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ENGINEERING PROGRAMS ACCREDITATION REPORT AT IOWA STATE UNIVERSITY

Action Requested: Receive the accreditation report from the Engineering Programs in the College of Engineering at Iowa State University.

Executive Summary: The College of Engineering offers Bachelor of Science programs in engineering in 12 areas - Aerospace Engineering, Agricultural Engineering, Biological Systems Engineering (new), Chemical Engineering, Civil Engineering, Computer Engineering, Construction Engineering, Electrical Engineering, Industrial Engineering, Materials Engineering, Mechanical Engineering, and Software Engineering (new).

All of the programs (1) underwent a self-study that addressed the criteria defined by the accrediting body; and (2) had an on-site visit by peer evaluators. The programs were accredited for the maximum period. There were no Deficiencies[2] identified for any of the programs. There were Weaknesses[3] identified for two programs (Chemical Engineering and Construction Engineering); both were resolved. Concerns[4] were identified for four programs (Aerospace Engineering, Chemical Engineering, Construction Engineering, and Mechanical Engineering); three concerns were resolved. There were Observations[5] identified for five programs (Aerospace Engineering, Chemical Engineering, Construction Engineering, Electrical Engineering, and Mechanical Engineering). This report addresses the Board's Strategic Plan priorities for "access, affordability, and student success; educational excellence and impact; and economic development and vitality."

Background:

- Description of Programs. Engineering is the application of science and mathematics to solve problems for society.
  - ☑ Aerospace Engineering – conduct cutting-edge research in nondestructive evaluation, complex systems, computational and experimental aerodynamics, guidance, navigation and control, aircraft icing, composite structure, and micro/nano mechanics of materials.
  - ☑ Agricultural Engineering – research agricultural water quality and management, engineering for economically and environmentally sound animal production systems, grain handling and food processing, agricultural machine design and automated controls, precision farming systems, agricultural safety, seed conditioning and processing, and soil tillage and management systems.

[2] A Deficiency indicates that a criterion, policy, or procedure is not satisfied. Therefore, the program is not in compliance with the criterion, policy, or procedures.
[3] A Weakness indicates that a program lacks the strength of compliance with a criterion, policy, or procedure to ensure that the quality of the program will not be compromised. Therefore, remedial action is required to strengthen compliance with the criterion, policy, or procedure prior to the next evaluation.
[4] A Concern indicates that a program currently satisfies a criterion, policy, or procedure; however, the potential exists for the situation to change such that the criterion, policy, or procedure may not be satisfied.
[5] An Observation is a comment or suggestion that does not relate directly to the accreditation action but is offered to assist the institution in its continuing efforts to improve its programs.

- ☑ Biological Systems Engineering – involve the sustainable production, storage, and conversion of biobased materials into useful products.
- ☑ Chemical and Biological Engineering – design plant equipment and devise processes for manufacturing chemicals and products; biological engineers analyze biological systems and solve problems in plant, animal or microbial systems.
- ☑ Civil Engineering – include five specialties: environmental engineers, geotechnical engineers, materials engineers, structural engineers, and transportation engineers.
- ☑ Computer Engineering – develop systems to protect critical infrastructures and invent new technologies.
- ☑ Construction Engineering – focus on a certain type of construction project, including building, heavy/highway, mechanical, and electrical.
- ☑ Electrical Engineering – include electric power systems, biomedical imaging equipment used by doctors, tiny chips that operate smartphones and other electronics, wireless technology, and nanotechnologies used by biologists to conduct experiments.
- ☑ Industrial Engineering – design, develop, implement, and improve integrated systems that include people, materials, information, equipment, and energy.
- ☑ Materials Engineering – study the structure and composition of materials on scales ranging from the electronic and atomic through the microscopic to large structures.
- ☑ Materials Engineering – create new materials and improve existing materials.
- ☑ Mechanical Engineering – apply the principles of motion, energy, and force to create mechanical solutions to technological problems.
- ☑ Software Engineering – expand the limits of what computers, cell phones, pacemakers, and other electronic devices can do by developing and improving software that runs the devices.

- ◈ Purpose of Accreditation. An accredited educational program is recognized by its peers as having met national standards for its development and evaluation. To employers, graduate schools, and licensure, certification, and registration boards, graduation from an accredited program signifies adequate preparation for entry into the profession. In fact, many of these groups require graduation from an accredited program as a minimum qualification. Accreditation is also intended to protect the interests of students, benefit the public, and improve the quality of teaching, learning, research, and professional practice.

- ◈ Accrediting Agency. The accrediting body is the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET).

- ◈ Review Process. The self-studies prepared by the Engineering Programs contained the responses to the criteria required by the accrediting body – students; program educational objectives; student outcomes; continuous improvement; curriculum; faculty; facilities; and institutional support; and program specific criteria.

- ◈ On-Site Team Report. In November 2012, the visiting team determined that the Engineering Programs met the requirements for accredited status.

- Sample Institutional Strengths Identified by the Visiting Team.
  - ☑ "The College of Engineering has exceptional laboratory facilities and has made a major investment in improving and maintaining its facilities.
  - ☑ The college and its faculty are dedicated to providing extensive, meaningful, hands-on applications for its students, and have made it a significant part of its brand.
  - ☑ Now only is Iowa State University a major research institution, the faculty are also passionate about providing the highest quality education for its undergraduate students."

- Sample Program Strengths Identified by the Visiting Team.
  - ☑ Aerospace Engineering. "The rich industrial and government experience of program faculty is beneficial to student learning of current professional practice."
  - ☑ Agricultural Engineering. "The program receives extensive support from industry and from the External Advisory Council which met with donors and members of the legislature to secure funding for the new building. This has resulted in teaching laboratories that are stocked with an impressive collection of state-of-the-art equipment and instrumentation, including an array of diesel engines, hydraulic trainers, electronic workstations, HVAC trainers, and CNC machines, as well as ongoing efforts to acquire equipment to furnish the new building with additional laboratory stations. This provides a level of hands-on learning combined with theory that is rare in academic settings. Several external advisory council members attested to the positive effect of these experiences on the students' learning."
  - ☑ Biological Systems Engineering. "The program has a student population is 50% female, demonstrating noteworthy gender equity in an academic engineering program. One of the minority faculty members specifically commented on the atmosphere of inclusiveness in the department. The commitment to diversity goes beyond fairness and demographics and is understood as essential to the creative nature and relevance of the engineering profession. The students are well-served by learning in a diverse environment."
  - ☑ Chemical Engineering. "The department faculty has been very proactive in supplementing funds from the College of Engineering to enhance the educational opportunities of students, particularly focusing on support to improve the quality and quantity of equipment for the undergraduate teaching laboratories."
  - ☑ Civil Engineering. "The faculty members are well qualified and cover the areas of structures, geotechnical, environmental, transportation, materials, and hydrology and hydraulics, with more than one person for each area."
  - ☑ Computer Engineering. "Two courses, computer architecture and embedded systems, are outstanding examples of the hands-on, laboratory-intensive education that characterizes engineering programs at Iowa State University. Students described these courses as challenging, work-intensive, transformative learning experiences, and the amount and quality of what they had learned as 'cool' or 'magical.' These exemplary learning experiences were made possible by the creativity and dedication of the faculty members who developed the projects and the laboratory facilities."

- ☑ Construction Engineering. "Students from the program have been especially successful in pressure-filled, time-constrained, realistic construction engineering and management competitions, such as those conducted by the Associated General Contractors and Associated Schools of Construction, placing first in 14 of the last 16 events, in competition with students from an eight-state region."
- ☑ Electrical Engineering. "The program has excellent laboratory facilities with appropriate funding for maintenance and upgrading. The program has an enthusiastic faculty that cares about the students."
- ☑ Industrial Engineering. "The faculty and staff of the program have developed a nurturing environment through enhanced faculty-student interactions. These include volleyball and dodge ball competitions, and dinners at faculty homes. Two effects of these interactions and the environment they have created are a 34% increase in the number of majors over the past three years and an outstanding retention rate of 90.5%."
- ☑ Materials Engineering. "The professional advisors, senior lecturers, and tenured and tenure-track faculty members work together to address all aspects of student development. The communication is exceptional and is focused on student achievement. This synergy assures that students get the best educational experience possible."
- ☑ Mechanical Engineering. "The program emphasizes experiential education opportunities. The program has enhanced hands-on opportunities in the laboratories. A large majority of its graduates complete a co-op or internship experience (83%) and many of its graduates study abroad (20%). The students are enriched by these opportunities and feel well-prepared for the workplace. The program shares manufacturing laboratories with the industrial engineering program. This synergy has allowed the purchase of four new CNC machines that are integrated with a CAD laboratory. The new CAD/CNC laboratory provides a rich learning experience for the mechanical engineering students."
- ☑ Software Engineering. "The software engineering program benefits from faculty members with great passion for undergraduate education and the software engineering field. This is evidenced by their enthusiasm for the curriculum and students, and by the positive feedback received from the students about the program faculty."

◈ Weaknesses Identified by the Visiting Team. (Institutional responses are in italics.)

- ☑ Chemical Engineering.
  - 🕮 Curriculum. "Criterion 5 requires that the faculty ensure that the program curriculum includes 1½ years of engineering topics, consisting of engineering sciences and engineering design appropriate to the student's field of study. The engineering sciences have their roots in mathematics and basic sciences but carry knowledge further toward creative application. The Self-Study Report identified 48 hours of engineering topics including three hours of professional electives that could be selected form advanced physical or life sciences, engineering, mathematics, statistics, or computer science. The list of courses used to meet this requirement includes courses that could not be appropriately considered engineering topics. Analysis of the transcript samples of recent

graduates indicated that two out of six graduates only had 45 hours of engineering topics. In subsequent discussions with program representatives, other required courses were identified which could possibly be partially counted toward the engineering topic requirement. However, the engineering content of these added courses was insufficient to bring the total to 48 hours of engineering topics. Consequently, the program lacks the strength of compliance with this criterion."

A curriculum change ensures that all graduates will have the required 48 hours of engineering topics. The three-credit hour chemical engineering course, Chemical Process Safety, which was offered as an elective in Fall 2012, is now required for graduation. This change increases the total number of credits required for graduation from 126 to 129.

The weakness was resolved.

☑ Construction Engineering.

🕮 Continuous Improvement. "Criterion 4 requires that a program regularly use appropriate, documented processes for assessing and evaluating the extent to which the student outcomes are being attained. The program has an assessment and evaluation process in place, but primarily uses opinion-based surveys which are subjective indicators of performance that are of limited value in assessing the attainment of student outcomes and identifying opportunities for improving the program. The program analyzes results from the Fundamentals of Engineering examination, but did not explain how it uses those results to evaluate the attainment of individual student outcomes. Various senior design project reports and presentations were used to infer student performance on an entire group of student outcomes collectively. Thus the program is not able to determine the extent to which students are attaining each individual outcome, and consequently may miss opportunities to improve the program. The program lacks strength of compliance with this criterion."

The program has developed and implemented additional tools with rubrics for assessment and evaluation of the extent to which individual student outcomes are attained. These tools include mapping of results on individual sections of the Fundamentals of Engineering examination to attainment of specific outcomes, and separate assessment of the level of attainment of each outcome based on laboratory report and final examination questions in junior- and senior-level courses as well as senior project design.

The weakness was resolved.

◈ Program Concerns Identified by the Visiting Team. (Institutional responses are in italics.)

☑ Aerospace Engineering.

🕮 Continuous Improvement. "This criterion requires that there be an assessment and evaluation process that periodically documents and demonstrates the degree to which the program educational objectives are attained. The aerospace engineering program has a process in place that satisfies this requirement. However, new assessment tools that were approved by the faculty and the Industrial Advisory Committee in spring 2011 have not yet been fully implemented. Should these new processes not prove effective for assessing

and evaluating the extent to which the program educational objectives are being attained, the potential exists for future compliance with this criterion to be jeopardized."

The Engineering Accreditation Commission notes that an approved change to the 2013-2014 Criteria for Accrediting Engineering Programs removes the requirement for assessing and evaluating the extent to which the program educational objectives are attained. Instruction from the ABET Board of Directors concerning implementation of this change renders this shortcoming moot in the future. No further action is expected from the program relative to assessment and evaluation of the extent to which program educational objectives are attained.

The concern was resolved.

☑ Chemical Engineering.

🕮 Program. "This criterion requires that the curriculum provide a thorough grounding the basic sciences including chemistry, physics, and/or biology, with some content at an advanced level, as appropriate to the objectives of the program. The program criteria further require that the curriculum include the engineering application of these basic sciences to the design, analysis, and control of chemical, physical, and/or biological processes, including the hazards associated with these processes. The program has incorporated curricular elements that address the hazards associated with relevant processes such that the program criteria are currently satisfied. The program is planning further modifications, with the goal of enhancing its coverage of hazards. However the impact of these changes is not yet known. The potential therefore exists for the program to fall out of compliance with this criterion in the future."

The curriculum change now ensures uniform and enhanced training in chemical hazards for all students in the program. The three-credit chemical engineering course, Chemical Process Safety, which was offered as an elective in Fall 2012, is now required for graduation. This change increases the total number of credits required for graduation from 126 to 129.

The concern was resolved.

☑ Construction Engineering.

🕮 Program. "This criterion requires the program to prepare graduates to analyze and design construction processes and systems in a construction engineering specialty field, applying knowledge of equipment. The program criteria also require the program to prepare students to explain the importance of professional engineering licensure in the construction industry. The program presented oral evidence that these topics are included in the curriculum; however, they are not documented in the self-study report, course titles, course descriptions, or course syllabi. Since these topics are not explicitly included in the curricular requirements, it is possible that they could be inadvertently omitted in the future, which would jeopardize compliance with the program criteria."

Revised syllabi for three courses demonstrate that all students are not explicitly required to include application of equipment in analysis and design of construction processes and systems. Revised syllabi were received for another three courses, which now explicitly address the preparation of students to explain the importance of licensure in the construction industry.

The concern was resolved.

☑ Mechanical Engineering.

🕮 Faculty. "This criterion requires that the faculty be of sufficient number and must have the competencies to cover all of the curricular areas of the program. The criterion further requires that there be sufficient faculty to accommodate adequate levels of student-faculty interaction, student advising and counseling, university service activities, professional development, and interactions with industrial and professional practitioners, as well as employers of students. During the last general review a concern was raised over the student-to-faculty ration of 33 in the program due to an increase in enrollment to 1,051 undergraduates. Since that time the program has hired additional full-time faculty members, resulting in an increased student-to-faculty ratio of 38. While the faculty size is currently sufficient, further increases in student enrollment without a commensurate growth in the faculty size may result in an insufficient number of faculty members to provide adequate coverage of the program's needs. The potential therefore exists for the program to fall out of compliance with this criterion in the future."

The engineering college allocates resources based on enrollment through structured resource management model, and that a lag in the college's response resulted from the abruptness of the increase in the program's enrollment (>12% from fall 2011 to fall 2012). In light of the growing enrollment in the mechanical engineering program, the interim dean has approved the hire of two additional faculty members in mechanical engineering for fall 2013. Further, the incoming dean has negotiated an additional 10 faculty positions to improve student-to-faculty ratios in the engineering college, of which the mechanical engineering program is expected to receive at least one. However, there was no evidence that any of these new faculty members has yet been hired, or that searches are in progress.

The concerns remains unresolved.

🕮 Facilities. "This criterion requires that the laboratories be adequate to support attainment of the student outcomes and provide an atmosphere conducive to student learning. The program enrollment has undergone considerable growth over the last four years. Laboratory space is currently sufficient to meet the requirements of the program. However, as the mechanical engineering program enrollments continue to increase, the potential exists that there will not be sufficient laboratory space to meet the demands of the program, thereby jeopardizing future compliance with this criterion."

The Dean's office has committed funds to allow the Department of Mechanical Engineering to hire an outside architectural firm to assist in assessing space utilization, space needs, and planning for more efficient use and possible expansion of its existing building to address the acute facility needs of the mechanical engineering program. The college is prepared to provide up to $100,000 to cover the expenses associated with such an investigation, which is expected to lead to increased availability of space for the program. This study is expected to be completed in six months. However, no results from the study are yet available at this stage of the process.

The concern remains unresolved.

◈ Program Observations Identified by the Visiting Team.

☑ Aerospace Engineering.

🕮 "Additional opportunities in the area of astronautical engineering beyond the single required course in astrodynamics could enhance the curriculum and broaden the range of opportunities for graduates."

☑ Chemical Engineering.

🕮 "The program faculty in consultation with the department's Advisory Council has been prioritizing student outcomes, and appears to have concluded that outcomes such as understanding professional and ethical responsibility, understanding the impact of engineering decisions, knowledge of contemporary issues, and engaging in lifelong learning have a lower priority than other outcomes. The program must ensure that it continues to meet Criterion 3 that requires the program to have documented student outcomes that prepare graduates to attain the program educational objectives. The engineering accreditation criteria define student outcomes as outcomes (a) through (k) plus any additional outcomes that may be articulated by the program.

☑ Construction Engineering.

🕮 "The program could be enhanced by coverage of building information modeling, either in a specific course or integrated throughout the curriculum. The program could be enhanced by the development of a dedicated construction engineering laboratory, to give students experience with construction equipment, temporary structures, and building materials, including structural, mechanical, and electrical components and systems."

☑ Electrical Engineering.

🕮 "Some classes require textbooks that are not sued. Given the high cost of books, students could benefit if the need for a textbook in a class were more carefully assessed. The teaching assistants in some classes have difficulty speaking English, resulting in a communications gap with the students. Assistance with language skills would help both the students in the program and their teaching assistants."

☑ Materials Engineering.

🕮 "The curriculum requires three engineering mechanics courses, Statics, Strength of Materials, and Dynamics. These courses use on-line software for receiving and grading class problem assignments. The on-line program provides no feedback or partial credit when students fail to solve problems correctly. The students would benefit from feedback on their incorrect solutions."

⟐ Accreditation Status. In August 2013, the Engineering Accreditation Commission of ABET awarded accreditation to the Engineering Programs, including the two new programs - Biological Systems Engineering and Software Engineering, at ISU for the maximum period through September 2019. No focused reviews or interim reports are required.