

## **AC 2008-1097: INFLUENCE OF THE NEW CIVIL ENGINEERING BODY OF KNOWLEDGE ON ACCREDITATION CRITERIA**

### **Stephen Ressler, United States Military Academy**

Colonel Stephen Ressler is Professor and Head of the Department of Civil and Mechanical Engineering at the U.S. Military Academy (USMA) at West Point. He earned a B.S. degree from USMA in 1979, a Master of Science in Civil Engineering degree from Lehigh University in 1989, and a Ph.D. from Lehigh in 1991. An active duty Army officer, he has served in a variety of military engineering assignments around the world. He has been a member of the USMA faculty for 16 years, teaching courses in engineering mechanics, structural engineering, construction, and professional practice.

## **Influence of the New Civil Engineering Body of Knowledge on Accreditation Criteria**

The purpose of this paper is to present an analysis of the American Society of Civil Engineers (ASCE) *Civil Engineering Body of Knowledge for the 21<sup>st</sup> Century*, Second Edition, (BOK2) from the perspective of accreditation. Specifically, the author proposes a methodology by which *potential* changes to the ABET Accreditation Criteria are derived from the BOK2 and then prioritized. Through a comparison of the BOK2 Outcomes and the current BOK1-compliant criteria, the author identifies specific criteria modifications that *might* be warranted as a mechanism for stimulating curricular change in support of ASCE's strategic vision. Potential changes are then scored according to both importance and feasibility, based on clearly delineated criteria for the scoring process. Finally the importance and feasibility scores are combined to create a prioritized list of potential changes, intended to provide a rational basis for the ultimate decision on which changes, if any, to implement. The focus of this paper is on the methodology, not on the potential changes. The author's intent is not to advocate changes to the criteria in conjunction with BOK2 implementation, but rather to inform the decision-making process by providing a means of logically anticipating the most likely changes, in order to judge their potential benefits and costs.

This paper also presents an analysis of timing and transition issues associated with implementation of the current BOK1-compliant accreditation criteria and any additional changes that might emerge from the BOK2 process. The results of this analysis suggest that disruptions to civil engineering programs will be minimized if any changes deemed necessary are initiated as quickly as possible.

### Background

In response to a growing consensus that the bachelor's degree is becoming increasingly inadequate as formal academic preparation for the professional practice of civil engineering, the ASCE Board of Direction adopted Policy Statement 465 in October 1998. This initial version of the 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."<sup>1</sup> Charged with implementing Policy Statement 465, the ASCE Committee on Academic Prerequisites for Professional Practice (CAP<sup>3</sup>) began by analyzing the three fundamental characteristics of a profession—an ethic of service, a professional organization, and a specialized body of knowledge.<sup>2</sup> The committee's analysis of the civil engineering profession suggested that only the first two of these three characteristics had been adequately defined. Thus began a broad-based effort to define the Civil Engineering Body of Knowledge.

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.<sup>1</sup> This report described the first edition of the Civil Engineering Body of Knowledge (BOK) in terms of 15 outcomes, the first eleven of which corresponded nominally to ABET Criterion 3(a)-(k).<sup>3</sup>

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.<sup>4</sup>

With the BOK formally defined and endorsed in ASCE policy, a broad-based effort to develop and implement new BOK-compliant accreditation criteria began. The CAP<sup>3</sup> Accreditation Committee was charged with leading this effort.

Implicit in the committee's charge is an underlying assumption that the ABET accreditation process is an appropriate mechanism for fostering a transition toward BOK-compliant curricula at ABET-accredited civil engineering programs nationwide. This assumption is well founded. "Engineering Change," a recent 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.<sup>5</sup> 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 the desired end.

Although the ABET criteria constitute a viable instrument for effecting BOK implementation, it is *not* true that the criteria are entirely adaptable to this purpose. The ABET criteria consist of three different components, each with its own unique limitations as an instrument for BOK implementation:

- The ***General Criteria for Baccalaureate Level Programs (GCBLP)*** are applicable to *all* ABET-accredited programs in *all* engineering disciplines. Changing these criteria would require the support of ABET and its 27 member societies. In the short term, ASCE has little capability to gain such broad support.
- 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 is at least feasible for ASCE to influence changes to these criteria. Nonetheless, 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" and are established by ASCE. Because ASCE has considerable authority to change these criteria, they must necessarily be the principal accreditation-related mechanism for BOK implementation.

In pursuit of its charge, the CAP<sup>3</sup> Accreditation Committee engaged in a collaborative two-year process of study, deliberation, and critical review, culminating in the submission of proposed new BOK-compliant accreditation criteria (GCMLP and CEPC) to ABET in June 2006 and final

approval by the ABET Board of Directors in November 2008. These criteria, provided in Appendix A of this paper, are currently being implemented for accreditation visits occurring during academic year 2008-2009.

As the development of these criteria proceeded, two parallel ASCE initiatives further clarified the strategic direction of the civil engineering profession. First, in June 2006, a diverse group of leaders from across the profession and around the world gathered to formulate an aspirational vision for civil engineering. The product of that endeavor was a vision for civil engineering in 2025, which is summarized as follows:

**Entrusted by society to create a sustainable world and enhance the global quality of life, civil engineers serve competently, collaboratively, and ethically as master:**

- **planners, designers, constructors, and operators of society's economic and social engine, the built environment;**
- **stewards of the natural environment and its resources;**
- **innovators and integrators of ideas and technology across the public, private, and academic sectors;**
- **managers of risk and uncertainty caused by natural events, accidents, and other threats; and**
- **leaders in discussions and decisions shaping public environmental and infrastructure policy.**<sup>6</sup>

The second ASCE strategic initiative was the development of an enhanced and updated version of the BOK. This second edition of the BOK, formally titled *Civil Engineering Body of Knowledge for the 21<sup>st</sup> Century*, Second Edition, (abbreviated BOK2) was developed in response to broad stakeholder feedback about the first edition (abbreviated BOK1), as well as the ideas expressed in ASCE's Vision 2025.<sup>7</sup> BOK2 is currently available in draft form, and the final product will be publicly released in February 2008.

The BOK2 includes two particularly substantive changes from the BOK1:

- The number of outcomes was increased from 15 to 24. For the most part, this increase reflects the BOK2 authors' attempt to enhance clarity and specificity, rather than to increase the scope of the body of knowledge. Nonetheless, the BOK2 Outcomes do place increased emphasis on such topics as the natural sciences, the humanities, sustainability, globalization, public policy, risk, and uncertainty.
- The BOK2 uses Bloom's Taxonomy as the basis for defining levels of achievement. 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.<sup>8</sup>

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 B, 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, the master’s degree (or equivalent), and for professional experience.

### Analysis Methodology

It attempting to identify potential accreditation criteria changes, two alternative approaches might logically be followed:

- The first approach would be to compare the BOK2 Outcomes with the BOK1 Outcomes to identify differences. These differences would then be used as the basis for incremental changes to the current BOK1-compliant criteria to better reflect the BOK2.
- The second approach would be to directly compare the BOK2 Outcomes with current BOK1-compliant criteria, to identify BOK2 Outcomes that are not adequately addressed in the current criteria. These shortfalls would then be used as the basis for incremental changes to the current BOK1-compliant criteria.

Of these two approaches, the second is more logically sound. The first approach implicitly assumes that the translation of BOK1 outcomes into the current criteria was completely successful. In practice, any inadequacies in that process would likely be carried over into a new criteria revision, because the criteria changes will be based entirely on *differences* between the two sets of BOK Outcomes. More importantly, any direct comparison of the two sets of outcomes would be greatly hindered by the fact that the BOK1 Outcomes were not based on Bloom’s Taxonomy. With no clear mapping between the levels of achievement defined in BOK1 and BOK2, identifying differences between them would be imprecise at best. The second approach overcomes this limitation by removing the BOK1 from the analysis entirely.

### Comparison of BOK2 Outcomes and Current Accreditation Criteria

A comparison of the relevant BOK2 Outcomes and the current ABET accreditation criteria is provided in Table 2 below. The outcome statements presented in the fifth column of this table are taken directly from the BOK2 Outcome Rubric, which includes an outcome statement for each of Bloom’s six levels of cognitive development, for each of the 24 outcomes. For the

purpose of this analysis, only the highest bachelor's level (B) outcome statement and only the highest master's level (M) outcome statement, if applicable, are shown in the table. Since accreditation applies strictly to education, none of the outcome statements associated with professional experience (E) have been included. The numbered level in the fourth column of the table is the level of achievement, as defined by Bloom's Taxonomy. The far right-hand column of the table shows a comparison of the associated outcome statement to all relevant provisions of the current ABET accreditation criteria. In making this comparison, the following terminology is used:

- “Fully addressed” indicates that there is a direct correspondence between the BOK2 Outcome and one or more criteria, such that compliance with the specified criteria will guarantee attainment of the BOK2 Outcome.
- “Adequately addressed” indicates that there is a strong consistency between the BOK2 Outcome and one or more criteria, such that compliance with the specified criteria will result in substantial progress toward attainment of the BOK2 Outcome.
- “Partially addressed” indicates that compliance with the specified criteria will only necessarily result in partial attainment of the BOK2 Outcome. Partial attainment may refer to a shortfall in either scope or level of achievement.
- “Not addressed” indicates that there are no criteria which, if attained, would necessarily result in substantial progress toward attainment of the BOK2 Outcome.

If more than one criterion is cited, *both* of these criteria are required to address the outcome. Obviously, these determinations reflect the author's subjective judgment, to a large extent. Others might legitimately find higher or lower levels of correspondence for any given outcome.

Outcome Title		Degree	Level	Outcome Statement		Comparison to Current Criteria
<b>F o u n d a t i o n a l O u t c o m e s</b>						
1	Mathematics	B	3	Solve problems in mathematics through differential equations and apply this knowledge to the solution of engineering problems.	Fully addressed by the CEPC.	
2	Natural Sciences	B	3	Solve problems in calculus-based physics, chemistry, and one additional area of natural science and apply this knowledge to the solution of engineering problems.	Fully addressed by the CEPC, except for the word “natural.”	
3	Humanities	B	3	Demonstrate the importance of the humanities in the professional practice of engineering.	Not addressed by any current criteria.	
4	Social Sciences	B	3	Demonstrate the incorporation of social sciences knowledge into the professional practice of engineering.	Adequately addressed by GCBLP Criterion 3(h).	
<b>T e c h n i c a l O u t c o m e s</b>						
5	Materials Science	B	3	Use knowledge of materials science to solve problems appropriate to civil engineering.	Not addressed by any current criteria.	
6	Mechanics	B	4	Analyze and solve problems in solid and fluid mechanics.	Not addressed by any current criteria.	
7	Experiments	B	4	Analyze the results of experiments and evaluate the accuracy of the results within the known boundaries of the tests and materials in or across more than one of the technical areas of civil engineering.	Fully addressed by the CEPC.	
		M	5	Specify an experiment to meet a need, conduct the experiment, and analyze and explain the resulting data.	Adequately addressed by GCBLP Criterion 3(b).	
8	Problem Recognition and Solving	B	3	Develop problem statements and solve well-defined fundamental civil engineering problems by applying appropriate techniques and tools.	Adequately addressed by GCBLP Criteria 3(e) and 3(k).	
		M	4	Formulate and solve an ill-defined engineering problem appropriate to civil engineering by selecting and applying appropriate techniques and tools.	Partially addressed by GCBLP Criterion 3(e). The ability to select techniques and tools is not addressed in any current criteria.	
9	Design	B	5	Design a system or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, constructability, and sustainability.	Fully addressed by GCBLP Criterion 3(c).	
10	Sustainability	B	3	Apply the principles of sustainability to the design of traditional and emergent engineering systems.	Not addressed by any current criteria.	
11	Contemporary Issues and Historic Perspectives	B	3	Drawing upon a broad education, explain the impact of historical and contemporary issues on the identification, formulation, and solution of engineering problems and explain the impact of engineering solutions on the economy, environment, political landscape, and society.	Partially addressed by GCBLP Criteria 3(h) and 3(j). The ability to explain historical issues is not addressed in any current criteria.	

Outcome Title	Degree	Level	Outcome Statement	Comparison to Current Criteria
12	B	3	Apply the principles of probability and statistics to <i>solve</i> problems containing uncertainties.	Not addressed by any current criteria.
13	B	3	<i>Develop</i> solutions to well-defined project management problems.	Partially addressed by the CEPC.
14	B	4	<i>Analyze</i> and solve well-defined engineering problems in at least four technical areas appropriate to civil engineering.	Partially addressed by the CEPC.
15	B	1	<i>Define</i> key aspects of advanced technical specialization appropriate to civil engineering.	Adequately addressed by the CEPC.
	M	5	<i>Design</i> a complex system or process or <i>create</i> new knowledge or technologies in a traditional or emerging specialized technical area appropriate to civil engineering.	Adequately addressed by the GCMLP.
<b>P r o f e s s i o n a l   O u t c o m e s</b>				
16	B	4	<i>Organize</i> and <i>deliver</i> effective verbal, written, virtual, and graphical communications.	Adequately addressed by GCBLP Criterion 3(g).
17	B	2	<i>Discuss</i> and <i>explain</i> key concepts and processes involved in public policy.	Adequately addressed by the CEPC.
18	B	2	<i>Explain</i> key concepts and processes used in business and public administration.	Partially addressed by the CEPC.
19	B	3	<i>Organize, formulate, and solve</i> an engineering problem in a global context.	Partially addressed by GCBLP Criterion 3(h).
20	B	3	<i>Apply</i> leadership principles to direct the efforts of a small, homogenous group.	Partially addressed by the CEPC.
21	B	3	<i>Function</i> effectively as a member of an intra-disciplinary team.	Adequately addressed by GCBLP Criterion 3(d).
22	B	2	<i>Explain</i> attitudes supportive of the professional practice of civil engineering.	Not addressed by any current criteria.
23	B	3	<i>Demonstrate</i> the ability for self-directed learning.	Adequately addressed by GCBLP Criterion 3(i).
24	B	4	<i>Analyze</i> a situation involving multiple conflicting professional and ethical interests to determine an appropriate course of action.	Partially addressed by GCBLP Criterion 3(f).

B=To be attained at the Bachelor's Degree Level

M=To be attained at the Master's Degree Level

Table 2. Comparison of BOK2 Outcomes and current ABET accreditation criteria



Given the subjectivity inherent in performing the comparison above, the following additional observations are provided to clarify the basis for all findings that are not self-evident:

- Outcome 2 requires the ability to apply “one additional area of natural science,” while the CEPC only require “one additional area of science.” Addition of the word “natural” in the BOK2 Outcome is significant, in that it addresses an ambiguity that has been the source of considerable discussion concerning the current criteria.
- One might infer that Outcome 3 is addressed by the GCBLP Criterion 3(h) requirement for a “broad education;” however, Criterion 3(h) clearly indicates that the specified educational breadth is necessary for understanding the impact of engineering solutions “in a global, economic, environmental, and social context.” These referenced subjects are social and behavioral sciences, not humanities. Hence, Outcome 4 is adequately addressed by Criterion 3(h), but not Outcome 3.
- The Outcome 7 requirement to “*specify* an experiment to meet a need” is adequately addressed by the GCBLP Criterion 3(b) requirement for *design* of experiments. The authors of BOK2 chose to use the word *specify* as a more appropriate characterization of experimentation in a civil engineering context; however, since both *specify* and *design* are defined as Level 5 activities, they can reasonably be considered equivalent.
- It should be noted that the Outcome 7 requirement to “*specify* an experiment” is intended to be attained at the master’s degree level; thus, for complete consistency, it should actually be addressed in the GCMLP rather than the GCBLP.
- Similarly, the Outcome 8 requirement to *formulate* engineering problems is intended to be attained at the master’s degree level, even though it is addressed in the GCBLP—the baccalaureate-level criteria.
- The Outcome 8 requirement to apply techniques and tools is adequately addressed in GCBLP Criterion 3(k); however, this criterion does not address the need to *select* appropriate techniques and tools.
- In order to conclude that the Criterion 9 requirement for design of a system or process is fully addressed by GCBLP Criterion 3(c), one must interpret the term “manufacturability” as equivalent to “constructability” in a civil engineering context.
- With regard to Outcome 10, sustainability is mentioned in GCBLP Criterion 3(c), but only as one possible constraint associated with the design process. Compliance with this criterion would not necessarily result in attainment of the outcome.
- The CEPC requirement to “explain basic concepts in management” falls short of the Outcome 13 requirement to “*develop* solutions to well-defined project management problems” in both scope (because *project* management is not specified) and level of achievement (because *explain* implies Level 2 while *develop* indicates Level 3).

- The Outcome 14 requirement to “*analyze* and solve well-defined engineering problems” is only partially addressed by the CEPC, because the criteria require the ability to “apply knowledge” in four civil engineering technical areas; thus they only specify Level 3.
- With regard to Outcome 15, the Level 1 bachelor’s degree requirement to “*define* key aspects of advanced technical specialization” is adequately addressed by the CEPC requirement to *apply* (Level 3) knowledge in four civil engineering technical areas. The Level 5 master’s degree requirement to “*design* a complex system or process or *create* new knowledge” is consistent with the GCMLP requirement for “masters level knowledge in a specialized area of engineering....”
- With regard to Outcome 18, there is a CEPC provision related to business but not to public administration; thus, these criteria only partially address the requirement to “*explain* key concepts and processes used in business and public administration.”
- The GCBLP Criterion 3(h) requirement that graduates *understand* the impact of engineering solutions in a global context would reasonably be regarded as a Level 2 activity. Thus, this criterion only partially addresses the Outcome 19 (Level 3) requirement to “*organize, formulate, and solve* an engineering problem in a global context.”
- The Outcome 20 requirement to “*apply* leadership principles to direct the efforts of a small, homogenous group” (a Level 3 outcome) is only partially addressed by the CEPC, because these criteria only require that graduates can *explain* basic concepts in leadership—a Level 2 activity.
- The Outcome 24 requirement to “*analyze* a situation involving multiple conflicting professional and ethical interests” (a Level 4 outcome) is only partially addressed by GCBLP Criterion 3(f), because this criterion only requires an *understanding* (Level 2) of professional and ethical responsibilities.

### Identifying Potential Criteria Changes

Consistent with the analysis presented in Table 2 above, Table 3 presents a comprehensive list of potential criteria changes that would be required to fully or adequately address each BOK2 Outcome. The “Criteria” column of this table reflects the author’s subjective judgment of the most appropriate set of criteria in which to address the associated issue. This determination was based on *the nature of the issue*, not on the feasibility of making the change. If a given issue is specific to the civil engineering discipline (e.g., breadth in civil engineering areas) or if it tends to be of greater concern in civil engineering than in other disciplines, then the criteria change is associated with the CEPC. If an issue is associated with an outcome that is to be attained at the master’s level, then the change is associated with the GCMLP. If an issue is clearly applicable to all engineering disciplines, and if the associated outcome is to be attained at the baccalaureate level, then the change is associated with the GCBLP. As noted above, however, effecting any substantive change to the GCBLP is likely to be extremely difficult. In practice, any GCBLP

change identified in Table 3 could also be implemented as a CEPC change, if the broad consensus necessary for a GCBLP change cannot be achieved.

In the “Criteria Change” column of Table 3, changes identified as “add a provision” could be accomplished by adding a new criterion or by modifying an existing criterion.

The “Importance” column provides a numerical score on a three-point scale, with 1 reflecting the highest importance and 3 representing the lowest. Although these scores have undoubtedly been influenced by the author’s subjective judgment, they are based primarily on the following rubric:

- **Importance=1** – The criteria change would directly enhance public safety or would promote the long-term attainment of ASCE’s Vision 2025.
- **Importance=2** – The criteria change would promote attainment of the BOK in curricular areas typically not addressed in current civil engineering programs.
- **Importance=3** – All other circumstances, to include adjustments to the specified level of achievement and curricular areas that are already addressed in most current civil engineering programs.

The “Feasibility” column also provides a numerical score on a three-point scale, with 1 reflecting the greatest feasibility and 3 representing the least. The scores are based primarily on the following rubric:

- **Feasibility=1** – The criteria change is minor, such that a broad consensus in favor of the change is readily attainable. Examples include simple administrative issues, clarifications, and changes involving curricular content that is already present in most curricula.
- **Feasibility=2** – The criteria change is substantive, but a relatively broad consensus on the need for change is attainable.
- **Feasibility=3** – The criteria change is substantive, and a broad consensus on the need for change will be difficult to achieve.

	Outcome Title	Criteria	Criteria Change Required to Fully or Adequately Address the Outcome	Importance	Feasibility	Remarks
1	Mathematics	---	None	---	---	
2	Natural Sciences	CEPC	Change “one additional area of science” to “one additional area of natural science.”	2	1	Effectively clarifies existing criterion.
3	Humanities	GCBLP	Add a provision requiring that graduates <i>demonstrate</i> the importance of the humanities in the professional practice of engineering.	2	3	Not addressed in current criteria. Typically not included in current programs.
4	Social Sciences	---	None	---	---	
5	Materials Science	CEPC	Add a provision requiring that graduates <i>use</i> knowledge of materials science to <i>solve</i> problems appropriate to civil engineering.	3	1	Not addressed by current criteria. Included in most current programs.
6	Mechanics	CEPC	Add a provision requiring that graduates <i>analyze</i> and solve problems in solid and fluid mechanics.	3	1	Not addressed by current criteria. Included in most current programs.
7	Experiments	---	None	---	---	
8	Problem Recognition and Solving	GCMLP	Add a provision requiring that graduates <i>select</i> appropriate techniques and tools	3	3	Partially addressed by GCBLP. Included in most current master’s programs.
9	Design	---	None	---	---	
10	Sustainability	GCBLP	Add a provision requiring that graduates <i>apply</i> the principles of sustainability to the design of engineering systems.	1	2	Promotes ASCE Vision 2025. Not addressed by current criteria.
11	Contemporary Issues and Historic Perspectives	CEPC	Add a provision requiring that graduates <i>explain</i> the impact of historical issues on the identification, formulation, and solution of engineering problems.	3	3	Partially addressed by GCBLP.
12	Risk and Uncertainty	CEPC	Add a provision requiring that graduates <i>apply</i> the principles of probability and statistics to <i>solve</i> problems containing uncertainties.	1	2	Promotes ASCE Vision 2025. Not addressed by current criteria.
13	Project Management	CEPC	Change existing management provision to focus on <i>project</i> management, and raise level of achievement to Level 3.	3	2	Partially addressed by CEPC.
14	Breadth in Civil Engineering Areas	CEPC	Raise level of achievement in existing provision from Level 3 to Level 4.	1	3	Public safety impact. Partially addressed by CEPC.

	Outcome Title	Criteria	Criteria Change Required to Fully or Adequately Address the Outcome	Importance	Feasibility	Remarks
15	Technical Specialization	---	None	---	---	
16	Communication	---	None	---	---	
17	Public policy	---	None	---	---	
18	Business and Public Administration	CEPC	Change existing management provision to include public administration.	3	3	Partially addressed by CEPC.
19	Globalization	GCBLLP	Raise level of achievement in existing provision in Criterion 3(h) from Level 2 to Level 3.	3	2	Partially addressed by GCBLLP.
20	Leadership	CEPC	Raise level of achievement in existing provision from Level 2 to Level 3.	3	3	Partially addressed by CEPC.
21	Teamwork	---	None	---		
22	Attitudes	CEPC	Add a provision requiring that graduates “ <i>explain</i> attitudes supportive of the professional practice of civil engineering.”	2	3	Not addressed in current criteria.
23	Life-long Learning	---	None	---	---	
24	Professional and Ethical Responsibility	GCBLLP	Raise level of achievement in existing provision in Criterion 3(4) from Level 2 to Level 4.	1	3	Public safety impact. Partially addressed by GCBLLP.

Table 3. Potential criteria changes that would be required to fully or adequately address the BOK2 Outcomes

The importance and feasibility scores presented in Table 3 are also summarized in Table 4 below.

Importance	Feasibility	Outcomes
1	1	None
1	2	10 (Sustainability) 12 (Risk & Uncertainty)
1	3	14 (Breadth in Civil Engineering Areas) 24 (Professional & Ethical Responsibility)
2	1	2 (Natural Sciences)
2	2	None
2	3	3 (Humanities) 22 (Attitudes)
3	1	5 (Materials Science) 6 (Mechanics)
3	2	13 (Project Management) 19 (Globalization)
3	3	8 (Problem Recognition & Solving) 11 (Contemporary Issues) 18 (Business and Public Administration) 20 (Leadership)

Table 4. Summary of importance and feasibility scores for criteria changes associated with BOK2 Outcomes

### Prioritizing Criteria Changes

As the organization of Table 4 suggests, in order to develop a single prioritized list of potential criteria changes, it is only necessary to decide whether *importance* or *feasibility* should be given precedence in the prioritization process. The author suggests that importance be given precedence. In other words, *all* changes having Importance=1 should be implemented before *any* changes having Importance=2. Consistent with the rubrics defined above, giving precedence to importance ensures that the highest priority is assigned to criteria changes associated enhanced public safety and attainment of ASCE’s Vision 2025. Within the group of Importance=1 tasks, priority should be given to those with the greatest feasibility. Based on this prioritization scheme, we can conclude that the top-priority issues to be addressed in any future ASCE-initiated revision to the ABET accreditation criteria are as follows:

- **Priority=1** – Provisions associated with sustainability (Outcome 10) and risk/uncertainty (Outcome 12).
- **Priority=2** – Increase in the specified levels of achievement associated with the four CE technical areas (Outcome 14) and professional and ethical responsibility (Outcome 24).
- **Priority=3** – Addition of the word “natural” to clarify the requirement for “one additional area of science” (Outcome 2).
- **Priority=4** – Provisions associated with the humanities (Outcome 3) and attitudes (Outcome 22).

The remaining issues, all of which the author scored at the lowest level of importance, can be listed in the same manner.

It is important to reemphasize that the intent of this paper is not to recommend that any of these criteria changes should occur. Rather, the analysis methodology and prioritization scheme presented above are recommended as tools to inform the decision-making process by providing a means of logically anticipating the most likely changes, in order to judge their potential benefits and costs.

### Timing and Transition Issues

Over the past year, as development of the BOK2 progressed and it became evident that some significant changes to the BOK Outcomes were in the offing, some department chairs have expressed concern with the prospect of having to implement two significant changes to accreditation criteria within a relatively short period of time. This concern, though entirely legitimate, warrants a more detailed analysis. If BOK2-compliant criteria are to be developed and implemented, does it make more sense to implement these changes immediately or to wait until the transition to the current set of BOK1-compliant criteria is complete?

First, let us consider the ongoing transition to the current BOK1-compliant CEPC and GCMLP, which were approved by the ABET Board of Directors in November 2007 and are being implemented for accreditation visits that will be conducted in the fall of 2008. Given the time required to plan and implement curricular change, there must be an allowance for some lag time between the publication of new criteria and the implementation of curriculum modifications designed to meet these criteria. Given that the current BOK1-compliant CEPC and GCMLP were just approved in the fall 2007, the class of freshmen entering a program in 2009 would logically be the first students enrolled in a baccalaureate-level curriculum designed to satisfy the new criteria. These students will complete their bachelor's degrees no earlier than 2013. Thus the first evaluations of graduates who can reasonably be expected to fully satisfy the current baccalaureate-level criteria will be conducted in the fall of 2013. By that time, six full accreditation cycles will have been conducted and 100% of the nation's civil engineering programs will have been evaluated under the new BOK1-compliant CEPC and GCMLP.

This implementation schedule has several important implications. First, should ASCE decide to postpone implementation of any new BOK2-compliant criteria until the transition to the current BOK1-compliant criteria is complete, the postponement would need to be until 2014—six years from now. Under these circumstances, each civil engineering program in the U.S. would need to implement the BOK1-compliant criteria for one accreditation visit, and then immediately begin transitioning to the BOK2-compliant criteria.

Now consider how the transition would transpire if BOK2-compliant criteria were implemented as quickly as possible. Based on ABET policy, criteria changes can only be submitted for consideration by the Engineering Accreditation Commission (EAC) at its annual meeting in July. Given that ASCE would devote at least one full year to developing and soliciting feedback on any new BOK2-compliant criteria, the earliest possible date for submission of these new criteria would be July 2009. A criteria change submitted at that time would be reviewed by the EAC and,

if “approved on first reading,” submitted to the ABET Board of Directors for consideration at its annual meeting in November of the same year. If approved, these criteria would be published for public comment in the back of the EAC criteria booklet for the 2010-2011 accreditation cycle. Assuming that no major problems emerged during the public comment period, these criteria would then be considered “on second reading” by the EAC in July 2010 and by the ABET Board in November 2010. If the Board granted final approval, then the BOK2-compliant criteria would become effective for evaluations conducted during the 2011-2012 accreditation cycle.

Programs being visited in the fall of 2011 would be evaluated under these new criteria; however, because of the inevitable lag in curricular transition, as discussed above, no program could reasonably be expected to have produced graduates who meet these BOK2-compliant criteria until 2016.

In this latter scenario, the amount of disruption to civil engineering programs would be significantly less. For programs visited in 2008 and 2009, the situation would likely be unchanged. These programs would need to transition to the current BOK1-compliant criteria for their evaluation visits and would subsequently continue the transition to the BOK2-compliant criteria. But all remaining programs—roughly two thirds of civil engineering programs nationwide—would only need to do a single transition.

## Conclusion

It has been shown that accreditation criteria provide an effective mechanism for fostering curricular change. Should ASCE decide to develop and implement new accreditation criteria in order to foster a transition toward BOK-compliant civil engineering curricula, a system for deriving these changes will be needed. This paper presents a methodology for deriving and prioritizing criteria changes, such that decision-makers will be able to focus their efforts on changes that (1) will have the greatest impact on civil engineering education and (2) are most likely to gain the acceptance of the civil engineering community. This paper also suggests, based on an analysis of several possible implementation timelines, that any criteria changes deemed necessary should be implemented as quickly as possible, in order to minimize disruption to a majority of the nation’s civil engineering programs.

## References

1. Body of Knowledge Committee of the Committee on Academic Prerequisites for Professional Practice. *Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future*. Reston, VA: American Society of Civil Engineers, 2004.
2. Lawson, William D. “Professionalism: The Golden Years.” *Journal of Professional Issues in Engineering Education and Practice*, 130 (1), 26-36.
3. ABET Engineering Accreditation Commission. “Criteria for Accrediting Engineering Programs – Effective for Evaluations during the 2008-2009 Accreditation Cycle.” ABET, Inc., November 2007. Accessed at <http://www.abet.org/Linked%20Documents-UPDATE/Criteria%20and%20PP/E001%2008-09%20EAC%20Criteria%2011-30-07.pdf>, January 16, 2008.



4. "ASCE Policy Statement 465: Academic Prerequisites for Licensure and Professional Practice." American Society of Civil Engineers, April 24, 2004. Accessed at [http://www.asce.org/pressroom/news/policy\\_details.cfm?hdlid=15](http://www.asce.org/pressroom/news/policy_details.cfm?hdlid=15), January 15, 2008.
5. Center for the Study of Higher Education. "Engineering Change." Pennsylvania State University, College of Education. Accessed at <http://www.ed.psu.edu/cshe/abet/ec2000.html>, January 15, 2006.
6. Steering Committee to Plan a Summit on the Future of the Civil Engineering Profession in 2025. *The Vision for Civil Engineering in 2025*. Reston, VA: American Society of Civil Engineers, 2007.
7. Body of Knowledge Committee of the Committee on Academic Prerequisites for Professional Practice. *Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future*, Second Edition (Final Draft). Reston, VA: American Society of Civil Engineers, November 9, 2007.
8. Bloom, Benjamin S. *Taxonomy of Educational Objectives*. New York: Longman, 1956.

## Appendix A. BOK1-Compliant Civil Engineering Program Criteria and General Criteria for Master's Level Programs

### 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. BOK2 Outcomes and Levels of Achievement

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