the Committee on Science, Engineering, and Public Policy (COSEPUP) has pointed out, engineering graduate education has evolved in the United States primarily as a byproduct of a national science policy for basic research. The United States does not have a coherent policy for the graduate development of the majority of the U.S. engineering workforce in industry whose professional careers are not centered on basic research, but rather are centered on the deliberate, and systematic engineering creation, development, and innovation of new/improved/breakthrough technology responsive to market driven-needs. As COSEPUP pointed out:¹¹

- “The process of graduate education is highly effective in preparing students whose careers will focus on academic research. It must continue this excellence to maintain the strength of our national science and technology enterprise. But education must also serve better the needs of those whose careers will not center on research.”
- “There needs to be a deliberate national reconsideration of graduate education so that the open policy questions, the current information gaps, and the contemporary stresses are systematically addressed by a suitable blend of university, industry, professional society, and government. Those improvements can be made without disruption of the traditional commitment to excellence in basic research that has been, and must continue to be, a hallmark of the U.S. system of graduate education.”

2.2 Investing in the U.S. Engineering Workforce for Tomorrow: The Driving Force for Transforming Engineering Graduate Education to Improve Competitiveness

As Lester Thurow pointed out: “Technological leaders remain economic leaders; technological laggards become losers.”¹² The generation of experienced engineers who have contributed to the vast majority of developments of U.S. technology since Sputnik is now retiring. By the year 2010, estimates indicate that 30% of America’s domestic engineering leadership base will have retired, causing a “brain drain” and a loss in U.S. engineering capacity because our future leaders in industry and government service are not being trained adequately to achieve engineering leadership positions. U.S. engineers must be provided the opportunity for a new type of professional graduate education throughout their professional careers.

The National Collaborative Task Force recognizes that there is a strong correlation between the further development of the nation’s graduate engineers and the further development of the nation’s innovative capacity for continuous technology development and innovation. As U.S. engineers grow and develop professionally, the U.S. capacity for innovation and competitiveness increases proportionally.

As the Council on Competitiveness has pointed out: “The Council’s business leaders agree that every company’s most important asset are the people who walk in its doors every morning. Talented people creating new ideas and innovative technologies keep the economy strong, and growing stronger. The education and training that spark Americans’ creativity and give them cutting-edge skills are a key to competitiveness.”¹³

Today, we can measure the worth of an engineer by their progressive professional responsibilities and by the worth of the level of innovative projects that they are responsible for or work on. Most engineers have either partial or full responsibility for multimillion dollar projects. Their salary is a cost of doing business. But the economic and sociological returns of their creative work and responsible engineering leadership far exceed these basic costs. Today, tuition reimbursement and investment in the further professional development of industry’s engineers is no longer considered a fringe benefit or charitable contribution. It is an investment in industry’s future.

If the U.S. is to remain preeminent in continuously creating new innovative technologies to enhance our economic prosperity, quality of life and national security, then the U.S. system of engineering education must remain the world’s leader for the creating and developing technology responsive to market-driven needs of people. But it must create new models for practice-oriented postgraduate education that better support the modern paradigm of engineering innovation itself and the lifelong development needs of the U.S. engineering workforce in industry. Technology development and innovation must be rebuilt into our innovation system and must become a core corporate engineering competence within American industry.

2.3 Meeting the Challenge through Planned Change: Why Invest in the Further Development of the U.S. Engineering Workforce ?

The nation can not afford any longer to be on an incorrect paradigm for continuous engineering innovation either in its technology policy or in its system of engineering education. As a result of promoting an unbalanced emphasis on science and scientific education as the singular driver of technology development (which it is not), the U.S. engineering workforce has been underdeveloped and as a result the nation’s technological thrust for competitiveness has declined over the last two decades. The nation must reverse this trend and shift to a more correct paradigm of engineering innovation in order to regain its competitive advantage. Both Science and Technology (S&T) are vital to the national interests, but they have different roles in the national innovation system.

Too often change in higher education has been evolutionary and has not kept up with the needs of the practicing profession which is moving at a faster pace. Change will not happen by itself without planned effort and execution. The National Collaborative Task serves as a catalyst and change agent for action. Major systemic reform in engineering graduate education must begin by establishing new innovative graduate programs in professional engineering practice for leadership of technology development and innovation in industry.

Whereas undergraduate engineering and technology education serve as the basic preparation for beginning entry into engineering practice, the National Collaborative Task Force recognizes that further professional education, beyond the baccalaureate and masters levels, is vital to the professional development of U.S. engineers in industry for competitiveness. As these creative engineers continue to grow professionally so grows U.S. innovative capacity for competitive advantage.

2.4 U.S. Engineering Workforce Development in Industry: The Driving Force for Transforming U.S. Professional Engineering Education for Innovation

As America competes in the 21st century, our system of engineering education must perceive the education of engineers as a lifelong growth process of continuous professional learning and of continuous professional development of innate “intellectual potential” to better develop our nation’s creative talent in engineering for responsible leadership. Although the development of creative talent for the practice of engineering must begin in the early years of K-12, it must continue through the productive years of advanced engineering practice in industry if creativity, innovation, and leadership is to flourish for the nation’s competitiveness.

The professional education of U.S. engineers must no longer be perceived as a one time experience to be finished in the early years of undergraduate education or to terminate at the professional master’s level, or professional doctoral level. The growth of an engineer extends beyond his or her last degree and can not occur without further self-directed learning, progressive experience, performance in actual creative work, and advanced studies integrative with advanced engineering practice.

This project is a bold initiative and an exciting new advancement in partnering professionally-oriented graduate education in engineering with the practicing profession in American industry that will develop the U.S. engineering workforce, stimulate new technological innovation, and stimulate regional economic growth across the country simultaneously. Without continuous technological advancements through creative engineering practice for innovation in industry, no amount of achievement in fundamental scientific progress can assure our economic prosperity and national security in the innovation-driven economy in the modern world.

2.5 Aligning Advanced Professional Education with the Progressive Skill-Sets of Leadership: Building the U.S. Pipeline for Creativity, Innovation, and Leadership of Technology Development

As the National Society of Professional Engineers has pointed out, there are nine progressive leadership levels of responsibility in engineering practice beyond entry-level (See Appendix A).¹⁴ A major function of the National Collaborative Task Force is to define the critical skill-sets for each of these levels, especially at Engineer IV for the professional master of engineering program, at Engineer VI for the professional doctor of engineering program, and at Engineer VIII for the professional fellow program.

Following the definition of skill-sets, the National Collaborative Task Force will then purposefully design a coherent professional curriculum and educational process, which is integrative with the on-going engineering practice in industry, and that supports the lifelong learning and professional development needs of the engineer throughout his or her professional career for leadership in engineering.

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2.6 Focus on Innovation as a Learning Mechanism for Engineering: Developing New Technology in Industry and Developing Engineering Leaders Simultaneously

The National Collaborative Task Force believes that promoting the nation's capability for innovation is integral with promoting advanced professional education of U.S. engineers who bring innovation into reality. From this perspective The Task Force reflects that a holistic approach is needed in designing the framework for professional graduate education, which combines progressive experiential learning, actual creative performance in the development of technology, self-directed learning, and relevant graduate studies, as all necessary ingredients for the engineer-leader to reach his or her fullest creative potential for leadership of technology development and innovation in the productive years of practice.

Various studies, such as the National Academy of Engineering report, *Engineer 2020*,¹⁵ and qualification descriptions of the progressive levels of engineering in industry/government will all be used to determine the functional critical skill-sets that are required for progressive leadership in engineering practice from entry level through Chief Engineer level. This analysis is critical to the National Collaborative initiative. The next step is to align these progressive skill-sets with practice-oriented curricula combined with a high-quality educational process that coherently supports and positively affects the growth of engineers from one level to the next.

2.7 The Process of Professional Development of Engineers: Building Leaders for Innovation at Every Level of Engineering in U.S. Industry

The National Collaborative is taking a systems approach in this national initiative with full realization that professional education of engineers is not a one-time event; but rather is a synergistic and reiterative process of professional maturation and further development of intellectual human potential and innate creative talent for leadership of creative work that extends over an engineer's entire professional career in practice. Based on this recognition, the National Collaborative Task Force is defining advanced professional education in the context of technology development as a unique model that extends from Entry-level engineer level through Chief Engineer level responsibility.

The National Collaborative Task Force recognizes that advanced professional education must include the full spectrum of professional development of professionals from novice to competent professional; from competent professional to expert; and from expert through senior and executive engineering leadership levels for corporate technological responsibility for competitiveness. In this process, there appear to be four primary stages for career development.. They include:

- (a) Early career development for beginning engineers (Engineer I,II)
- (b) Middle engineering levels for technology development/innovation (Engineer III,IV,V)
- (c) Senior engineering levels for technology development/innovation (Engineer V,VI,VII)
- (d) Executive engineering levels for technology development/innovation (Engineer VIII,IX)

2.8 Importance of the Experience Factor in Creating, Developing, and Innovating New/Improved/Breakthrough Technology

The National Collaborative Task Force recognizes that the process for postgraduate professional education, intended to develop engineers as leaders of future technology, must include three essential ingredients. The process must: a) be integrative with on-going engineering practice in industry; b) support the engineer's residency in engineering practice in industry, and; c) utilize the wealth of the engineer's progressive experience as a valuable aid to learning and further growth.

Subsequently, as an outcome of defining this national initiative, it is clear to members of the Task Force that engineers have creative worth which is gained in practice by developing their innate creative talent through actual professional experience in significant technology development projects. As such, professionally-oriented engineering graduate programs can no longer operate in a vacuum or be considered high-quality without integrating into the professional curriculum project-based (problem-centered) learning that focuses on innovation and employs the systematic engineering method which is primarily used to conceive, develop, and innovate new technology. No longer can these programs be limited to the “transmission and acquisition of knowledge” as pervasive as it is on many campuses today.

Recognition of the creative worth of the nation’s engineers and experience factor, which is gained through a long-term understanding by the engineer in his or her field of technology, combined with development of innate talent in the creation of new/improved/breakthrough technology is a major factor in implementing this educational transformation as a national initiative to strengthen U.S. competitiveness. The experience factor and worth of the creative engineer has been undervalued. But creative engineering talent must be rightfully valued today if America is to regain its technological competitiveness. Isenson pointed out that the experience factor and expertise gained through actual creative work plays a vital role in fostering effective cultures for innovation and for the professional development of the nation’s engineers for creative technology leadership (Project HINDSIGHT):¹⁶

- “In examining the personal histories of engineers who had contributed most heavily to the new technology of use to the Department (DOD), the employment stability of these individuals stood out as a most significant factor. Moreover, it was found that the most effective engineer — in terms of the probability that he will come up with something that will be profitable to the organization — is one who has been in the company for a number of years.”
- “The modal point on the distribution curve displaying length of employment against probability of making a useful contribution occurs at between seven and nine years of employment. Clearly if the professional turnover rate exceeds 10% to 15% per year, it will be most unlikely that the peak performance of the laboratory will ever be achieved.”

3. A Work in Progress: Defining the Framework and Requirements For Professional Doctoral Programs for Technology Leaders in Industry

As a result of this national initiative, the National Collaborative Task Force is defining specific requirements for continued professional development that supports the growth of high-caliber engineers in industry beyond the professional master of engineering level through the professional doctoral and fellow levels of engineering. This is a work in progress. The Subcommittee on Framework has put forth sample recommendations which will undergo further modification and refinement.

3.1 What is a Professional Doctor of Engineering ? Defining the Difference between the Practice-Oriented D. Eng. and the Research-Oriented PhD

While research-oriented doctoral programs have been underway in the U.S. for over a century, a new educational innovation is emerging in practice-oriented engineering and technology education, which is integrative with on-going engineering practice in industry. This innovative advancement in professional engineering education is a direct outcome of the joint industry-university National Collaborative Task Force on Engineering Graduate Education Reform (See Appendix B).

The practice-oriented engineering doctorate (D.Eng.) is being designed as a postgraduate degree program intended specifically for U.S. engineers who are pursuing leadership careers in industry/government service. The program is a complementary alternative to the research-oriented PhD, specifically designed to better support the needs of emerging engineering leaders in U.S. industry providing a more professionally oriented doctorate in engineering for leadership of technology development and innovation.

Whereas traditional doctoral programs are research-oriented to prepare young graduate students for research and discovery careers, professional doctor of engineering (D.Eng.) programs are specifically intended to serve as a complementary alternative to traditional research-oriented doctoral degrees to meet the needs of experienced engineers who are pursuing careers in creative engineering practice. The professional doctor of engineering should be integrative with engineering practice and designed to be a two-year postgraduate professional degree program beyond the professional master of engineering. The Doctor of Engineering degree (D.Eng.) is specifically intended to further the growth of the nation's development engineers who are already employed full-time in industry; have an already established experience base in engineering practice; have an already established technology expertise; and who show promise as emerging senior engineering leaders.

The practice-oriented professional doctorate is specifically designed to support the progressive skill-sets of creative engineering practice in the middle to senior stages of the working professional's career development in industry. Whereas high-quality research-oriented graduate programs, whose purpose is to educate competent scientific researchers for discovery must be integrative with and in the context of active scientific research (yielding tangible scientific results), high-quality professional graduate programs, whose purpose is to educate competent engineers for creative technology development and innovation, must be integrative with and in the context of active engineering development at the advanced level of engineering practice (yielding tangible technological results).

3.2 Professional Doctor of Engineering: Defining Credit Hour Requirements and the Technology Development Project

The innovative professional Doctor of Engineering degree (D.Eng.) should require a minimum of 30 semester-based credit hours (or 45 quarter credits) beyond the professional Master of Engineering. All participants (working professionals) are expected to earn at least 18 credit hours of coursework which are

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acceptable for graduate credit. In addition, a minimum of 12 credit hours toward the degree is earned through work on an independent project that focuses on technology development and builds upon the knowledge and skill-sets acquired through the core and elective courses in the program, the participant's prior undergraduate education, professional engineering education, self-directed learning, and expertise acquired through progressive experience in creative engineering practice.

The technology development project culminates in the preparation of a comprehensive written report and oral presentation that include a description of the scope of and motivation for the work, the technical approach and development strategies employed, and the final outcomes relevant to the participant's company. The examining committee is responsible for determining the acceptability of the work, based upon the significance of the project, the quality and completeness of the written report, the suitability of the oral presentation, and the engineer's ability to explain and defend the approach, program details and analysis in the question and answer session following the oral presentation.

Traditionally, all doctoral level degree programs in engineering require some form of comprehensive examination which not only assesses the acceptability of the participant for the degree but also defines the quality standard for the degree program. For this professional Doctor of Engineering degree, the requirement of a comprehensive examination is satisfied by the successful completion of the written report, oral presentation and defense. As is the case for all research-based advanced degree programs (e.g., the PhD with thesis), the level of effort expended by the engineer to successfully complete the project requirement may substantially exceed the amount of time and effort implied by the graduate credit hours assigned to the project. It is important to recognize that the quality and ultimate value of the degree is contingent in large measure upon the standards set for the outcomes of this project.

3.3 Professional Doctor of Engineering: Defining the Composition of the Examining Committee

Each university partner that offers the Doctor of Engineering degree is likely to have its own standard practice with respect to the composition of the examining committee and the manner in which the oral presentation and examination are administered. Typically, such examining committees are comprised of at least three faculty members, of which at least two are from within the department/unit that sponsors the degree program. For this specific Doctor of Engineering degree program, the examining committee should additionally include a senior manager from one of the participating companies (typically an individual who has some level of leadership responsibility for the degree candidate).

3.4 Professional Doctor of Engineering: Defining the Focus, Experience in Practice, and Demonstrated Outcomes at Engineer VI

The focus of the professional Doctor of Engineering should be to develop engineers in the mid stages of their professional development process as senior leaders in the context of advanced engineering practice for systematic engineering innovation to create, develop and innovate new/improved technology continuously in the form of new/improved/breakthrough products, processes, systems, and operations to meet real-world needs. Participants are expected to improve, create, develop and innovate new technology in industry and to develop professionally in engineering practice as Engineer-Leaders with Level VI Engineer skill-sets for responsible leadership of continuous technology development and innovation at program level.

4. A Work in Progress: Defining the Framework and Requirements For Professional Fellow Programs for Technology Leaders in Industry

As a result of this national initiative, the National Collaborative Task Force is defining specific requirements for continued professional development that supports the growth of high-caliber engineers in industry beyond the professional doctor of engineering level through the fellow level of engineering. This is a work in progress. The Subcommittee on Framework has put forth sample recommendations which will undergo further modification and refinement.

4.1 What is a Professional Engineering Fellow ?

Defining the Progressive Difference in Growth between the D. Eng. and the Fellow

The professional Engineering Fellow award (F. Eng.) is a unique professional award, and a unique opportunity for further professional growth integrative with advanced engineering practice beyond the professional doctor of engineering. It provides real opportunity for high-caliber engineers to further grow from Level VI Engineer to Level VIII Engineer (See Appendix C).

4.2 Professional Engineering Fellow:

Defining the Credit Hour Requirements and the Technology Development Project

The innovative professional Engineering Fellow award (F. Eng.) requires a minimum of 30 semester-based credit hours (or 45 quarter credits) beyond the professional Doctor of Engineering degree (or its equivalent). All participants are expected to earn at least 12 credit hours of coursework. In addition, a minimum of 18 credit hours toward the award is earned through work on an independent project that focuses on technology development and builds upon the knowledge and skill-sets acquired through the core and elective courses in the program, the participant's prior professional engineering education, self-directed learning, and expertise acquired through progressive experience in creative engineering practice.

The technology development project culminates in the preparation of a comprehensive written report and oral presentation that include a description of the scope of and motivation for the work, the technical approach and development strategies employed, and the final outcomes relevant to the participant's company. The examining committee is responsible for determining the acceptability of the work, based upon the significance of the project, the quality and completeness of the written report, the suitability of the oral presentation, and the engineer's ability to explain and defend the approach, program details and analysis in the question and answer session following the oral presentation.

The Engineering Fellow award is unique to the technology leaders program. It is expected that the standards set for written and oral presentation of the participant's project work will be reflective of work of work of the highest caliber at this level. The professional Engineering Fellow is of high professional distinction and is conferred upon engineer-leaders with outstanding qualifications and experience in engineering practice for creative leadership of technology development, innovation, and policy. The level of effort expended by the participant to successfully complete the project requirement may substantially exceed the amount of time and effort implied by the graduate credit hours assigned to the project. It is important to recognize that the quality and ultimate value of the award is contingent in large measure upon the standards set for the outcomes of this project as determined by the participant's company.

4.3 Professional Engineering Fellow:

Defining the Composition of the Examining Committee

Each university partner that offers the Engineering Fellow award is likely to have its own standard practice with respect to the composition of the examining committee and the manner in which the oral

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4.4 Professional Engineering Fellow: Defining the Focus, Experience in Practice, and Demonstrated Outcomes at Engineer VIII

The focus of the professional Engineering Fellow award is to develop engineers in the senior stages of their continuous professional development process as executive engineer leaders in the context of advanced engineering practice for systematic engineering innovation and the leadership thereof to create, develop and innovate new technology continuously in the form of new/improved/breakthrough products, processes, systems, and operations to meet real-world needs. Participants are expected to lead the creation, development, and innovation of new/improved technology in industry and to develop professionally in engineering practice as Engineer-Leaders with Level VIII Engineer skill-sets for responsible leadership of continuous technology development & innovation at technology policy level.

5. Drawing the Right Conclusion: A Work in Progress in Implementing the U.S. Innovation Agenda for Competitiveness

As America competes in the 21st century, urgency exists to continue the professional development of the U.S. engineering workforce in all states and regions across the country in order to increase global competitiveness as a nation. The need for continued professional development of our domestic engineers extends beyond the professional master of engineering to the highest leadership levels of engineering for innovation. Opportunity must be provided that create new approaches for professional Doctor of Engineering and Engineering Fellow programs that further develop the innate creative potential of U.S. engineers for creative work and as leaders in responsible charge for significant technology development and innovation in industry to enhance U.S. competitiveness. A major aim of the National Collaborative Task Force is to provide this opportunity through planned educational change. The return benefits to the nation are formidable. This innovative concept for improvement in professional education builds the U.S. engineering infrastructure for world-class leadership of technological innovation and develops new technology in industry simultaneously to strengthen U.S. competitiveness. The National Collaborative Task Force is underway, is making steady progress, and is on-target. To accomplish its mission, the National Collaborative Task Force is building a critical mass of leaders from industry, universities, and government to allow this transformation to happen. Once the critical mass is obtained, the progress will become even faster in implementing the innovation agenda for competitiveness. It is a work in progress to enhance the nation's continuous thrust for technological development and innovation through professional education and creative engineering practice in industry.

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Appendix: A -1

Stages of Professional Maturation, Autonomy, and Responsibilities in Engineering Practice for Responsible Technology Leadership

<u>Stages of Growth</u>	<u>Typical Responsibilities-Autonomy-Judgment</u>
ENGINEER IX	An engineer-leader at this level is in responsible charge of programs so extensive and complex as to require staff and resources of sizeable magnitude to meet the overall engineering objectives of the organization.
ENGINEER VIII	An engineer-leader at this level demonstrates a high degree of creativity, foresight, and mature judgment in planning, organizing, and guiding extensive engineering programs and activities of outstanding novelty and importance. Is responsible for deciding the kind and extent of engineering and related programs needed for accomplishing the objectives of the organization.
ENGINEER VII	In a leadership capacity, is responsible for an important segment of the engineering program of an organization with extensive and diversified engineering requirements. The overall engineering program contains critical problems, the solutions of which require major technological advances and opens the way for extensive related development.
ENGINEER VI	In a leadership capacity, plans, develops, coordinates, and directs a number of large and important projects or a project of major scope and importance. Or, as a senior engineer, conceives, plans, and conducts development in problem areas of considerable scope and complexity. The problems are difficult to define and unprecedented. This involves exploration of subject area, definition of scope, and selection of important problems for development.
ENGINEER V	In a leadership capacity, plans, develops, coordinates, and directs a large and important project or a number of small projects with many complex features. Or, as an individual principle engineer, carries out complex or novel assignments requiring the development of new or improved techniques and procedures. Work is expected to result in the development of new or refined equipment, materials, processes, or products. Technical judgment knowledge, and expertise for this level usually result from progressive experience.
ENGINEER IV	Plans, schedules, conducts, or coordinates detailed phases of engineering work in part of a major project or in a total project of moderate scope. Fully competent engineer in all conventional aspects of the subject matter of the functional areas of assignments. Devises new approaches to problems encountered. Independently performs most assignments requiring technical judgment.
ENGINEER III	Performs work that involves conventional types of plans, investigations, or equipment with relatively few complex features for which there are precedents. Requires knowledge of principle and techniques commonly employed in the specific narrow areas of assignments.
ENGINEER I/II (Entry Level Engineer)	Requires knowledge and application of known laws and data. Using prescribed methods, applies standard practices/techniques under direction of an experienced Engineer.

Appendix: A - 2

Levels of Responsibilities in Creative Engineering Practice for Engineering Leadership of Continuous Technology Development and Innovation In Industry and Government Service

Top Levels of Technology Leadership

Position Title:

Engineer IX (GS-18, 17, 16)
Chief Engineer / Vice President of Engineering & Technology

Engineer VIII (GS-15)
Director of Engineering

Middle Levels of Technology Leadership

Position Titles:

Engineer VII (GS-14)
Department/Division Manager

Engineer VI (GS-13)
Technical Area Manager

First Levels of Technology Leadership

Position Titles:

Engineer V (GS-12)
Senior Engineer/Principal Engineer/Project Leader/Group Leader

Engineer IV (GS-11)
Project Engineer/Process Engineer

Engineer III (GS-9)
Design/Development Engineer

Entry Level Engineer

Position Titles:

Engineer II/I (GS-7, 5)
Entry Level Engineer

Appendix: B - 1

Aims of Professional Doctor of Engineering (D. Eng.) Programs for Working Professionals in Industry

Professional Doctor of Engineering – For Creative Engineering Practice and Leadership Level VI Engineer – Skill-Sets / Outcomes

□ *Aims of professional Doctor of Engineering programs for engineering practice and leadership*

- a) Professional Doctor of Engineering (D.Eng.) programs provide a professional alternative to research-based PhD programs for engineers engaged in needs-driven technology development and innovation in industry and a coherent component of lifelong learning for continuous professional development in creative engineering practice beyond the professional M.Eng.
- b) Professional D.Eng. programs for engineering practice and technology leadership should be specifically designed to be integrative with and in the context of on-going engineering practice for leadership of technology development and innovation in industry and should emphasize project-based (problem-centered) — “innovation-based learning” — concurrent with practice.
- c) Professional D.Eng. programs should support the skill-sets required for responsible leadership of significant work at Engineer VI level of technical program responsibility.
- d) Professional D.Eng. programs should recognize postgraduate education not only as a continuous learning process beyond the master’s, but as a process for continuous professional development of intrinsic human potential for further development of creativity, innovation, and leadership wherein self-directed learning, progressive experience, tangible project-based learning, and further advanced studies all serve as integral components of a working professional’s lifelong growth process to reach his or her potential for leadership in engineering practice.
- e) Professional D.Eng. programs should be specifically designed to be concurrent with and to support the working professional’s on-going creative work and stage of growth in engineering practice for responsible leadership of creative, systematic technology development & innovation.
- f) Residency should be viewed as residency in engineering practice in the professional’s workplace in industry/government service. Postgraduate professional D.Eng. programs enable the working professional to continuously learn, grow, and develop while he or she is fully employed without disrupting the practitioner’s normal work activities or uprooting home, family, or career to continue high-quality professional education in engineering practice.

□ *Target market for professional Doctor of Engineering programs*

- a) Professional doctoral programs in engineering practice and technology leadership should be targeted to enhance the innovative capability of engineers within the U.S. Engineering Workforce (in regional industry) who are pursuing career paths that are not centered on research but are centered on the purposeful, systematic engineering creation, development and innovation of new/improved technology in the form of processes, systems, or technical operations.
- b) Professional D.Eng. programs should be specifically designed to continue the professional education of engineers, after entry into industry, who have at least 5 to 10+ years of progressive experience beyond entry-level, hold the professional M.Eng. (or equivalent), and are actively engaged in leadership of innovative technology development in industry/government service.

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□ **Integrative professional curriculum with practice**

- a) Whereas traditional graduate scientific education and research-oriented PhD programs are purposefully designed to prepare traditional graduate students as future academic researchers and independent scientific investigators in the context of on-going scientific research investigations — and emphasize inquiry-based learning for scientific “discovery” — the intent of the professional D.Eng. program is to further the professional development of experienced engineers beyond the professional M.Eng. level toward their fullest potentials for creativity, innovation, and leadership for needs-driven technology development and innovation in engineering practice in industry.
- b) High-quality professional D.Eng. programs, designed for technology development engineers, should shift from emphasis on inquiry-based learning for scientific “discovery” to purposeful, creative problem solving and engineering innovation driven by real-world human needs; and should be designed in the context of advanced engineering practice to emphasize project-based (problem-centered) — “innovation-based learning” — concurrent with engineering practice.
- c) Professional curriculum for the D.Eng. should be practice-oriented and designed from a holistic approach that more fully develops the engineer’s breadth and depth in the context of engineering practice for leadership of on-going technology development and innovation projects.
- d) Professional education should shift from the traditional perspective of one-time learning to a process of continuous professional development that builds upon the growing wealth of the working professional’s progressive experience, expertise, and an already established technical knowledge base and skill-sets base in his or her field of technology. Emphasis should shift from classroom instruction to increasing self-directedness and leadership of technology development.
- e) Professional D.Eng. programs should be specifically designed to be concurrent with engineering practice and should build upon six major integrative ingredients. These include:
 - (1) Knowledge and skill-sets acquired by undergraduate and master’s education in engineering.
 - (2) The engineer’s already established competency base in a technological field in industry.
 - (3) On-going experiential-based learning in creative engineering practice.
 - (4) Self-directed learning necessary to gain technological expertise in the practitioner’s field.
 - (5) Project-based learning in substantive technology development project work.
 - (6) Planned professional core studies and electives concurrent with practice.

□ ***Scope of technology projects and expected project outcomes and impact***

- a) Technology development projects should be specifically selected to be directly relevant to significant needs of the participant’s sponsoring industry/or of society; and should be selected by the participant with the approval of an oversight committee from industry and the university.
- b) Technology development projects are selected to provide the participant a meaningful professional learning experience at Engineer VI level for technical program responsibility and are expected to result in substantial improvements/breakthroughs in products, processes, systems, or operations to the participant’s sponsoring industry.
- c) Technology projects should yield new “ideas and concepts” for creative engineering solutions through proof of feasibility for new technological improvements, developments, and innovations for products, processes, systems, and technical operations or organizational infrastructure that ultimately contribute to the body of new technological knowledge of benefit to the advancement of engineering practice, the participant’s corporate sponsor, and society as a result of this deliberate creative engineering work for constant innovation.

- d) Technology development projects will be of a directed nature resulting in a project report and a quality tangible experience of meaningful significance that is directly relevant to the technology development and innovation needs of the participant's sponsoring industry/ or society. This professional work should represent creation, improvement, development and innovation at the technical program leadership level wherein the participant is in responsible charge.

□ ***Expectations of skill-sets / outcomes for participant Engineer-Leaders***

- a) The professional D.Eng. program should be a two-year postgraduate program beyond the professional M.Eng. that is project-based and is specifically designed to foster the professional growth of senior Engineer-Leaders while they are fully employed in industry/government service. The program should be designed to nurture the engineer's leadership of technology development & innovation by combining advanced studies with engineering practice in a synergistic fashion.
- b) The D.Eng. program should be designed to meet the progressive skill-sets of creative engineering practice for senior Engineer-Leaders who are engaged in career paths of responsible leadership in engineering practice for technology development and innovation relevant to their corporate engineering mission. The program should be designed to further the growth of senior engineers for progressive levels of attainment as full-fledged practitioners, systems developers, innovators, integrators leaders for responsible leadership charge of meaningful technology programs.
- c) The D.Eng. program should be designed to foster the continuous professional development of Engineer-Leaders who lead the systematic creation, improvement, development, and innovation of new/improved technology for products, processes, systems, or operations on which regional industrial growth and economic development depends for creation of new wealth, employment, or for national security purposes.
- d) The professional D.Eng. program should be designed for those senior engineers who can make original contributions through their leadership of systematic technology development for constant innovation and as a resulting outcome of their creative leadership add to the body of technological knowledge as responsible leaders of the region's and nation's technological progress for competitiveness.
- e) Participants are expected to emerge from the professional D.Eng. program as fully competent professionals and experienced Engineer-Leaders in a functional area of the sponsor's technology with the skill-sets, knowledge, experience, and outcomes ready to assume responsibilities associated with Engineer VI qualifications for leadership of significant technology programs.

□ ***Entrance requirements***

- High-quality postgraduate professional D.Eng. programs should be formulated to enable working professionals to enter them at a career stage of professional development in engineering practice when the additional learning and growth experience would be most valuable. It is now understood that the integrative combination of progressive practical engineering experience plus further advanced studies is a valuable component of an engineer's continuing professional education beyond the professional master's.
- Because many of the skill-sets that are required during the professional maturation process in engineering practice for senior leadership of technology development & innovation in industry can only be attained through progressive practical experience, it is recommended that a minimum of at least five to ten years of progressive professional experience in engineering practice, beyond entry-level, plus the professional M.Eng. should be required for entrance into these professionally-oriented graduate programs. Completion of the PE is also recommended when appropriate.

Appendix: B - 2

Framework: For High Quality Postgraduate Professional Education Leading to
The Professional Doctor of Engineering that is Integrative with Practice and
Enables Lifelong learning and Professional Development of Engineers as
Creative Professionals and Technology Leaders in Industry

**Professional Doctor of Engineering – For Creative Engineering Practice & Leadership
Level VI Engineer - Skill-Sets / Outcomes**

**Focus: Professional Development of Experienced Engineer-Leaders in Industry
For Creative Technology Development and Innovation at Program Leadership Level**

Postgraduate Professional Education Integrative with Creative Engineering Practice

12 Credit Hours Core Professional Courses

Emphasis on the professional dimensions / knowledge / critical skill-sets required in advanced engineering practice (Level VI Engineer) for engineering leadership, professional responsibility, and creative problem solving at technical program level for technology development and innovation in industry/government service.
(Four Professional Courses)

6 Credit Hours Professional Electives

Emphasis on flexibility in tailoring the program electives to be relevant to the participant's field of technology or other professional needs to be selected by the participant with approval of oversight committee; including self-directed learning and independent study in special topics, as well as formal courses/modules.
(Two Elective Courses)

12 Credit Hours Directed Technology Development Project

Emphasis on gaining real-world experience in creative problem-solving through project-based (problem-centered learning) focusing on innovation through a quality tangible experience of meaningful significance that is directly relevant to the technology development & innovation needs of the participant's sponsoring industry. This work should represent significant innovative development e.g. at the technical program leadership level wherein the participant is in responsible charge at (Level VI Engineer).

30 Credit Hours

Appendix: B - 3

Components: For High-Quality Postgraduate Professional Education Leading to the Professional Doctor of Engineering that are Integrative with Practice and Enable Lifelong learning and Professional Development of Engineers as Creative Professionals and Technology Leaders in Industry

Professional Doctor of Engineering – For Creative Engineering Practice and Leadership Level VI Engineer – Skill-Sets / Outcomes

**Focus: Professional Development of Experienced Engineer-Leaders in Industry
For Creative Technology Development and Innovation at Program Leadership Level**

Integrative Components:

□ Curricular Components

- 12 cr. Core Professional Modules
- 6 cr. Elective Modules
- 12 cr. Technology Development Project
In Industry (Focus on Innovation)

30 cr. Total

□ Professional Maturation Components

a) Residency Component

Full-time employment in engineering practice in industry/government service

b) Progressive Experience Component Beyond Entry-Level

Minimum of ten years of progressive experience beyond entry-level in engineering practice

c) Technical Competency Component

Demonstrated growth from competent professional to expert in a specific technological field

□ Admission Requirements to Program

Holder of the professional Master of Engineering (M.Eng.) degree or equivalent; ten years of progressive experience in engineering practice beyond entry-level; Level IV Engineer; plus strong letters of recommendation from participant's sponsor / practicing professionals in engineering; and PE when appropriate.

Appendix: C - 1

Aims of Professional Fellow of Engineering (F.Eng.) Programs For Working Professionals in Industry

Professional Fellow of Engineering – For Creative Engineering Practice and Leadership Level VIII Engineer – Skill-Sets / Outcomes

□ *Aims of professional Fellow of Engineering programs for engineering practice and leadership*

- a) Professional Engineering Fellow (F.Eng.) programs provide a very innovative approach that enables further professional development of senior Engineer-Leaders beyond the D.Eng./PhD being specifically designed to meet the needs of the practicing professional in industry at the highest levels of engineering practice and technology leadership within the practicing profession.
- b) High-quality professional Engineering Fellow programs for engineering practice & technology leadership should be specifically designed to be integrative with and in the context of on-going creative engineering practice for leadership of technology development and innovation and emphasize – “innovation-based learning”— concurrent with practice that enables these engineers to grow to progressive levels of attainment beyond Level VI Engineer to levels VIII, and IX for responsible engineering leadership at large scale systems and technology policy issues.
- c) Professional F.Eng. programs should support the skill-sets required for responsible leadership of significant work at Engineer VIII level of technology policy issues setting the technological thrust of the technology-based organization for competitive advantage.
- d) Professional F.Eng. programs provide opportunity for professional development beyond the doctoral level and recognize postgraduate professional education as a facilitating process of professional development wherein self-directed learning, progressive professional experience, tangible project-based learning, and advanced studies all serve as integral components of a working professional’s lifelong growth process to reach his or her potential for leadership of significant work in engineering practice.
- e) Professional F.Eng. programs should be specifically designed to be concurrent with and to support the working professional’s on-going creative work and stage of growth in engineering practice for responsible leadership of creative, systematic technology development & innovation.
- f) Residency should be viewed as residency in engineering practice in the professional’s workplace in industry/government service. Professional F.Eng. programs enable the working professional to continuously develop beyond the doctoral level toward their fullest creative, innovative, and leadership potential in responsible charge of significant corporate technological endeavors while he/she is fully employed without uprooting home, family, or career to continue high-quality postgraduate professional education in engineering.

□ *Target market for professional Fellow programs*

- a) Professional F.Eng. programs should be targeted to enhance the innovative capability of senior executive leaders of technology within the regional U.S. engineering workforce who are actively involved in innovative technology development in industry/government service.
- b) Professional F.Eng. programs should be designed with flexibility for those senior executive engineers who are pursuing development oriented technology leadership careers as strategic

generalists, technology policy leaders, and senior executive engineers in responsible charge of complex/multidisciplinary functional/corporate engineering areas of technological development, innovation responsibility, and technology policy leadership.

- c) These programs are specifically designed for holders of the D.Eng. (or equivalent) with required experience (15+ years) and maturity level who are growing as senior executive engineer-leaders of technology.

□ ***Integrative professional curriculum with practice***

- a) Professional F.Eng. programs should be designed to take the practicing professional to the highest senior levels of strategic policy leadership and technical corporate program making. Study is concurrent with the participant's engineering practice in industry or government service. The emphasis shifts from classroom instruction to leadership of technology development policy issues, future directions in engineering practice, and needs-driven technological innovation.
- b) Professional F.Eng. programs should be implemented from a holistic perspective and designed to nurture the necessary breadth and depth of the executive engineer in the context of advanced engineering practice and leadership of technology and should build upon six major ingredients. These include:
 - (1) Knowledge and skill-sets acquired by undergraduate engineering education, professional master's education, and professional doctoral education.
 - (2) Experiential learning in creative engineering practice and progressive leadership
 - (3) The engineer's already proven/established leadership expertise in a technological field
 - (4) Self-directed learning
 - (5) Advanced seminars and independent studies
 - (6) Project-based learning in meaningful technological activity/policy studies responsive to significant real-world needs

□ ***Scope of technology projects and expected project outcomes and impact***

- a) Technology development projects should be selected to be directly relevant to significant needs of the participant's sponsoring industry/or society; and should be selected by the participant with the approval of an oversight committee.
- b) Technology projects should be selected to provide the participant a meaningful experience at Engineer VIII level and should result in substantial improvements/developments/breakthroughs in products, processes, systems, or operations to the participant's sponsoring industry/or society.
- c) Technology projects should yield significant work, resulting in original "ideas and concepts", through proof of feasibility, that ultimately result as contributions to the body of technical knowledge as a result of the creative engineering method and process for technological innovation, which should be of benefit to the advancement of the practicing profession and the corporate thrust of the participant's technology-based organization.

□ ***Expectation of skill-sets / outcomes for participant Engineer-Leaders***

- a) High-quality professionally-oriented Engineering Fellow programs provide a very practical educational approach at the highest leadership levels of engineering practice for continuous lifelong learning; a credible and prestigious recognition; and an integrated approach that combines further advanced studies with actual experience that emphasizes project-based (problem-centered) "innovation-based learning-practice" by enhancing work-related professional

and technical skills that are required for progressive levels of attainment beyond doctoral level through Level VIII Engineering for responsible executive technology leadership.

- b) Professional F.Eng programs should be two-year postgraduate programs that are project-based and specifically designed to foster the professional development of executive Engineer-Leaders beyond the professional D.Eng. while they are fully employed in industry/government service. The programs should be designed to nurture the engineer's leadership of technology development & innovation by combining self-directed learning, creative work, progressive experience, and advanced studies with engineering practice in a synergistic fashion.
- c) The professional F.Eng. programs should be designed to meet identified needs of senior engineering executives, who are assuming increasing responsibilities for leadership of technology development & innovation relevant to setting technology policy and the corporate technological thrust.
- d) Participants are expected to emerge from professional F.Eng. programs with the skill-sets, knowledge, and experience ready to assume the responsibilities associated with Engineer VIII level for technology policy leadership and corporate technological responsibility.
- e) At Engineer VIII level of technology policy making and executive leadership, Engineering Fellows are expected to perform strategic planning and to set the corporate culture, vision, and leadership for engineering innovation that enables creativity and innovation to flourish within the technology-based organization for competitive advantage.

□ ***Entrance requirements***

- a) High-quality professional F.Eng. programs should be formulated to enable experienced engineers to enter them at a senior career stage of professional development in engineering practice when the additional learning and growth experience would be most valuable. Leadership development in engineering practice is a lifelong growth process that does not end at the doctoral level. It is now understood that the integrative combination of self-directed learning, progressive engineering experience, actual creative work, and further advanced studies is a valuable component of an engineer's continuing professional education beyond the professional doctorate.
- b) Because many of the skill-sets that are required during the professional maturation process in engineering practice for executive leadership of technology development and innovation in industry can only be attained through progressive experience, it is recommended that a minimum of at least ten to fifteen years of progressive professional experience in engineering practice, beyond entry-level, plus the professional D.Eng. (or equivalent) should be required for entrance into these distinctive, professionally-oriented graduate programs. Completion of the PE is also recommended when appropriate.

Appendix: C - 2

Framework: For High-Quality Postgraduate Professional Education Leading to
The Professional Fellow of Engineering that is Integrative with Practice and
Enables Lifelong learning and Professional Development of Engineers
As Creative Professionals and Technology Leaders in Industry

Professional Fellow of Engineering — For Creative Engineering Practice and Leadership Level VIII Engineer - Skills-Sets / Outcomes

**Focus: Professional Development of Senior Engineer-Leaders in Industry for
Creative Technology Development and Innovation at Technology Policy Leadership Level**

Postgraduate Professional Education Integrative with Creative Engineering Practice

- 6 Credit Hours Advanced Professional Seminars/Courses**
Emphasis on the professional dimensions / knowledge / critical skill-sets required in advanced engineering practice (Level VIII Engineer) at the levels of executive technology policymaking, strategic planning, and corporate engineering responsibility for the technological corporate thrust
(Two Professional Courses)
- 6 Credit Hours Professional Electives**
Emphasis on flexibility in tailoring the program electives to be relevant to the participant's field of technology or other professional needs to be selected by the participant with approval of oversight committee; including self-directed learning and independent study in special topics, as well as formal courses/modules.
(Two Elective Courses)
- 18 Credit Hours Directed Technology Development Project**
Emphasis on gaining real-world experience in creative problem-solving through project-based (problem-centered learning) focusing on innovation through a quality tangible experience of significant attainment that is directly relevant to the corporate leadership needs for technology development & innovation of the participant's sponsoring industry. This work should represent leadership of significant innovative technology development at the level of a white paper setting technology policy for the sponsoring organization e.g. at the technology leadership policy leadership level wherein the participant is in responsible charge at (Level VIII Engineer).

30 Credit Hours

Appendix: C - 3

Components: For High-Quality Postgraduate Professional Education Leading to the Professional Fellow of Engineering that are Integrative with Practice and Enable Lifelong Learning and Professional Development of Engineers as Creative Professionals and Technology Leaders in Industry

Professional Fellow of Engineering — For Creative Engineering Practice and Leadership Level VIII Engineer – Skill-Sets / Outcomes

**Focus: Professional Development of Senior Engineer-Leaders in Industry for
Creative Technology Development and Innovation at Technology Policy Leadership Level**

Integrative Components:

□ Curricular Components

- 6 cr. Core Professional Modules
- 6 cr. Elective Modules
- 18 cr. Technology Development Project
In Industry (Focus on Innovation)

30 cr. Total

□ Professional Maturation Components

a) Residency Component

Full-time employment in engineering practice in industry/government service

b) Progressive Experience Component Beyond Entry-Level

Minimum of 15 years of progressive experience beyond entry-level in engineering practice

c) Technical Competency Component

Demonstrated growth from competent professional to expert in a specific technological field

□ Admission Requirements to Program

Holder of the professional Doctor of Engineering (D.Eng.) degree or equivalent; fifteen years of progressive experience in engineering practice beyond entry-level; Level VIII Engineer; plus strong letters of recommendation from participant's sponsor / practicing professionals in engineering; and PE when appropriate.