AC 2012-3971: THE RAISE THE BAR INITIATIVE: CHARTING THE FUTURE BY UNDERSTANDING THE PATH TO THE PRESENT - ACCREDITATION CRITERIA

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The Raise the Bar Initiative: Charting the Future by Understanding the Path to the Present – Accreditation Criteria

Background

At the 1995 American Society of Civil Engineers (ASCE) Civil Engineering Education Conference (CEEC '95), key leaders from industry and academia identified four primary issue areas requiring the focused attention of the U.S. civil engineering community:

- faculty development,
- integration of the civil engineering curriculum,
- practitioner involvement in education, and
- the professional degree.[1]

The fourth of these issue areas—the professional degree—reflected a growing consensus that the traditional four-year baccalaureate degree was becoming increasingly inadequate as formal academic preparation for the professional practice of civil engineering. In October 1998, the call for action issued at the CEEC '95 resulted in the passage of ASCE Policy Statement 465—Academic Prerequisites for Licensure and Professional Practice. The initial version of this policy stated that the Society "supports the concept of the master's degree as the First Professional Degree for the practice of civil engineering at the professional level."[2]

In 2002, an ASCE Board-level committee, the Committee on Academic Prerequisites for Professional Practice (CAP[3]), was formed to guide the implementation of Policy Statement 465—dubbed the "Raise the Bar" initiative. In the succeeding decade, the initiative has made substantial progress in five distinctly different but interrelated domains—establishing a formalized civil engineering body of knowledge, developing revised accreditation criteria, fostering curriculum reform, formulating experiential guidelines, and modifying licensure laws and rules.[3]

Today, the Raise the Bar initiative is in transition. Several key leaders of CAP[3] are moving to new roles, even as ASCE is working to integrate Policy Statement 465 implementation into the Society's broader strategic planning process. At this important juncture, there is a critical need to document the achievements of the past, discern key lessons learned, and chart an appropriate course for the future.

Purpose

The purposes of this paper are (1) to summarize the decade-long process of developing and implementing new accreditation criteria in support of the ASCE Raise the Bar initiative; (2) to identify the principal lessons learned through this process; and (3) to provide recommendations for future developments in the accreditation domain of this ongoing effort to raise the educational standard for civil engineering professional practice.

The Civil Engineering Body of Knowledge

Soon after its establishment in 2002, CAP[3] determined that the initial focus of Policy Statement 465 on the master's degree was misplaced. Considering the general characteristics of an ideal profession, the committee came to recognize that the specification of academic degree requirements should follow from a more fundamental analysis of the profession's body of knowledge (BOK). Consistent with this insight, CAP[3] initiated a broad-based effort to formally define the Civil Engineering BOK. In January 2004 this endeavor achieved a major milestone with ASCE's publication of *Civil Engineering Body of Knowledge for the 21st Century*—a report describing the knowledge, skills, and attitudes necessary for entry into the practice of civil engineering at the professional level.[4] This report introduced a conceptual framework that has proved to be enormously valuable in guiding the subsequent implementation of Policy Statement 465. The conceptual framework includes three key characteristics:

- The Civil Engineering BOK is defined in terms of *outcomes*.
- The outcomes have clearly defined *levels of achievement.*
- Expected levels of achievement are separately specified for baccalaureate-level education, master's-level education, and pre-licensure experience.

This first edition of the Civil Engineering BOK (commonly abbreviated BOK1) defined 15 outcomes, the first eleven of which nominally corresponded to Criterion 3(a)-(k) of the ABET Criteria for Accrediting Engineering Programs.[5] The inclusion of four BOK outcomes *beyond* the eleven of ABET Criterion 3 suggested that the BOK could not be adequately addressed in the traditional four-year baccalaureate degree program—a conclusion subsequently affirmed by a comprehensive curriculum analysis.[6]

In October 2004, the ASCE Board reinforced the importance of the BOK by modifying the wording of Policy Statement 465 as follows:

> The American Society of Civil Engineers supports the attainment of a Body of Knowledge for entry into the practice of civil engineering at the professional level. This would be accomplished through the adoption of appropriate engineering education and experience requirements as a prerequisite for licensure.[7]

Translating the BOK to Accreditation Criteria

With the Civil Engineering BOK formally defined and endorsed in ASCE policy, a broad-based effort to develop and implement new BOK1-compliant ABET accreditation criteria began immediately. The CAP[3] Accreditation Committee was established and charged with leading this effort in January 2004.

Implicit in the committee's work was an underlying assumption that the ABET accreditation process is an appropriate mechanism for fostering a transition toward BOK1-compliant curricula in ABET-accredited civil engineering programs. This assumption is well founded. "Engineering Change," a study conducted by the Penn State Center for the Study of Higher Education, clearly demonstrates that accreditation criteria can provide a powerful stimulus for curricular reform.[8] And once curricular reform is underway, the accreditation process provides an effective quality

control mechanism to ensure that changes are being implemented in accordance with desired ends.

Given this linkage between accreditation and curricular reform, CAP[3] has proposed that civil engineers should be able to fulfill the Civil Engineering BOK by following either of two alternative paths—each of which includes at least one ABET-accredited degree. The two paths are as follows:

- **$B^{ABET} + (M/30)^{Validated}$ & E** – This is currently considered to be the primary path for BOK fulfillment. "B^{ABET}" refers to a civil engineering baccalaureate degree accredited by the Engineering Accreditation Commission (EAC) of ABET. "M/30" refers to a master's degree or approximately 30 semester credits of acceptable graduate-level or upper-level undergraduate courses in a technical or professional practice area related to civil engineering. "E" refers to engineering experience. For this path, the accreditation process provides validation of the baccalaureate component of the BOK. Validation of the "M/30" program will be provided by an approved outside entity, which might also be ABET.

- **$B + M^{ABET}$ & E** – This alternate path is being considered by ASCE to allow for greater flexibility in BOK fulfillment. For this path, the baccalaureate degree need not be an ABET EAC-accredited civil engineering degree. Rather, validation of the baccalaureate and master's-level components of the BOK is accomplished through ABET EAC-accreditation of the civil engineering master's degree.

A detailed discussion of this "two-path model" is beyond the scope of this paper. However, in the specific context of accreditation criteria development, three key characteristics of the model must be emphasized:

- ABET accreditation is essential to the validation of BOK fulfillment on *both paths*.
- The two-path model is only feasible if ABET EAC accreditation is possible at *both* the baccalaureate level and the master's level.
- Master's-level accreditation must validate the attainment of baccalaureate-level BOK outcomes as well as masters-level BOK outcomes.

Although the ABET criteria have been shown to constitute a viable instrument for facilitating BOK fulfillment, it is *not* true that these criteria are fully adaptable to this purpose. The ABET EAC criteria consist of three different components, each with its own unique limitations as an instrument for BOK fulfillment:

- The ***General Criteria for Baccalaureate Level Programs (GCBLP)*** are applicable to *all* ABET EAC-accredited programs in *all* engineering disciplines. Changing these criteria would require the support of ABET and its 29 member societies. The ABET Engineering Accreditation Commission (EAC) is currently considering the establishment of a process for reviewing and updating the GCBLP;[9] however, that process is unlikely to be implemented in the short term, and ASCE's influence over it will necessarily be somewhat limited.

- The ***General Criteria for Masters Level Programs (GCMLP)*** are also applicable to all engineering disciplines; however, because very few programs are currently accredited at the master's level, it has been possible for ASCE to influence changes to these criteria. In general, however, such changes must still be applicable and acceptable to all engineering disciplines. Discipline-specific additions to the GCMLP would not be permissible.

- The ***Program Criteria*** are applicable only to specific engineering disciplines and are established and maintained by the associated ABET member societies. The ***Civil Engineering Program Criteria (CEPC)*** are applicable to "civil and similarly named engineering programs." As Lead Society for the civil engineering curricular area, ASCE has responsibility for developing and maintaining the CEPC. Because ASCE has considerable authority to change these criteria, the CEPC must necessarily be the principal accreditation-related mechanism for BOK implementation. Nonetheless, ASCE is not able to exercise complete control over these criteria. All engineering program criteria are subject to approval by the EAC and the ABET Board of Directors; and in order to gain approval, proposed criteria can address only curricular content and faculty qualifications, and they must not be overly prescriptive. In an era when new engineering disciplines are constantly emerging and existing disciplinary boundaries are blurring, program criteria are viewed as anachronistic in some ABET circles. In this environment, ASCE's ability to use the CEPC as its principal instrument for implementing curricular reform is significantly constrained.

Another major challenge in the use of ABET criteria as a mechanism for BOK implementation lies in a fundamental difference between the nature of the BOK and the nature of accreditation criteria. Although it was not intended as such, the BOK has many characteristics of a strategic vision. It represents, by its very nature, an ambitious, comprehensive, future-oriented goal—one to which all civil engineering programs should aspire, but one that few programs will ever achieve in all of its aspects. Conversely, accreditation criteria represent only a *minimum standard* of educational attainment. They are grounded firmly in the present; they tend to be narrow in scope; and they must be *reasonably attainable by all programs*.

The CAP^3 Accreditation Committee addressed this challenge by adopting the following approach to the formulation of BOK-compliant criteria:

- The criteria should not conflict with the BOK outcomes.
- Each BOK outcome should map to at least one readily identifiable criterion (or portion of a criterion).
- Each of these criteria should communicate an appropriate *direction* toward attainment of the associated BOK outcome. Taken as a whole, however, the criteria should stop short of prescribing full BOK attainment, because doing so would be overly prescriptive.

This approach is illustrated graphically in Figure 1 below. As indicated in this graphic, the accreditation criteria represent only a small subset of the BOK; yet there is a clear one-to-one mapping from BOK outcomes to criteria provisions.

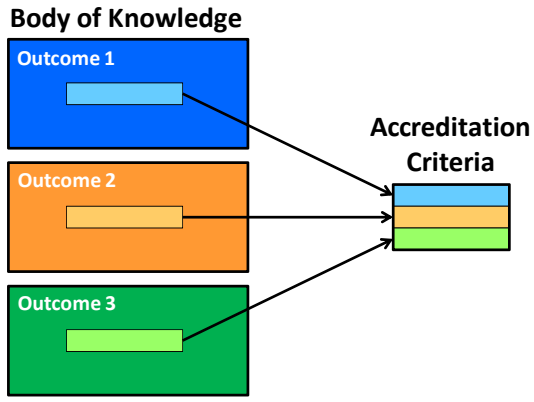

Figure 1. Approach for translating BOK outcomes to accreditation criteria provisions.

This approach evolved during a collaborative two-year process of study, deliberation, and critical review, and culminated in the submission of proposed new BOK1-compliant accreditation criteria (both GCMLP and CEPC) to the ABET EAC in June 2006. These criteria, provided in Appendix A, achieved final approval by the ABET Board of Directors in October 2007 and were implemented for accreditation visits starting in the fall of 2008. Given the six-year ABET accreditation cycle, all U.S. civil engineering programs will have been evaluated under these BOK1-compliant criteria by Academic Year 2013-14.

In conjunction with developing these new criteria, the CAP^3 Accreditation Committee recognized the need to provide supplemental written guidance for civil engineering department heads and ABET Program Evaluators. This guidance was intended to serve two specific purposes:

- Provide a scholarly *rationale* for each provision of the new criteria vis-à-vis the Civil Engineering BOK, by articulating the mapping from BOK outcomes to criteria provisions.
- Provide specific operational guidelines on criteria compliance.

The CAP^3 Accreditation Committee fulfilled both of these purposes through the publication of an extensive ASCE Commentary.[10]

Appendix B shows the mapping between BOK outcomes and specific provisions of the BOK1-compliant accreditation criteria, in tabular format. In successive columns, this table lists the fifteen BOK1 outcomes, the specific requirements articulated for each outcome in *Civil Engineering Body of Knowledge for the 21st Century*, and the associated provisions of the ABET GCBLP, GCMLP, and CEPC. In general terms, the mapping is as follows:

- Outcomes 1 through 11 map directly to Criterion 3(a)-(k) of the GCBLP.
- Additional requirements associated with Outcomes 1, 2, 3, and 6 correspond to supplemental provisions in the CEPC.
- Outcome 12 (advanced-level specialization) maps to the GCMLP.
- Outcomes 13 through 15 (the professional practice outcomes) map to the CEPC.

Appendix B also illustrates the approach used by the CAP[3] Accreditation Committee to formulate BOK1-compliant accreditation criteria, as discussed above. An outcome-by-outcome comparison clearly demonstrates that the BOK outcomes represent a significantly more ambitious and comprehensive standard than do the ABET criteria. For example, consider BOK Outcome 1, which includes explicit requirements for "biology, chemistry, ecology, geology/geomorphology, engineering economics, mechanics, material properties, systems, geo-spatial representation, and information technology." The corresponding provision of the CEPC requires only "one additional area of basic science, consistent with the program educational objectives."

The sharp difference between the BOK outcomes and the criteria is entirely appropriate, as it reflects the distinctly different natures of these two documents. If the criteria were written at the same level of detail as the BOK, they would be overly prescriptive and perhaps unattainable. If the BOK were formulated as a minimum standard, it would fail to serve as an aspirational goal. The difference suggests, however, that the translation of BOK outcomes to accreditation criteria will always be an inherently challenging process.

Removing the Prohibition on Dual-Level Accreditation

In 2004, as the development of BOK1-compliant accreditation criteria was just getting underway, the CAP[3] Accreditation Committee encountered another significant constraint in the ABET accreditation system—the prohibition on dual-level accreditation. This long-standing ABET policy specified that engineering programs at a given institution could seek EAC accreditation at *either* the baccalaureate level *or* the master's level, *but not both*. From ASCE's perspective, the prohibition on dual-level accreditation was problematic, because it effectively eliminated the alternate path to BOK fulfillment, $\mathbf{B + M^{ABET} \& E}$, as described above.

In early 2005, CAP[3] responded to this challenge by formally requesting, in writing, that ABET modify its *Policies and Procedures Manual* to eliminate the prohibition. ABET referred ASCE's request to the Engineering Deans Council for comment; and in June 2005, the deans responded by passing a resolution opposing any change to the policy.[11] Their principal points of opposition were as follows:

- Many states mandate accreditation of all programs for which accreditation is available; thus, if the prohibition were lifted, master-level accreditation would become mandatory.
- If the prohibition were lifted, market forces would dictate that both baccalaureate and master's programs be accredited.
- Discipline-specific accreditation at the master's level would discourage and put undesirable restrictions on interdisciplinary breadth.
- Masters-level accreditation would restrict opportunities for admission of international graduate students and students with non-engineering undergraduate degrees.

In turn, ASCE responded with a communications campaign aimed at articulating the benefits of removing the prohibition, while addressing the deans' key points of opposition. For example, after an extensive search, ASCE was unable to identify any states that mandate accreditation of all programs for which accreditation is available. And ASCE was able to demonstrate that

international students and students with non-engineering undergraduate degrees would actually *benefit* from dual-level accreditation, because broader availability of accredited master's degree programs would greatly simplify their path to professional licensure in the U.S.

In response to the deans' opposition, CAP[3] members prepared white papers and wrote articles in ASEE *Prism* magazine, *PE* magazine (National Society of Professional Engineers), and the *Proceedings of the 2006 ASEE Annual Conference*.[12, 13,14] This campaign also gained considerable credibility from the National Academy of Engineering (NAE) *Educating the Engineer of 2020* report, which explicitly recommended removal of the prohibition on dual-level accreditation.[15] Ultimately, after an intensive ASCE lobbying effort, the ABET Board of Directors voted to remove the prohibition in March 2008, and the *ABET Policies and Procedures Manual* was amended accordingly. As a result of this policy change and the implementation of new master's-level accreditation criteria (GCMLP), effective in the fall of 2008, the alternate path (**B + M^{ABET} & E)** has become a viable route to BOK attainment—though not yet to professional licensure.

The Evolving BOK

While the formulation of new BOK1-compliant accreditation criteria was still in progress, it became apparent that significant updates to BOK1 itself would be required. These revisions were driven by:

- aspects of the 1st Edition that did not lend themselves to effective measurement and assessment;

- publication of several strategic vision documents that called for future engineers to develop certain knowledge, skills, and attitudes that had *not* been included in BOK1;[16,17] and

- continuing changes in the global civil engineering professional environment (e.g., a dramatic increase in the importance of sustainability and green technologies).

As a result, a second edition of the Civil Engineering BOK was initiated in October 2005 and published in February 2008. The *Civil Engineering Body of Knowledge for the 21st Century, Second Edition,* (abbreviated BOK2) incorporates two particularly substantive changes from the first edition:[18]

- The number of outcomes was increased from 15 to 24. To some extent, this increase reflects the BOK2 authors' attempt to enhance clarity and specificity, rather than to increase the scope of the BOK. Nonetheless, the BOK2 Outcomes do place increased emphasis on such topics as the natural sciences, the humanities, sustainability, globalization, risk and uncertainty, and public policy.

- The BOK2 uses Bloom's Taxonomy as the basis for defining levels of achievement.[19] The fundamental premise of Bloom's Taxonomy is that an educational objective can be referenced to a specific level of cognitive development through the verb used in the

objective statement. Table 1 shows Bloom's six levels of cognitive development, accompanied by illustrative examples of verbs associated with each level. The use of measurable, action-oriented verbs linked to levels of achievement is beneficial, in that the resulting outcome statements can be assessed more effectively and consistently.

Level		Illustrative Verbs
1	Knowledge	define, identify, label, list,
2	Comprehension	classify, describe, explain, generalize, paraphrase
3	Application	apply, calculate, compute, demonstrate, solve
4	Analysis	analyze, differentiate, formulate, organize, prioritize
5	Synthesis	create, design, develop, devise, integrate, plan
6	Evaluation	critique, evaluate, judge, justify

Table 1. Six levels of cognitive development and illustrative verbs, as defined in Bloom's Taxonomy

A complete list of the 24 BOK2 Outcomes is provided in Appendix C, along with the expected level of achievement for each one. Note that the outcomes are organized into three broad categories—foundational, technical, and professional. Note also that separate levels of achievement are defined for the bachelor's degree, for the master's degree (or equivalent), and for pre-licensure experience. Following the framework established by the BOK1, this structure emphasizes that both education and experience are essential for full attainment of the Civil Engineering BOK. A formal comparison of these outcomes with the BOK1-compliant accreditation criteria strongly suggests that the criteria will need to be further modified to foster BOK2 implementation.[20]

Although CAP[3] has not yet initiated the development of BOK2-compliant accreditation criteria, it has formed two committees to study and formulate guidelines for the fulfillment of the Civil Engineering BOK:

- The BOK Educational Fulfillment Committee was formed in 2007. Composed of representatives of ten widely varying institutions, this committee investigated the incorporation of the 24 BOK2 outcomes into civil engineering curricula.

- The BOK Experiential Fulfillment Committee was formed in early 2009 to address those BOK2 outcomes requiring pre-licensure experience. The committee was charged with developing early-career experience guidelines for engineer interns, supervisors, and mentors.

In the course of their work, both of these committees identified a need for further refinement of BOK2. For example, the Experiential Fulfillment Committee suggested additional emphasis on quality management and public safety.[21]

Taken as a whole, ASCE's experience with the development and refinement of the Civil Engineering BOK has been one of near-constant change. Immediately upon publication of the BOK1 report, it was evident that a second edition would be required. The process of implementing the BOK2 identified the need for further modifications.

Many of the short-term changes in the BOK can be attributed to the specific circumstances associated with the implementation of ASCE Policy Statement 465. No professional society had previously attempted to articulate its BOK; thus, some trial and error was perhaps inevitable. Design is inherently iterative; and, in this case, the iterations have been performed by a succession of committees, each with somewhat different perspectives.

Nonetheless, there is good reason to expect that the BOK will continue to evolve over the long term. The sociological Theory of Professions supports the notion that continuous change is an inherent characteristic of any professional BOK. In Abbott's model of the *system of professions*, the BOK is the principal means by which a profession establishes jurisdictional claims with respect to other occupational groups.[22] Because the professional environment and the relationships between professions are dynamic entities, jurisdictional claims and the associated professional bodies of knowledge are constantly in flux. As Abbott demonstrates, a strong profession must be able to adapt its BOK in response to emerging needs, opportunities, and threats.

Thus we can expect that the Civil Engineering BOK will continue to evolve over time, as a result of such influences as:

- new engineering challenges (e.g., climate change, emphasis on sustainability, energy shortages, terrorism, increase in the frequency and severity of natural disasters);
- new technologies (e.g., building information management, high-performance materials, smart buildings and sensing technologies);
- changes in the international business environment (e.g., limited financial capital, low-cost engineering services delivered via the internet, increased market consolidation);
- changes in law and the regulatory environment (e.g., licensure laws, environmental regulation);
- changes in relationships between and within engineering disciplines (e.g., evolving role of paraprofessionals); and
- engineering failures (e.g., Hurricane Katrina, Gulf oil spill, I-35 bridge collapse).

Planning for Long-Term Management of BOK and Criteria Changes

Table 2 summarizes the sequence of events associated with the development of BOK1, BOK2, and BOK1-compliant accreditation criteria. Events associated with BOK1 and BOK2 are listed in separate columns.

Note that, with the establishment of the CAP^3 Accreditation Committee in January 2004, the initiation of BOK1-compliant criteria development effectively coincided with the publication of the BOK1 report. However, in the four years since the publication of the BOK2 report, CAP^3 has chosen *not* to initiate the development of new BOK2-compliant accreditation criteria. Why not?

As the timeline suggests, the publication of the BOK2 did not fully account for the inevitable time lag associated with accreditation criteria implementation. The BOK2's publication seven months *ahead of* the first accreditation visits under BOK1-compliant criteria caused both

confusion and concern among civil engineering department heads. Some programs moved aggressively to implement the BOK2 outcomes in their curricula but worried that they would still be evaluated under BOK1-compliant criteria. For others, the prospect that BOK2-compliant criteria changes might be initiated before all programs had been evaluated under the BOK1-compliant criteria caused considerable (if unfounded) angst. In either case, it can be argued that BOK2 was published too soon, at least from the perspective of criteria implementation.

DATE	EVENT	
	BOK, 1st Edition	**BOK, 2nd Edition**
June 2002	BOK1 Committee of CAP[3] organized	
November 2003	BOK1 finalized	
January 2004	Accreditation Committee of CAP[3] organized	
February 2004	BOK1 published	
October 2005		BOK2 Committee of CAP[3] organized
February 2006	Draft BOK1-compliant CE Program Criteria published	
July 2006	BOK1-compliant CE Program Criteria approved by ABET EAC (1st reading)	
October 2006	BOK1-compliant CE Program Criteria approved by ABET Board of Directors (1st reading)	
November 2006	Public review of CE Program Criteria initiated	
July 2007	BOK1-compliant CE Program Criteria approved by ABET EAC (2nd reading)	
October 2007	BOK1-compliant CE Program Criteria approved by ABET Board of Directors (2nd reading)	
November 2007		BOK2 finalized
February 2008		BOK2 published
September 2008	First accreditation visits under BOK1-compliant CE Program Criteria	
December 2013	Completion of six accreditation cycles under BOK1-compliant CE Program Criteria	

Table 2. Sequence of Events in the development of the Civil Engineering BOK and associated accreditation criteria

By 2011, the need for long-term synchronization of the published BOK and its associated accreditation criteria had become quite clear. That year, CAP[3] formed a special task committee to develop a strategic plan for long-term management of change. The principal objectives of this project were:

- to institutionalize the systematic review and updating of the Civil Engineering BOK;

- to keep the ABET Civil Engineering Program Criteria appropriately synchronized with the BOK; and
- to enhance BOK implementation by providing more *predictability* in the change process.

To achieve these objectives, the task committee developed, and CAP[3] approved, the long-term schedule shown in Table 3 below. The key characteristic of this schedule is a ***fixed eight-year cycle*** for both BOK updates and accreditation criteria updates. This schedule was developed by adding eight years to the implementation of BOK1-compliant accreditation criteria (September 2008), to obtain the target date for implementation of BOK2-compliant criteria (September 2016). All remaining milestones were derived from this date, using experience-based time intervals and due dates derived from Table 2.

The eight-year time interval was chosen because it can comfortably accommodate both:

- the six- to seven-year period of time required to formulate and publish a new edition of the Civil Engineering BOK and to formulate, publish, gain approval of, and implement new ABET program criteria; and

- the six-year period required for all U.S. engineering programs to be evaluated under a new set of accreditation criteria.

Event	BOK 2nd Edition	BOK 3rd Edition	BOK 4th Edition
BOK Committee of CAP[3] organized	Already accomplished	October 2016	October 2024
BOK finalized		September 2018	September 2026
BOK published		March 2019	March 2027
Accreditation Committee of CAP[3] organized	October 2012	October 2020	October 2028
Draft CE Program Criteria published	March 2014	March 2022	March 2030
CE Program Criteria approved by ABET EAC (1st reading)	July 2014	July 2022	July 2030
CE Program Criteria approved by ABET Board of Directors (1st reading)	October 2014	October 2022	October 2030
Public Review of CE Program Criteria initiated	November 2014	November 2022	November 2030
CE Program Criteria approved by ABET EAC (2nd reading)	July 2015	July 2023	July 2031
CE Program Criteria approved by ABET Board of Directors (2nd reading)	October 2015	October 2023	October 2031
First Reviews Under New CE Program Criteria	September 2016	September 2024	September 2032

Table 3. Long-term schedule for BOK and accreditation criteria development

The principal purpose of the fixed schedule is to enhance *predictability* for civil engineering programs. With the implementation of criteria changes restricted to specified years (e.g., 2016, 2024, 2032), programs will be able to schedule routine reviews and updates of their Program Educational Objectives and Student Outcomes during these same years. Curriculum modifications and subsequent assessment of the revised objectives and outcomes can then be accomplished with a reasonable assurance of "closing the loop" before any new criteria changes occur. Thus, enhanced predictability will facilitate more effective change management.

Lessons Learned

The development of BOK-compliant accreditation criteria began with the establishment of the CAP^3 Accreditation Committee in January 2004 and continues today. During this period, the leaders of ASCE's Raise the Bar initiative have learned the following invaluable lessons about this process:

- Effective translation of BOK outcomes to accreditation criteria requires a careful balance between establishing a clear direction for curricular reform, on one hand, and avoiding excessive prescriptiveness on the other. There should be a clear mapping from BOK outcomes to criteria provisions; however, the criteria cannot possibly specify every aspect of BOK fulfillment without exceeding their purpose of establishing minimum standards.

- In conjunction with developing new criteria, there is a clear need to provide supplemental written guidance for both educators and ABET Program Evaluators. This guidance must serve two different purposes: (1) provide a rationale for each provision of the new criteria and (2) provide specific guidelines on criteria compliance. The CAP^3 Accreditation Committee chose to create a single document (the ASCE Commentary) to achieve both purposes. In retrospect, it would have been more effective to achieve these two purposes with two separate documents. The written rationale serves primarily as scholarly underpinning for the criteria and documentation of the criteria development process; once written, it becomes part of the literature and should not be changed. On the other hand, the compliance guidelines are used operationally by Program Evaluators and department heads to facilitate accreditation visits; thus, these guidelines must be kept as simple as possible and must be updated frequently, as new issues arise. These distinct differences in usage and permanence suggest that the rationale and guidelines should be promulgated in separate documents.

- The civil engineering community must recognize the dynamic nature of its professional BOK and plan for change. Periodic updates to both the Civil Engineering BOK and the associated accreditation criteria will continue to be needed. The key to developing and implementing these updates with minimum disruption is to manage change according to a predictable long-term cycle that exceeds the six-year ABET accreditation cycle.

- Persistence pays. Despite strong opposition, ASCE effected the removal of ABET's prohibition on dual-level accreditation by remaining focused on the issue for *four years*—building a scholarly rationale for change, communicating with key constituencies,

cultivating allies, and ultimately achieving a critical mass of support on the ABET Board of Directors. Persistence will continue to serve ASCE well in overcoming opposition to other aspects of the Raise the Bar initiative.

- Changes to accreditation criteria require intensive communication and coordination with all relevant constituencies—but most importantly with civil engineering department heads. And this communication must continue long after the new criteria are implemented, because of the high rate of turnover among department heads and other educational leaders.

Recommendations for the Future

Over the past decade, ASCE's Raise the Bar initiative has achieved many successes, but has also experienced a number of failures, false starts, and less-than-optimal paths to desired goals. Nonetheless, successes and failures alike have contributed to advancing the initiative—enhancing our understanding of a very complex professional environment, while informing our subsequent efforts to move forward. As new Raise the Bar leaders take charge, they should take advantage of these lessons to the greatest extent possible.

Based on the historical analysis presented in this paper, the author provides the following recommendations for the future of the Raise the Bar initiative:

- Implement future updates of the Civil Engineering BOK and associated accreditation criteria according to a long-term schedule based on a predictable eight-year cycle.

- For all future accreditation criteria updates, use the approach depicted in Figure 1 for translating BOK outcomes into criteria provisions.

- Continue to use Bloom's Taxonomy as the basis for defining desired levels of achievement in both BOK outcomes and accreditation criteria.

- In conjunction with the development of new accreditation criteria, create two separate supplemental guidance documents—one providing a scholarly rationale for each provision of the new criteria and one providing specific operational guidelines for criteria compliance.

- Develop a plan for the implementation of **B + M^{ABET} & E** as an alternate path to BOK fulfillment and licensure.

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Appendix A. BOK1-Compliant Civil Engineering Program Criteria and General Criteria for Master's Level Programs, as submitted to the EAC of ABET

PROGRAM CRITERIA FOR
CIVIL
AND SIMILARLY NAMED ENGINEERING PROGRAMS
Lead Society: American Society of Civil Engineers

These program criteria apply to engineering programs including "civil" and similar modifiers in their titles.

1. Curriculum

The program must demonstrate that graduates can: apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of science, consistent with the program educational objectives; apply knowledge of four technical areas appropriate to civil engineering; conduct civil engineering experiments and analyze and interpret the resulting data; design a system, component, or process in more than one civil engineering context; explain basic concepts in management, business, public policy, and leadership; and explain the importance of professional licensure.

2. Faculty

The program must demonstrate that faculty teaching courses that are primarily design in content are qualified to teach the subject matter by virtue of professional licensure, or by education and design experience. The program must demonstrate that it is not critically dependent on one individual.

II. GENERAL CRITERIA FOR MASTERS LEVEL PROGRAMS

Masters level programs must develop, publish, and periodically review, educational objectives and program outcomes. The criteria for masters level programs are fulfillment of the baccalaureate level general criteria, fulfillment of program criteria appropriate to the masters level specialization area, and one academic year of study beyond the baccalaureate level. The program must demonstrate that graduates have an ability to apply masters level knowledge in a specialized area of engineering related to the program area.

Appendix B

Comparison of BOK1 Requirements and ABET Criteria

Civil Engineering Body of Knowledge		ABET Engineering Criteria		
Outcome Statement	**Specific Provisions or Requirements**	**General Criteria for Baccalaureate Level Programs**	**General Criteria for Master's Level Programs**	**CE Program Criteria**
1. An ability to apply knowledge of mathematics, science, and engineering	Breadth of coverage in mathematics, science and civil engineering topics	3(a) An ability to apply knowledge of mathematics, science, and engineering		Apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of basic science, consistent with the program educational objectives; apply knowledge of four technical areas appropriate to civil engineering.
	Mathematics through differential equations, probability and statistics, calculus-based physics, biology, chemistry, ecology, geology, geomorphology, engineering economics, mechanics, material properties, systems, geo-spatial representation, and information technology			
	Understand fundamentals of several recognized major civil engineering areas			
2. An ability to design and conduct experiments, as well as to analyze and interpret data	Design and conduct field and laboratory studies, gather data, create numerical and other models, and then analyze and interpret the results—in at least one of the evolving or current major civil engineering areas	3(b) An ability to design and conduct experiments, as well as to analyze and interpret data		Conduct civil engineering experiments and analyze and interpret the resulting data
3. An ability to design a system, component, or process to meet desired needs	Problem definition, scope, analysis, risk assessment, environmental impact statements, creativity, synthesizing alternatives, iteration, regulations, codes, safety, security, constructability, sustainability, and multiple objectives and various perspectives	3(c) An ability to design a system, component, or process to meet desired needs		Design a system, component, or process in more than one civil engineering context
	Bidding versus qualifications-based selection; estimating engineering costs; interaction between planning, design and construction; design review; owner-engineer relationships; and life-cycle assessment			
	Understanding large-scale systems, including the need to integrate information, organizations, people, processes, and technology			
	Design experiences integrated throughout the professional component of the curriculum			
4. An ability to function on multi-disciplinary teams	Lead a design team or other team	3(d) An ability to function on multi-disciplinary teams		
	Participate as a member of a team			
	Team formation and evolution, personality profiles, team dynamics, collaboration among diverse disciplines, problem solving, time management, and being able to foster and integrate diversity of perspectives, knowledge, and experiences			

Civil Engineering Body of Knowledge		ABET Engineering Criteria		
Outcome Statement	**Specific Provisions or Requirements**	**General Criteria for Baccalaureate Level Programs**	**General Criteria for Master's Level Programs**	**CE Program Criteria**
5. An ability to identify, formulate and solve engineering problems	Assessing situations in order to identify engineering problems, formulate alternatives, and recommend feasible solutions	3(e) An ability to identify, formulate and solve engineering problems		
6. An understanding of professional and ethical responsibility	Hold paramount public safety, health, and welfare	3(f) An understanding of professional and ethical responsibility		Explain the importance of professional licensure
	Thoughtful and careful weighing of alternatives when values conflict			
	understanding of and commitment to practice according to the seven Fundamental Canons of Ethics and the associated Guidelines to Practice Under the Fundamental Canons of Ethics			
7. An ability to communicate effectively	Listening, observing, reading, speaking, and writing	3(g) An ability to communicate effectively		
	Fundamentals of interacting effectively with technical and non-technical or lay individuals and audiences in a variety of settings			
	Versatility with mathematics, graphics, the worldwide web and other communication tools			
8. The broad education necessary to understand the impact of engineering solutions in a global and societal context	Appreciate, from historical and contemporary perspectives, culture, human and organizational behavior, aesthetics and ecology and their impacts on society	3(h) the broad education necessary to understand the impact of engineering solutions in a global, and societal context		
	History and heritage of the civil engineering profession			
9. A recognition of the need for, and an ability to engage in, life-long learning	Life-long learning mechanisms—additional formal education, continuing education, professional practice experience, active involvement in professional societies, community service, coaching, mentoring, and other learning and growth activities	3(i) A recognition of the need for, and an ability to engage in, life-long learning		
	Personal and professional development—developing understanding of and competence in goal setting, personal time management, communication, delegation, personality types, networking, leadership, the socio-political process, effecting change, career management, increasing discipline knowledge, understanding business fundamentals, contributing to the profession, self-employment, additional graduate studies, and achieving licensure and specialty certification			

Civil Engineering Body of Knowledge		ABET Engineering Criteria		
Outcome Statement	**Specific Provisions or Requirements**	**General Criteria for Baccalaureate Level Programs**	**General Criteria for Master's Level Programs**	**CE Program Criteria**
10. A knowledge of contemporary issues	relationship of engineering to critical contemporary issues such as multicultural globalization of engineering practice; raising the quality of life around the globe; the growing diversity of society; and the technical, environmental, societal, political, legal, aesthetic, economic, and financial implications of engineering projects	3(j) A knowledge of contemporary issues		
11. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	Role and use of appropriate information technology, contemporary analysis and design methods, and applicable design codes and standards as practical problem-solving tools to complement knowledge of fundamental concepts Ability to select the appropriate tools for solving different types and levels of problems	3(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice		
12. An ability to apply knowledge in a specialized area related to civil engineering	Specialized technical coursework (or equivalent) in such areas as environmental engineering, structural engineering, construction engineering and management, public works management, transportation engineering and water resources management		One academic year of study beyond the basic level Ability to apply advanced level knowledge in a specialized area of engineering	
13. An understanding of the elements of project management, construction, and asset management	Project management—project manager responsibilities, defining and meeting client requirements, risk assessment and management, stakeholder identification and involvement, contract negotiation, project work plans, scope and deliverables, budget and schedule preparation and monitoring, interaction among engineering and other disciplines, quality assurance and quality control, and dispute resolution processes. Construction—owner-engineer-contractor relationships; project delivery systems (e.g., design-bid-build, design-build); estimating construction costs; bidding by contractors; labor and labor management issues; and construction processes, methods, systems, equipment, planning, scheduling, safety, cost analysis and cost control. Asset management—effective and efficient long-term ownership of capital facilities via systematic acquisition, operation, maintenance, preservation, replacement, and disposition.			Explain basic concepts in management

Civil Engineering Body of Knowledge		ABET Engineering Criteria		
Outcome Statement	**Specific Provisions or Requirements**	**General Criteria for Baccalaureate Level Programs**	**General Criteria for Master's Level Programs**	**CE Program Criteria**
14. An understanding of business and public policy and administration fundamentals	Business—legal forms of ownership, organizational structure and design, income statements, balance sheets, decision (engineering) economics, finance, marketing and sales, billable time, overhead, and profit			Explain basic concepts in business and public policy
	Public policy and administration—political process, public policy, laws and regulations, funding mechanisms, public education and involvement, government-business interaction, and public service responsibility of professionals			
15. An understanding of the role of the leader and leadership principles and attitudes.	Leading—broad motivation, direction, and communication knowledge and skills			Explain basic concepts in leadership
	Attitudes—commitment, confidence, curiosity, entrepreneurship, high expectations, honesty, integrity, judgment, persistence, positiveness, and sensitivity			
	Behaviors—earning trust, trusting others, formulating and articulating vision, communication, rational thinking, openness, consistency, commitment to organizational values, and discretion with sensitive information			

Appendix C. BOK2 Outcomes and Levels of Achievement[13]

Outcome number and title	Level of achievement					
	1 Know-ledge	2 Compre-hension	3 Appli-cation	4 Analy-sis	5 Synthe-sis	6 Evalu-ation
Foundational						
1. Mathematics	B	B	B			
2. Natural sciences	B	B	B			
3. Humanities	B	B	B			
4. Social sciences	B	B	B			
Technical						
5. Materials science	B	B	B			
6. Mechanics	B	B	B	B		
7. Experiments	B	B	B	B	M/30	
8. Problem recognition and solving	B	B	B	M/30		
9. Design	B	B	B	B	B	E
10. Sustainability	B	B	B	E		
11. Contemp. Issues & hist. perspectives	B	B	B	E		
12. Risk and uncertainty	B	B	B	E		
13. Project management	B	B	B	E		
14. Breadth in civil engineering areas	B	B	B	B		
15. Technical specialization	B	M/30	M/30	M/30	M/30	E
Professional						
16. Communication	B	B	B	B	E	
17. Public policy	B	B	E			
18. Business and public administration	B	B	E			
19. Globalization	B	B	B	E		
20. Leadership	B	B	B	E		
21. Teamwork	B	B	B	E		
22. Attitudes	B	B	E			
23. Life-long learning	B	B	B	E	E	
24. Professional and ethical responsibility	B	B	B	B	E	E

Key:		
	B	Portion of the BOK fulfilled through the bachelor's degree
	M/30	Portion of the BOK fulfilled through the master's degree or equivalent (approximately 30 semester credits of acceptable graduate-level or upper- level undergraduate courses)
	E	Portion of the BOK fulfilled through the pre-licensure experience