2006-1317: ENABLING A STRONG U.S. ENGINEERING WORKFORCE FOR LEADERSHIP OF TECHNOLOGY DEVELOPMENT AND INNOVATION IN INDUSTRY: CRITICAL SKILL-SETS FOR EARLY CAREER DEVELOPMENT LEADING TO THE PROFESSIONAL MASTER OF ENGINEERING

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Enabling a Strong U.S. Engineering Workforce for Leadership of Technology Development and Innovation in Industry: Critical Skill-Sets for Early Career Development Leading to the Professional Master of Engineering

1. Introduction

This is the second of four papers prepared for a special panel session of the National Collaborative Task Force on Engineering Graduate Education Reform that is focusing on the deliberate advancement of professional engineering graduate education to enhance the innovative capacity of the U.S. engineering workforce in industry for global competitiveness. Founded in 2000, the National Collaborative Task Force is an initiative of the ASEE-Graduate Studies Division, Corporate Members Council, and College Industry Partnership Division. The National Collaborative is comprised of leaders from industry, academia, and government all coming together to advance engineering education for the practice of engineering in the national interest. This paper describes the critical skills identified by industry as essential for early career development of engineers at the project management level and formulates an integrative educational approach leading to the professional Master of Engineering for responsible engineering leadership of systematic technology development & innovation.

2. Professional Education for Engineers – The New Challenge for Industrial Innovation

While the U.S. system of graduate education continues to set the world standard and sustains the preeminence of the U.S. scientific workforce for basic research at the universities, the National Collaborative Task Force is leading a major reform in professionally oriented engineering graduate education to enhance the innovative capacity of the U.S. engineering workforce in industry to retain U.S. preeminence in engineering practice for technology development & innovation to enhance competitiveness.

2.1 The Modern Practice of Engineering for Leadership of the Continuous Technology Development & Innovation Process in Industry

A new paradigm of the practice of engineering for the creation (invention), design, development, and innovation of new / improved / breakthrough technology has emerged for economic prosperity and the nation's defense which is substantially different from that portrayed by science policy of 1945 for the development of technology. The reform of professional engineering graduate education is mandated by the new paradigm that has occurred in the practice of engineering for creating, developing, and innovating new, improved, and breakthrough technology as a systematic practice of engineering (See Appendix A).
Contrary to popular belief, engineers do not simply apply existing technology to contemporary problems or sequentially transfer results from basic research into development as the primary driver for creative engineering practice. What engineers apply is their use of the engineering

method combined with their accumulated professional skills, their creativity, their knowledge gained through study and experience, their judgment, and their leadership in the solution of real-world problems to create, invent, and improve technology to meet the hopes, wants, and needs of people through innovative design. By their innovative designs and conceptualization of new" ideas" and "concepts" to meet real-world needs of people, engineers actually obsolete existing technology through their improvements and breakthroughs.

In today's innovation-driven economy, the vast majority of engineering innovations are needs-driven and market-focused requiring deliberate engineering problem-solving and responsible leadership. Today the practice of engineering for creative technology development & innovation is a very purposeful and systematic practice, and is not a linear or sequential process following basic research as portrayed in 1945.[1] Rather, creative engineering projects in industry frequently drive the need for directed strategic research efforts at universities (when necessary or anticipated) in order to gain a better understanding of the natural phenomena involved.

New technology is brought about primarily by a very purposeful and systematic practice of engineering involving the deliberate recognition of meaningful human needs and the deliberate engineering creation of new "ideas and concepts" to effectively meet these needs though responsible leadership. Engineering practice and its resulting outcome technology have been redefined for the 21st century. Engineering is no longer misconstrued as "applied science." Rather, as the National Academy of Engineering defines it, "engineering is design under constraint".

As the National Academy of Engineering (NAE) Phase II report, *Engineering 2020*, points out:[2]

- Engineering is a profoundly creative process.
- Technology is the outcome of engineering.
- Engineering is problem recognition, formulation, and solution.

2.2 Modern Practice of Engineering for Technology Development & Innovation Mandates Reform of Professional Graduate Education for U.S. Engineering Workforce in Industry

Although the modern practice of engineering for systematic, technology development & innovation has changed substantially since 1945, the U.S. system of engineering graduate education has not kept pace with the modern paradigm. As the Committee on Science, Engineering, and Public Policy (COSEPUP)[3] has pointed out, graduate education in engineering has evolved primarily in the United States as a byproduct of a national science policy for scientific research. The United States has not had a coherent policy for the graduate development of the vast majority of its domestic engineering graduates in the U.S. engineering workforce whose professional careers are not centered on academic scientific research but rather are centered on creating, developing, and innovating new, improved, and breakthrough technology in industry for competitiveness and the nation's defense.

Whereas the nation invested heavily during the 1960's, 70's, 80's, and 90's in the graduate education of the U.S. scientific workforce for basic academic research, we have not as a nation placed a balanced emphasis on investing in the further professional education of the nation's graduate engineers who enter industry and are the nation's primary creators, developers, and leaders of U.S. technological progress for competitiveness and national security purposes. As a consequence of this unbalanced emphasis, lasting over four decades, the U.S. engineering workforce in industry is the nation's most underdeveloped resource for innovation.

The nation is paying the price for long-term underdevelopment of the U.S. engineering workforce in industry that is showing up by a long-term decline in U.S. technological leadership and by a loss in our innovative capacity to compete. But, we now know 50 years later that one size or type of graduate education doesn't fit all. Science and Engineering (S&E) are two different pursuits; have different missions and purposes; and for the most part are not sequential. As such, Science and Engineering (S&E) require two different types of education at the graduate level of practice. The modern practice of engineering for creative technology development & innovation mandates reform for a new type of professionally oriented engineering education at the graduate level to better develop the innovative capacity of the U.S. engineering workforce for competitiveness and national security purposes.

The implications of this finding are far reaching in how we conduct creative technology development & innovation for economic and defense purposes; and in how we educate U.S. engineers for innovation. We cannot retain U.S. preeminence in engineering if the system of U.S. engineering graduate education does not reflect the modern practice of engineering for creative technology development & innovation or if we do not educate our engineers in industry for the highest levels of leadership responsibility required in the practice of engineering for effective technology development & innovation.

3. Next Generation Professional Education for Lifelong Learning ─ Combining Advanced Professional Studies, Experience, and Engineering Practice

The Task Force believes that further postgraduate development of the U.S. engineering workforce in industry is critical to the development of the nation's capacity for continuous technology development and innovation which is the primary engine for the nation's economic prosperity and security.

3.1 Accelerating Innovation through U.S. Engineering Workforce Development

Today, the U.S. engineering workforce in industry is the backbone of the nation's thrust for continuous technological development & innovation. If we want our nation's engineers to continue to grow beyond entry level to reach their creative and innovative potentials, to do over-the-horizon engineering, and to become creators, innovators and leaders of new technology innovations throughout their professional careers, then this requires universities to create a new type of professional education for lifelong leaning that develops engineers as emerging leaders at every level of responsibility for the practice of engineering in industry.

3.2 Reshaping Professional Engineering Education for Creative Practice

To meet the challenge, the National Collaborative Task Force is engaged in a complex project that requires a total systems approach as the stakes to enhance the innovative capacity of the U.S. engineering workforce for competitiveness are too high to fail. Broad sweeping changes are needed for a new type of professionally oriented engineering graduate education that is combined with engineering practice and that is primarily designed for practicing engineers in industry and government service that spurs innovation at the professional master of engineering level. But these changes won't occur by themselves without vision, commitment, and leadership.

The modern teaching of engineering for working professionals at the graduate level must correlate with the modern practice of engineering. Professional education for the practice of engineering is quite different from traditional graduate education for scientific research. The design of professional graduate education for creative engineering practitioners, who are emerging as leaders of the technology development process in industry, requires a different approach and process than presently provided by research-based graduate education for the graduate education of academic research scientists. And, it also requires a different type of faculty and focus as well.

4. Professional Education for Innovation ─ Leading to the Professional Master of Engineering

The Task Force recognizes that the education of an engineer as a creative professional is not a one time event. Rather, professional education is a process that extends throughout the engineer's career. It does not terminate at the undergraduate entry level, professional master's level, or professional doctoral level in the profession. The education of an engineer is truly a process of lifelong learning, growth and further professional development that continues beyond the rudimentary level of entry level preparation.

4.1 Aims of Professional Education ─ Developing the U.S. Engineering Workforce in Industry

Although the aims of traditional research-based graduate education are primarily focused on preparing future academic faculty for teaching and scientific research positions at the nation's universities, the aims of professional education are quite different.

- Whereas undergraduate engineering education prepares the engineering student for entry into engineering practice with the foundation for lifelong learning

- The intent of advanced professional education is to further the development of the practicing engineer beyond entry level to his or her fullest potential at the highest leadership levels of engineering practice.

4.2 Focus on Education for Innovation and Leadership to Strengthen the U.S. Engineering Workforce for Competitiveness

The reform necessitates a new type of professionally oriented engineering education at the graduate level that develops the innovative capacity of the U.S. engineering workforce for competitiveness and that supports the innovation skills required of engineers at all levels of leadership responsibility for the continuous development & innovation of technology in industry. The National Collaborative is leading the development of a new model of professional education for graduate engineers in industry focusing on innovation and leadership and solving unknown problems.

Educating engineers as creative professionals is a career long process of growth and further professional development including the development of intrinsic creative and innovative potential for leadership in engineering practice. This process extends beyond entry level undergraduate education to the highest levels of engineering leadership within the practicing profession. Professional education at this level requires an integrative combination of self-directed learning, experiential learning, and advanced professional engineering studies combined with real-world experience in creative engineering practice.

The Task Force believes that the development of the professional engineer in industry or government service as a creative professional, innovator, and leader can be classified by three stages of growth:

- Early Career Development — From Level I Engineer through Level IV Engineer
- Mid-Career Development — From Level IV Engineer through Level VI Engineer
- Senior Career Development— From Level VI Engineer through Level IX Engineer

4. 3 Early Career Development of Engineers — Beyond Entry Level for Innovation and Leadership in Engineering Practice

As the National Academy of Engineering report, *Educating the Engineer of 2020*[4], points out: “The future engineering curriculum should be built around developing skills and not around teaching available knowledge. We must focus on shaping analytic skills, problem-solving skills, and design skills. We must teach future engineers to be creative and flexible, to be curious and imaginative.” The Task Force believes that at the graduate level of engineering practice, the critical skills must include innovation and professional engineering leadership. Mastery of these skills at Level IV Engineer is the objective of the integrative program of study leading to the professional Master of Engineering (M. Eng.). (See Appendix B, C, and D)

The Task Force also believes that reinventing engineering education at the graduate level for creative professional engineering practice requires not only change with an increased emphasis toward professionally oriented curriculum for innovation but also a change with an increased emphasis on provision of a new professional educational process as well that supports the practice of engineering for innovation, the professional maturation characteristics of emerging leaders, and the characteristics of how advanced engineering professionals learn, grow, and develop (See Appendix E).

5. Conclusions ─ A Work in Progress To Enhance the U.S. Engineering Workforce for Competitiveness

The modern practice of engineering for technology development & innovation has changed substantially from that portrayed by 1945 science policy. Subsequently, the paradigm shift that has occurred in engineering practice for technology development & innovation mandates a different type of professional curriculum and approach at the graduate level for the practice of engineering than that which has emerged for the graduate education of the nation's scientists for research. Whereas the United States has built a world-class infrastructure for academic scientific research and a system of graduate education envied in other countries since 1945, for the buildup and federal support for U.S. scientific workforce development at the universities, it is time today for the United States to place an equal investment and educational emphasis for U.S. engineering workforce development in industry.

The United States must increase its commitment and investment in the advancement of professional education for development of the U.S. engineering workforce in industry which will directly optimize the U.S. economy for global competitiveness and productive innovation. Investing in the development of the U.S. engineering workforce for innovation in industry is critical in retaining U.S. technological leadership. The work of the National Collaborative Task Force is a work in progress. Recommendations by the National Collaborative Task Force are based on two guiding tenets. First, professional engineering education does not end at entry level if we want to unleash America's engineering potential for economic competitiveness and national security purposes. Our technological progress requires an experienced, well-educated U.S. engineering workforce that is further nurtured at all levels of engineering practice beyond entry level to fuel America's preeminence for world-class technology development & innovation.

Second, closer collaboration between industry and universities will be critical to the success of this reform. The Task Force believes that the further graduate development of the U.S. engineering workforce in industry can neither be done by universities working alone nor by industry working alone. Industry and universities must engage in new collaborative ways to remove the barriers and obstacles that stifle the creativity, further graduate education, and innovative growth of U.S. engineers in industry. Reinventing professional engineering education for creative engineering practice in industry requires industry's steady and consistent input aimed at what we want the nation's engineers to do and to become. The next steps of the Task Force are to implement these recommendations into action in the national interest.

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1. Science: The Endless Frontier, Vannevar Bush, 1945.
2. National Academy of Engineering, Educating the Engineer of 2020: Phase II Report, 2005
3. COSEUP Reshaping Report
4. National Academy of Engineering, Educating the Engineer of 2020: Phase I Report, 2004.
5. Council on Competitiveness, http://www.compete.org, 2006

Appendix A

Engineering Process for Needs-Driven, (Market-Focused) Technology Development & Innovation in Industry

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Needs → Engineering → Technology

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Directed Scientific Research to gain a better understanding of phenomena when needed or anticipated during the technology development project

Appendix: B - 1

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

Stages of Growth	**Typical Responsibilities-Autonomy-Judgment**
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: B - 2

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

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Senior 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 - 3

A Comparison between Career Paths that Support Academic Research at Universities and those that Support Engineering Practice for Innovative Technology Development in Industry and Government Service

Industry/Government (Technology Development)	**Universities (Academic Research)**
Senior Executive Levels	Senior Executive Levels
Engineer IX (GS-18, 17,16) Vice President of Engineering and Technology	Dean of Engineering/Technology
Executive Engineer Levels - Technology Leadership	Administrative Academic Levels
Engineer VIII (GS-15) Director of Engineering	Department Head
Engineer VII (GS-14) Department/Division Manager	Distinguished Professor
Engineer VI (GS-13) Technical Area Manager	Professor
Senior Engineer/Project Management Levels	Senior Research Specialist Levels
Engineer V (GS-12) Senior/Principal Engineer/Project Leader/Group Leader	Associate Professor
Engineer IV (GS-11) Project Engineer/Process Engineer	Assistant Professor (PhD)
Engineer III (GS-9) Design/Development Engineer	Post-Doctorate in Research
Entry Level in Engineering Practice	Entry Level in Academic Research
Engineer II/I (GS-7, 5) Entry Level Engineer/Engineer-in-Training	Graduate Research Assistant

Appendix B - 4

Professional Characteristics, Leadership Responsibilities, And Growth Levels in Engineering Practice – (NSPE)

Engineer IX

Equivalent Federal General Schedule Grade
Senior Executive Service GS - 18, 17, 16

General Characteristics. An engineer in this level is either: 1) in charge of programs so extensive and complex as to require staff and resources of sizable magnitude (e.g., research and development, a department of government responsible for extensive engineering programs, or the major components of an organization responsible for the engineering required to meet the objectives of the organization); or 2) is an individual researcher or consultant who is recognized as a national and/or international authority and leader in an area of engineering or scientific interest and investigation.

Typical Position Titles. Director of Engineering, General Manager, Vice President, President, Partner, Dean, Director of Public Works

Education. Bachelor's Degree in engineering from an ABET accredited curriculum, or equivalent, plus appropriate continuing education.

Licensure Status. Licensed Professional Engineer

Typical Professional Attainments. Member of Professional Society (Member Grade), Member of Technical Societies (Member Grade); Publishes engineering papers, articles, textbooks

Engineer VIII

Equivalent Federal General Schedule Grade
GS-15

General Characteristics. Make decisions and recommendations that are recognized as authoritative and have a far-reaching impact on extensive engineering and related activities of the company. Negotiates critical and controversial issues with top-level engineers and officers of other organizations and companies. Individuals at this level demonstrate a high degree of creativity, foresight, and mature judgment in planning, organizing and guiding extensive engineering programs and activities of outstanding novelty and importance.

Direction Received. Receives general administrative direction

Typical Duties & Responsibilities. One or both of the following: 1) In a supervisory capacity is responsible for a) an important segment of a very extensive and highly diversified engineering program, or b) the entire engineering program when the program is of moderate scope. The programs are of such complexity that they are of critical importance to overall objectives, include problems of extraordinary difficulty that often have resisted solution and consist of several segments requiring subordinate supervisors. Is responsible for deciding the kind and extent of engineering and related programs needed for accomplishing the objectives of the organization, for choosing the scientific approaches, for planning and organizing facilities and programs, and for interpreting results; 2) As individual researcher and consultant, formulates and guides the attack on problems of exceptional difficulty and marked importance to the organization or industry. Problems are characterized by their lack of scientific precedents and source material, or lack of success of prior research and analysis so that their solution would represent an advance of great significance and importance. Performs advisory and consulting work for the organization as a recognized authority for broad program areas or in an intensely specialized area of considerable novelty and importance.

Responsibility For Direction of Others. Supervises several subordinate supervisors or team leaders, some of whose positions are comparable to Engineer VII, or individual researchers some who whose positions are comparable to Engineer VII. As an individual researcher and consultant may be assisted on individual projects with other engineers and technicians.

Typical Position Titles. Chief Engineer, Bureau Engineer, Director of Research, Department Head or Dean, County Engineer, City Engineer, Director of Public Works, Senior Fellow, Senior Staff, Senior Advisor, Senior Consultant, Engineering Manager.

Education. Bachelor's Degree in engineering from an ABET accredited curriculum, or equivalent, plus appropriate continuing education.

Licensure Status. Licensed Professional Engineer

Typical Professional Attainments. Member of Professional Society (Member Grade), Member of Technical Societies (Member Grade); Publishes engineering papers, articles, textbooks

Engineer VII

Equivalent Federal General Schedule Grade
GS-14

General Characteristics. Make decisions and recommendations that are recognized as authoritative and have an important impact on extensive engineering activities. Initiates and maintains extensive contacts with key engineers and officials of other organizations and companies, requiring skill in persuasion and negotiation of critical issues. At this level individuals will have demonstrated creativity, foresight, and mature engineering judgment in anticipating and solving unprecedented engineering problems, determining program objectives and requirements, organizing programs and projects, and developing standards and guides for diverse engineering activities.

Direction Received. Supervision received is essentially administrative with assignments given in terms of broad general objectives and limits.

Typical Duties & Responsibilities. One or both of the following: 1) in a supervisory capacity is responsible for a) an important segment of the engineering program of an organization with extensive and diversified engineering requirements, or b) the entire engineering program of an organization when it is more limited in scope. The overall engineering program contains critical problems the solution of which requires major technological advances and opens the way for extensive related development. The extent of responsibilities generally requires several subordinate organizational segments or teams. Recommends facilities, personnel, and funds required to carry out programs which are directly related with and directed toward fulfillment of overall organization objectives; 2) As individual researcher and consultant is a recognized leader and authority in the organization in a broad area of specialization or in a narrow but intensely specialized field. Selects research problems to further the organization's objectives. Conceives and plans investigations of broad areas of considerable novelty and importance for which engineering precedents are lacking in areas critical to the overall engineering program. Is consulted extensively by associates and others with a high degree of reliance placed on the scientific interpretations and advice. Typically, will have contributed inventions, new designs, or techniques which are regarded as major advances in the field.

Responsibility For Direction of Others. Directs several subordinate supervisors or team leaders, some of whom are in a position comparable to Engineer VI, or as individual researcher and consultant, may be assisted on individual projects by other engineers and technicians.

Typical Position Titles. Principal Engineer, Division or District Engineer, Department Manager, Director or Assistant Director of Research, Consultant, professor, Distinguished Professor or Department Head, Assistant Chief or Chief Engineer, City or County Engineer.

Education. Bachelor's Degree in engineering from an ABET accredited curriculum, or equivalent, plus appropriate continuing education.

Licensure Status, Licensed Professional Engineer

Typical Professional Attainments. Member of Professional Society (Member Grade), Member of Technical Societies (Member Grade); Publishes engineering papers, articles, textbooks

Engineer VI

Equivalent Federal General Schedule Grade
GS-13

General Characteristics. Has full technical responsibility for interpreting, organizing, executing, and coordinating assignments. Plans and develops engineering projects concerned with unique or controversial problems which have an important effect on major organization programs. This involves exploration of subject area, definition of scope and selection of problems for investigation and development of novel concepts and approaches. Maintains Liaison with individuals and units within or outside the organization with responsibility for acting independently on technical matters pertaining to the field. Work at this level usually requires extensive progressive experience.

Direction Received. Supervision received is essentially administrative, with assignments given in terms of broad general objectives and limits.

Typical Duties & Responsibilities. One or more of the following: 1) in a supervisory capacity a) plans, develops, coordinates, and directs a number of large and important projects or a project of major scope and importance; or b) is responsible for the entire engineering program of an organization when the program is of limited complexity and scope. The extent of his or her responsibilities generally requires a few (3 to 5) subordinate supervisors or team leaders with at least one in a position comparable to level V; 2) As individual researcher or worker conceives, plans and conducts research in problem areas of considerable scope and complexity. The problems must be approached through a series of complete and conceptually related studies, are difficult to define, require unconventional or novel approaches, and require sophisticated research techniques. Available guides and precedents contain critical gaps, are only partially related to the problem or may be largely lacking due to the novel character of the project. At this level, the individual researcher generally will have contributed inventions, new designs, or techniques which are of material significance in the solution of important problems; 3) As a staff specialist serves as the technical specialist for the organization (division or company) in the application of advanced theories, concepts, principles, and processes for an assigned area of responsibility (i.e. subject matter, function, type of facility or equipment, or product). Keeps abreast of new scientific methods and developments affecting the organization for the purpose of recommending changes in emphasis of programs or new programs warranted by such developments.

Responsibility For Direction of Others. Plans, organizes, and supervises the work of a staff of engineers and technicians. Evaluates progress of the staff and results obtained and recommend major changes to achieve overall objectives. Or, as individual research or staff specialist may be assisted on individual projects by other engineers or technicians.

Typical Position Titles. Senior or Principal Engineer, Division or District Engineer, Production Engineer, Assistant Division, District or Chief Engineer, Consultant, Professor, City or County Engineer.

Education. Bachelor's Degree in engineering from an ABET accredited curriculum, or equivalent, plus appropriate continuing education.

Licensure Status. Licensed Professional Engineer

Typical Professional Attainments. Member of Professional Society (Member Grade).Member of Technical Societies (Member Grade); Publishes engineering papers, articles, textbooks

Engineer V

Equivalent Federal General Schedule Grade
GS-12

General Characteristics. Applies intensive and diversified knowledge of engineering principles and practices in broad areas of assignments and related fields. Make decisions independently on engineering problems and methods, and represents the organization in conferences to resolve important questions and to plan and coordinate work. Requires the use of advanced techniques and the modifications and extension of theories, precepts and practices of the field and related sciences and disciplines. The knowledge and expertise required for this level of work usually result from progressive experience.

Direction Received. Supervision and guidance relate largely to overall objectives, critical issues, new concepts, and policy matters. Consults with supervisor concerning unusual problems and developments.

Typical Duties & Responsibilities. One or more of the following: 1) In a supervisory capacity, plans, develops, coordinates, and directs a large and important engineering project or a number of a small projects with many complex features. A substantial portion of the work supervised is comparable to that described for engineer IV; 2) As individual researcher or worker, 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 improved techniques and procedures. Work is expected to result in the development of new or refined equipment, materials, processes, products, and/or scientific methods; 3) As staff specialist, develops and evaluates plans and criteria for a variety of projects and activities to be carried out by others. Assesses the feasibility and soundness of proposed engineering evaluation tests, products, or equipment when necessary data are insufficient or confirmation by testing is advisable. Usually performs as a staff advisor and consultant as to a technical specialty, a type of facility or equipment, or a program function.

Responsibility For Direction of Others. Supervises, coordinates, and reviews the work of a small staff of engineers and technicians, estimates personnel needs and schedules and assigns work to meet completion date. Or, as individual researcher or staff specialist may be assisted on projects by other engineers or technicians.

Typical Position Titles. Senior or Principal Engineer: Resident, Project, Office, Design, Process, Research, Assistant Division Engineer, Associate Professor, Project Leader.

Education. Bachelor's Degree in engineering from an ABET accredited curriculum, or equivalent, plus appropriate continuing education.

Licensure Status. Licensed Professional Engineer

Typical Professional Attainments. Member of Professional Society (Member Grade), Member of Technical Societies (Member Grade); Publishes engineering papers, articles, textbooks

Engineer IV

Equivalent Federal General Schedule Grade
GS-11

General Characteristics. As a fully competent engineer in all conventional aspects of the subject matter of the functional area of the assignments, plans and conducts work requiring judgment in the independent evaluation, selection, and substantial adaptation and modification of standard techniques, procedures, and criteria. Devises new approaches to problems encountered. Requires sufficient professional experience to assure competence as a fully trained worker, or, for positions primarily of a research nature, completion of all requirements for a doctoral degree may be substituted for experience.

Direction Received. Independently performs most assignments with instructions as to the general results expected. Receives technical guidance on unusual or complex problems and supervisory approval on proposed plans for projects.

Typical Duties & Responsibilities. Plans, schedules, conducts, or coordinates detailed phases of the engineering work in a part of a major project or in a total project of moderate scope. Performs work which involves conventional engineering practice but may include a variety of complex features such as conflicting design requirements, unsuitability of conventional materials, and difficult coordination requirements. Work requires a broad knowledge of precedents in the specialty area and a good knowledge of and practices of related specialties.

Responsibility For Direction of Others. May supervise or coordinate the work of engineers, drafters, technicians, and others who assist in specific assignments.

Typical Position Titles. Engineer or Assistant Engineer, Resident, Project, Plant, Office, Design, Process, Research, Chief Inspector, Assistant Professor.

Education. Bachelor's Degree in engineering from an ABET accredited curriculum, or equivalent, plus appropriate continuing education.

Licensure Status. Licensed Professional Engineer

Typical Professional Attainments. Member of Professional Society (Member Grade),Member of Technical Societies (Associate Grade or Equivalent)/Member of Technical Societies (Member Grade); Publishes engineering papers, articles, text books

Engineer III

Equivalent Federal General Schedule Grade
GS-9

General Characteristics. Independently evaluates, selects, and applies standard engineering techniques, procedures, and criteria, using judgment in making minor adaptations and modifications. Assignments have clear and specified objectives and require the investigation of a limited number of variables. Performance at this level requires developmental experience in a professional position or equivalent graduate level education.

Direction Received. Receives instructions on specific assignment objectives, complex features, and possible solutions. Assistance is furnished on unusual problems and work is reviewed for application of sound professional judgment.

Typical Duties & Responsibilities. Performs work which involves conventional types of plans, investigations, surveys, structures, or equipment with relatively few complex features for which there are precedents. Assignments usually include one or more of the following: Equipment design and development, test of materials, preparation of specifications, process study, research investigations, report preparation, and other activities of limited scope requiring knowledge of principles and techniques commonly employed in the specific narrow area of assignments.

Responsibility For Direction of Others. May supervise or coordinate the work of drafters, technicians, and others who assist in specific assignments.

Typical Position Titles. Engineer or Assistant Engineer, Project, Plant, Office, Design, Process, Research Chief Inspector, Assistant Professor

Education. Bachelor's Degree in engineering from an ABET accredited curriculum, or equivalent, plus appropriate continuing education.

Licensure Status. Certified Engineer Intern/Licensed Professional Engineer

Typical Professional Attainments. Member of Professional Society (Associate Grade/Member Grade), Member of Technical Societies (Associate Grade or Equivalent)

Engineer I/II

Equivalent Federal General Schedule Grade
GS- 5, 7

General Characteristics. This is the entry level for professional work. Performs assignments designed to develop professional works knowledge and abilities, requiring application of standard techniques, procedures, and criteria in carrying out a sequence of related engineering tasks. Limited exercise of judgment is required on details of work and in making preliminary selections and adaptations of engineering alternatives.

Direction Received. Supervisor screens assignments for unusual or difficult problems and selects techniques and procedures to be applied on non-routine work. Receives close supervision on new aspects of assignments.

Typical Duties & Responsibilities. Using prescribed methods, performs specific and limited portions of a broader assignment of an experienced engineer. Applies standard practices and techniques in specific situations, adjusts and correlates data, recognizes discrepancies in results, and follows operations through a series of related detailed steps or processes.

Responsibility For Direction of Others. May be assisted by a few aides or technicians.

Typical Position Titles. Junior Engineer, Associate Detail Engineer, Engineer-in-Training, Assistant Research Engineer, Construction Inspector.

Education. Bachelor's Degree in engineering from an ABET accredited curriculum, or equivalent, plus appropriate continuing education.

Licensure Status. Certified Engineer Intern/Engineering-In-Training

Typical Professional Attainments. Member of Professional Society (Associate Grade), Member of Technical Societies (Associate Grade or Equivalent)

Appendix C

Progressive Critical Skill-Sets, Knowledge, and Experience Required in Engineering Practice for Leadership of Technology Development And Innovation in Industry and Government Service

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Core Qualifications - Senior Executive Engineer Levels

Top Levels of Corporate Technology Leadership

Engineers at the top levels of corporate technology leadership act in responsible charge for defining the core character, mission, vision, goals, and objectives of the technology-based organization; for setting responsible technology policy; for building an organizational culture that fosters a core value system of ethical responsibility; for planning, staffing, organizing, and allocating financial, professional, and material resources to enhance the organization's overall technological thrust; and for building an innovative culture that continually fosters the organization's core competence and innovative capacity for constant technology development and innovation such that industrial creativity and innovation can flourish to sustain the organization's competitive advantage responsive to customer needs.

Engineer IX (GS-18,17,16) 20+ years of progressive experience
Vice President of Engineering and Technology

Critical Skills-Sets, Knowledge, and Experience Required as Defined by Tasks and Responsibilities of Engineering Practice and Technology Leadership:

- Broad overall knowledge of corporate systems technology
- External awareness of competitive technology
- Strategic vision
- Leading change
- Leading people
- Results driven
- Business acumen
- Building coalitions/communications
- Technology policy making
- Ethical value judgment
- Integrity

Core Qualifications - Executive Engineer Levels

Third Level of Technology Leadership

Engineers at the third level of corporate technology leadership act in responsible charge for defining, planning, organizing, integrating, and leading the overall technological development of new or improved large scale/complex programs, systems, or operations responsive to corporate objectives, goals, vision and mission of the technology-based organization.

Engineer VIII (GS-15) 20+ years of progressive experience
Director of Engineering

Engineer VII (GS-14) 15+ years of progressive experience
Department/Division Manager

Critical Skills-Sets, Knowledge, and Experience Required as Defined by Tasks and Responsibilities of Engineering Practice and Technology Leadership:

- Expert knowledge of corporate systems technology
- Broad understanding of emerging sciences relevant to organization's technological thrust
- Leading major systems engineering and cross functional teams
- Financial management/understanding of the economics of technology development and innovation
- Human resources management and development of engineering profession
- Organizational development of innovative cultures for technology development
- Corporate decision analysis/decision making for innovative technology programs
- Value judgment and ethical decision-making regarding safety issues, environmental issues, understanding systems failures, and prevention
- Mentoring of creative professionals for future leadership positions

Core Qualifications - Senior Engineer/Project Management Levels

Second Level of Technology Leadership

Engineers at the second level of corporate technology leadership act in responsible charge for defining, planning, organizing, integrating, and leading the development and innovation of large-scale complex programs within functional technological areas.

Engineer VI (GS-13) 12+ years of progressive experience
Functional Area Manager

Engineer V (GS-12) 9+ years of progressive experience
Senior Engineer/Principal Engineer/Project Leader/Group Leader

Critical Skills-Sets, Knowledge, and Experience Required as Defined by Tasks and Responsibilities of Engineering Practice and Technology Leadership:

- Expert knowledge of functional area technology
- Core systems engineering and multidisciplinary thinking with responsible charge
- Needs-finding and identification of problems/opportunities for technology program-making
- Innovative thinking and strategic vision for program development planning from phases of conceptual exploratory development through advanced engineering development, and recognizing the need for directed research to gain a better understanding of anticipated or unknown phenomenon during technology development programs
- Contracting processes and regulations
- Project leadership and tracking
- Teambuilding
- Coaching of creative professionals
- Customer orientation
- Quality focus

Core Qualifications – Project Engineer Levels

First Levels of Technology Leadership

Engineers at the first levels of corporate technology leadership are fully competent engineering professionals and act in responsible charge for development and innovation of new or improved components of a subsystem or project.

Engineer IV (GS-11) 7+ years of progressive experience
Project Engineer/Process Engineer

Engineer III (GS-9) 5+ years of progressive experience
Design/Development Engineer

Critical Skills-Sets, Knowledge, and Experience Required as Defined by Tasks and Responsibilities of Engineering Practice and Technology Leadership:

- Expert knowledge of core project technology/process technology/product technology
- Competency in engineering method for systematic technology development and innovation
- Creative problem solving for innovative solutions to open-ended problems/opportunities
- Ethical judgment relevant to safety issues and environmental issues
- Engineering-technical judgment
- Project engineering
- Communication
- Critical thinking
- Self-directed learning

Core Qualifications - Entry Level Engineer

Entry Level– Trainee Level

Engineers at the entry-level of technology responsibility work at the level of known laws and data under close supervision of an experienced engineer on specific and limited portions of a broader assignment using prescribed methods, standard techniques, and procedures.

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

Critical Skills-Sets, Knowledge, and Experience Required as Defined by Tasks and Responsibilities of Engineering Practice and Technology Leadership:

- Graduate of ABET approved program in engineering or technology
- Initiative, enthusiasm, ability to work well with others, and high growth potential for technology development and leadership of innovation in industry
- Attainment of ABET requirements at the basic educational level for entry into engineering practice

a) an ability to apply knowledge of mathematics, science, and engineering
b) an ability to design and conduct experiments, as well as to analyze and interpret data
c) an ability to design a system, component, or process to meet desired needs
d) an ability to function on multi-disciplinary teams
e) an ability to identify, formulate, and solve engineering problems
f) an understanding of professional and ethical responsibility
g) an ability to communicate effectively
h) the broad education necessary to understand the impact of engineering solutions in a global and societal context
i) a recognition of the need for, and an ability to engage in lifelong learning
j) a knowledge of contemporary issues
k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Appendix D

System Summary of Skills and Professional Curricula Required for Early Career, Mid-Career and Senior Career Development in Engineering Practice for Leadership of Technology Development & Innovation in Industry

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Early Career Development

From Entry Level Engineer I
Thru Level IV Engineer

Leading to Professional
Master of Engineering M.Eng.
At Level IV Engineer

Project Level
Core-Competence Skills

- Systems Engineering
- Project Management
- Economic Issues of Technology Innovation
- Engineering Ethics
  Case Studies and Cannons of Practice
- Communications for Project Leaders
- Six-Sigma for Continuous Innovation
- Leading Effective Technology Innovation - Needs finding; Team building
- Applied Engineering Statistics

- Planned Studies
- Creative Problem Solving – Technical Project Level (Technology Development Project)
- Self-Directed Learning - Growing from novice to expert at the cutting edge of a specific core technology (On-Job / Industry)
- Experiential Learning in Engineering Practice - Growing in experience & engineering judgment at project level in practice

Mid-Career Development

From Level IV Engineer
Thru Level VI Engineer

Leading to Professional
Doctor of Engineering D. Eng.
At Level VI Engineer

Program Level
Core-Competence Skills

- Systems Engineering Management
- Technical Program Management
- Creating Cultures for Innovation - Fostering Collaborative Creativity - Mentoring Champions
- Fostering Ethics and Decision Making
- Financial Issues of Technology Innovation
- Communications for Program Managers
- Emerging Technologies

- Planned Studies
- Creative Problem Solving – Technical Program Level (Technology Development Project)
- Self-Directed Learning - Growing from technical expert to expertise in technology leadership (On-Job / Industry)
- Experiential Learning in Engineering Practice - Growing in experience & engineering judgment at program level in practice

Senior-Career Development

From Level VI Engineer
Thru Level IX Engineer

Leading to Chief Engineer
At Level IX Engineer

Policy Level
Core-Competence Skills

- Technology Policy Making
- Strategic Decision Making
  - Assessment of Core Areas for Technology Improvements and Breakthroughs
  - Evaluation of Risk / Return
- Setting Corporate Engineering Ethics
- Communications for Policy Makers
- Corporate Financial Issues for Technology Innovation
- Building the Corporate Culture for Engineering Creativity and Innovation

- Planned Studies
- Creative Problem Solving – Technical Policy Level (Technology Development Project)
- Self-Directed Learning - Growing in breadth of leadership expertise for technology innovation (On-Job / Industry)
- Experiential Learning in Engineering Practice - Growing in experience & engineering judgment at policy level in practice

Appendix E – 1

Aims of Professional Master of Engineering (M. Eng.) Programs for Working Professionals in Industry

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Professional Master of Engineering ─ For Creative Engineering Practice & Leadership Level IV Engineer –Skill-Sets / Outcomes

- ***Aims of professional Master of Engineering programs for engineering practice & leadership***

  a) Professional Master of Engineering (M.Eng.) programs provide a very practical component to lifelong learning; a recognized professional degree; and an integrated approach that combines advanced studies with self-directed learning, progressive experience in engineering practice, and actual engagement in creative technology development & innovation.

  b) High-quality, postgraduate professional M.Eng. programs should emphasize project-based (problem-centered) ─ "innovation-based learning" ─ concurrent with creative engineering practice thereby enhancing work-related professional skill-sets required for progressive levels of attainment from entry-level to Engineer IV level proficiency.

  c) Professional M.Eng. programs should support the skill-sets/outcomes required for responsible leadership of significant work at Engineer IV level of project responsibility.

  d) Professional M.Eng. programs should recognize postgraduate education not only as a learning process beyond the baccalaureate, 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 M.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 M.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 Master of Engineering programs***

  a) The professional master's programs in engineering practice & technology leadership should be targeted to enhance the innovative capability of engineers within the U.S. Engineering Workforce (in regional industry across the nation) who are actively engaged in innovative technology development and continuous improvement at project engineering level of responsibility.

  b) The professional M.Eng. programs should be specifically designed to continue the professional education of engineers, after entry into industry, who are emerging as leaders and are pursuing career paths that are not centered on research but are centered on the purposeful, systematic engineering creation, development & innovation of new/improved technology in the form of new/improved/breakthrough products, processes, systems, or technical operations.

- ***Integrative professional curriculum with engineering practice***

  a) Whereas, basic undergraduate engineering education prepares young, inexperienced engineers for entry into engineering practice and is predominantly based on a faculty-centered, content-model of instruction focusing on the transmission of knowledge from teacher to student for postponed application, the intent of advanced professional engineering education is to further the continued professional development of experienced engineers beyond entry-level toward their fullest potentials as creative professionals and leaders at the highest levels of leadership responsibility in engineering practice.

  b) As such, high-quality professional education should shift from a traditional faculty-centered, content-model of instruction to a learner-centered, process-oriented model of continuous professional development focusing on further development of the working professional's intrinsic creative, innovative, and leadership potential for increasing self-directedness, inventiveness, and engineering leadership skills for immediacy of application in actual creative engineering work.

  c) Professional education should be practice-oriented and designed from a holistic approach that more fully develops the engineer's breadth and depth in the context of actual engineering practice for leadership of on-going technology development & innovation projects.

  d) Professional education for engineers should shift from the traditional perspective of one-time learning to a process of continuous professional development that builds upon the wealth of the working professional's progressive experience; an already established technical knowledge base; and an already established skill-sets base and competency base in his or her field of technology.

  e) Professional M.Eng. programs for working professionals should be specifically designed to build upon six major integrative ingredients. These include:

     (1) Knowledge and skill-sets acquired by undergraduate 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 & 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 should provide the participant a meaningful professional learning experience at Engineer VI level of technical program leadership responsibility and result in substantial improvements 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 should be directed resulting in a project report and a quality tangible experience of meaningful significance that is directly relevant to the technology development & innovation needs of the participant's sponsoring industry/or society. This work should represent deliberate creation, improvement, development and innovation at the technical program engineering leadership level wherein the participant is in responsible charge.

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

a) The professional master's program should be a two-year postgraduate program, which is integrated concurrently with engineering practice, that is project-based and is specifically designed to foster the professional growth of experienced working professionals beyond entry-level in industry/government service on a continuous basis while they are fully employed. 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 program should be designed to meet the progressive skill-sets of creative engineering practice for ABET graduates (engineering/engineering technology) who are assuming career paths and responsible leadership roles in engineering practice for technology development & innovation relevant to their corporate engineering mission. The program should be designed to further the growth of experienced engineers for progressive levels of attainment as full-fledged practitioners, systems developers, innovators, integrators, and leaders for responsible charge of meaningful engineering project work.

c) The program should be designed to foster the continuous professional development of Engineer-Leaders who contribute to the creation, improvement, development, and innovation of new technology-based systems, operations, products, and processes on which regional industrial growth and economic development depends for creation of new wealth/employment/national security purposes.

d) The program should be designed for those engineers who can make original contributions to the creation, invention, and development of new/improved technology through purposeful, systematic improvement/breakthrough innovation. And as a result of their creative engineering work, add to the body of new technological knowledge as leaders for the region's and nation's technological progress and competitiveness.

e) Participants are expected to emerge from the professional master's 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 IV qualifications for technology project leadership.

- ***Entrance requirements***

a) High-quality postgraduate professional master's programs should be formulated to enable working professionals to enter them at an early career stage in engineering practice/and at later stages of professional development when the additional learning and growth experience would be most valuable. It is now understood that the integrative combination of practical engineering experience plus further advanced studies is a valuable component of an engineer's continuing professional education beyond the baccalaureate.

b) Because many of the skill-sets that are required during the professional maturation process in engineering practice for leadership of technology development & innovation in industry can only be attained through practical experience, it is recommended that a minimum of at least six months of professional experience in engineering practice, beyond a four-year undergraduate education in engineering/engineering technology from an ABET accredited institution, should be required for entrance into these professionally-oriented graduate programs. Completion of the FE for progression toward licensure is also recommended when appropriate.

Appendix E - 2

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

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Professional Master of Engineering ─ For Creative Engineering Practice & Leadership
Level IV Engineer – Skill-Sets / Outcomes

Focus: Professional Development of Emerging Engineer-Leaders in Industry
For Creative Technology Development & Innovation at Project Leadership Level

Postgraduate Professional Education Integrative with Creative Engineering Practice

18 Credit Hours	**Core Professional Courses:** Emphasis on the professional dimensions / knowledge / critical skill-sets required in engineering practice (at Level IV Engineer) for engineering leadership, professional responsibility, and creative problem solving at project engineering level for technology development & innovation in industry/government service. (Six Professional Courses)
6 Credit Hours	**Professional Electives:** Emphasis on flexibility in tailoring 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)
6 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 innovative development at the project leadership level wherein the participant is in responsible charge.
30 Credit Hours	

Appendix: E - 3

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

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Professional Master of Engineering ─ For Creative Engineering Practice & Leadership
Level IV Engineer – Skill-Sets / Outcomes

Focus: Professional Development of Emerging Engineer-Leaders in Industry
For Creative Technology Development & Innovation at Project Leadership Level

Integrative Components:

- **Curricular Components**

18 cr.	Core Professional Modules
6 cr.	Elective Modules
6 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

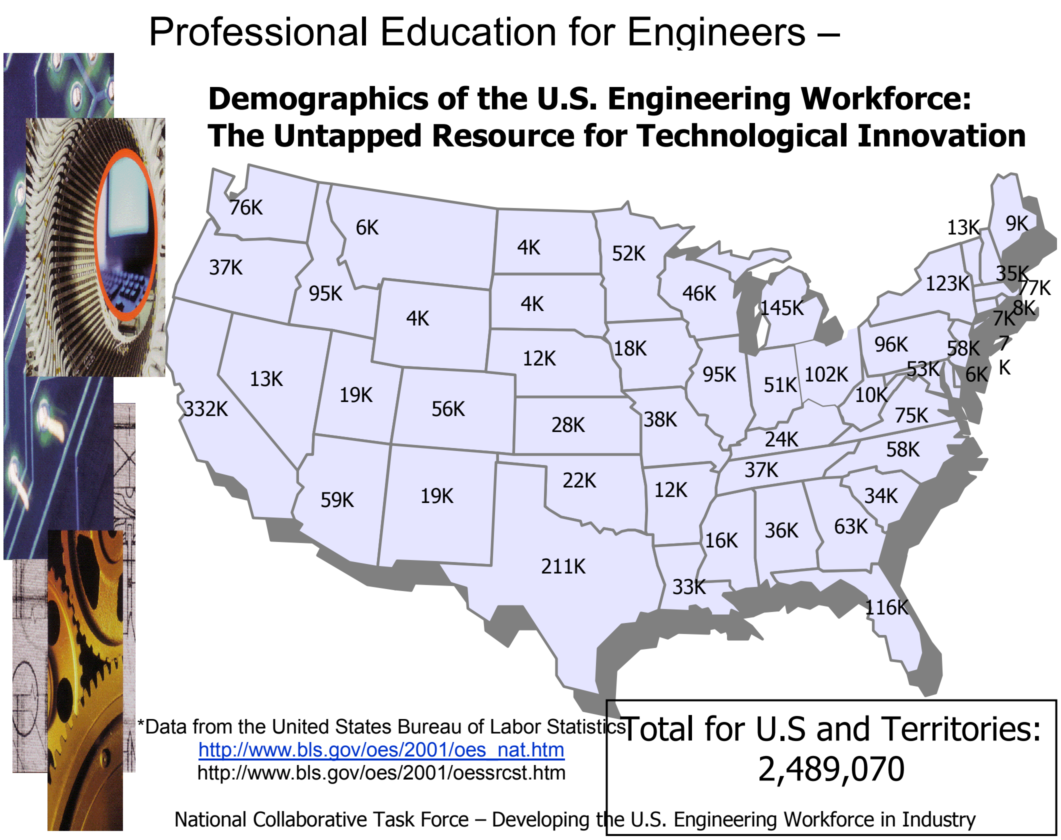
  b) Progressive Experience Component Beyond Entry-Level
  Minimum of 3 to 5 years of progressive experience beyond entry-level in engineering practice

  c) Technical Competency Component
  Demonstrated growth from novice to competent professional in a specific technological field

- **Admission Requirements to Program**
  Graduate of ABET program in engineering / or engineering technology; Minimum of at least 6 months beyond entry-level experience in engineering practice; Level II Engineer; plus strong letters of recommendation from participant's sponsor / practicing professionals in engineering; and FE when appropriate

Appendix: F

Demographics of the U.S. Engineering Workforce:
The Untapped Resource for Technological Innovation



Appendix G

Guidelines for Engineering Education Reform to Develop Professionally Oriented Graduate Education to Enhance the Innovative Capacity of the U.S. Engineering Workforce in industry

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GUIDELINES FOR NATIONAL COLLABORATIVE TASK FORCE

- Focus on innovation and leadership

- Focus on development of U.S. Engineering Workforce for innovative competitiveness in industry, second to none in the world

- Vision ─

  "Innovation fosters the new ideas, technologies, and processes that lead to better jobs, higher wages and a higher standard of living. For advanced industrial nations no longer able to compete on cost, the capacity to innovate is the most critical element in sustaining competitiveness."

  Council on Competitiveness

- Workforce Development ─

  "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.

  Council on Competitiveness

- Create a new, innovative professional curriculum combined with engineering practice that matches and supports the progressive core-competence skills required for effective engineering leadership of technology development & innovation in industry ─ from beginning Entry Level Engineer through Chief Engineer Level for corporate technology responsibility

- Graduate centers that will be "statewide clusters" for advanced professional education for engineering innovation and leadership in all 50 states across the nation

- Use the combined formidable teaching and human resource strengths of regional universities and industry in this process

- Unique collaboration between industry and universities in developing the creative and innovative capacity of the U.S. Engineering Workforce in industry for world-preeminence in technology development & innovation