

Understanding and Influencing Systems Engineering in Academia

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The International Council on Systems Engineering (INCOSE) has an inherent obligation and unique opportunity to influence Systems Engineering (SE) degree programs in academia. But, to be credible, initiatives intended to influence must be based on an understanding of both the academic setting and SE degree program structures. This is advisable due to the keen interest of other engineering societies in their own aspects of systems engineering.

Understanding and insight are essential prerequisites for INCOSE to effectively and professionally influence SE in academia. Accordingly, this paper will begin with a classification of SE degree programs. Then, a status report is presented regarding the INCOSE initiative to participate in accreditation through the Accreditation Board for Engineering and Technology (ABET). Academic program certification by INCOSE is then offered as a concept for influencing academia beyond the means available through ABET.

A Classification of Systems Engineering Degree Programs

Seventy-five (75) institutions in the United States offer 130 undergraduate and graduate degree programs in incorporating systems engineering. These programs were partitioned into two categories, Systems Engineering Centric and Domain Centric Systems Engineering. For more detail see Fabrycky, W. J. and E. A. McCrae *Systems Engineering Degree Programs in the United States*, Proceedings, 15th International Symposium, July 2005, Rochester, NY. Institutional contact and related information, current as of academic year 2004-05, is available in spreadsheet form from www.a2i2.com

Systems Engineering Centric (SEC) Programs. Basic and advanced level programs leading to a bachelors or higher degree in Systems Engineering comprise a distinct category with a discipline-like focus. Included are only those degree programs where the concentration is designated as Systems Engineering; where SE is the intended major area of study.

There are 31 institutions offering 48 degree programs in the Systems Engineering Centric category. The count by degree program level is given in the following table:

Systems Engineering Centric (SEC) Programs

	<u>BS</u>	<u>MS</u>	<u>PhD</u>	
Program count	11	+ 27	+ 10	Total = 48

Domain Centric Systems Engineering (DCSE) Programs. Basic and advanced level programs leading to a bachelors or higher degrees with the major designated as X Systems Engineering, Systems and X Engineering, etc. Included in this category are those degree programs embedding aspects of systems engineering into a parent engineering domain.

There are 48 institutions (4 of these duplicate institutions in the SEC category) offering 82 Domain Centric Systems Engineering degree programs across an array of domains. These are summarized by degree program level in the following table:

Domain Centric Systems Engineering (DCSE) Degree Programs

	<u>BS</u>	<u>MS</u>	<u>PhD</u>	
SE with Biological Engineering	16	5	3	24
SE with Computer Engineering	1	4	2	7
SE with Electrical Engineering		1		1
SE with Industrial Engineering	14	15	7	36
SE with Management Engineering		3	1	4
SE with Manufacturing Engineering	<u>1</u>	<u>8</u>	<u>1</u>	<u>10</u>
Totals	32	36	14	= 82

Program Organization and Administration. Not all SE degree programs are organized and administered under a classical departmental structure within an academic institution. Although most undergraduate programs are classically organized, the following variants are found:

1. There are instances where an academic administrative unit will be the home for more than one degree program or program major; e.g., Systems Engineering and Industrial Engineering. The department name may or may not include the names of all degree programs administered.
2. There are instances where the institution will offer both a SE Centric (SEC) and a Domain Centric SE (DCSE) program; e.g., Systems Engineering and Manufacturing Systems Engineering. The SEC program may be administered in an interdepartmental mode, whereas the DCSE program will usually be administered within a department.
3. In those instances where an institution offers a SEC program at the basic and advanced levels, all are usually administered within a department. This is also true for DCSE programs, except that the SE component may not exist at all degree levels.

The above variants are listed to emphasize that the name of the administrative home for a degree program may not be indicative of its program characteristics and focus. It is usually best to looking at the degree program itself. When considering basic and advanced level programs in the SEC and DCSE categories, program understanding will be improved by recognizing that Systems Engineering is broad in nature. It should not be viewed in the same context as the traditional engineering disciplines.

Many engineering disciplines are seeking a better technological balance by adopting systems thinking and SE topics. This is the primary reason for the rapid growth in the number of engineering domains adding a systems component to their degree programs, as well as "systems" to the name of the program itself. Over time, infusion of systems material into engineering curricula has been formalized by discrete courses. Nonetheless, systems engineering will likely continue to mean different things to different people.

Increasing the Influence of INCOSE in Academia

The need to influence SE academic degree programs is derived from the professional nature of Systems Engineering. As a technologically based interdisciplinary process for bringing systems and products (human-made entities) into being, SE can be advanced and improved in academia by INCOSE in partnership with the engineering domain societies. Herein is the point of leverage for increasing the influence of INCOSE. The SEC and DCSE degree classification can be invaluable in bringing understanding to this endeavor.

Then there are the legions of academicians and practicing professionals developing and applying powerful tools for analysis, experimentation, modeling, and simulation to the operational domain. These individuals represent engineering management, industrial engineering, management science, operations research, and systems analysis. Too often the contributions of these individuals are mistakenly called "systems engineering". From an INCOSE perspective, these methodologies and tools are necessary, but not sufficient. Systems engineering is process and synthesis centered, and depends on all of the above for its effective execution.

It is well known that a degree program containing the systems engineering designation at one institution may not be the same as a degree program with the same designation at another institution. Accordingly, in considering the content of degree programs embracing systems engineering, one should go directly to published curricula to examine specific course and program content against requirements externally solicited. This approach is being promulgated by ABET. It can be applied best to systems engineering by having INCOSE influence the accreditation process in collaboration with the domain societies.

The Accreditation Board for Engineering and Technology.

ABET is the professional body that accredits academic programs in engineering and engineering technology. Unlike bodies that accredit an entire academic institution, ABET focuses on the characteristics of programs and the products of these programs for the purpose of advancing the quality thereof.

The Anticipated INCOSE Role Within ABET. The mission of ABET is accomplished through the professional engineering societies serving as participating bodies. Currently there is no professional society (and no specific criteria) for accrediting academic degree programs in systems engineering. Systems engineering programs are accredited by ABET upon request under a special or "other" category.

The International Council on Systems Engineering began an initiative to become an ABET participating body in October of 2001. INCOSE has an opportunity and obligation to advance its interest in the quality of systems engineering degree programs by offering to participate in and support the mission of ABET. The ABET opportunity is viewed by INCOSE to be critical to the advancement of SE in its own right, as well as essential to the infusion of SE thinking within the domain manifestations of engineering.

INCOSE has a unique dual role to fulfill within ABET. Systems Engineering Centric (SEC) programs provide a primary oversight opportunity. Domain Centric SE Programs (DCSE) provide a secondary INCOSE opportunity. The latter should be pursued in collaboration with the participating bodies representing the domains of engineering.

Application of Program Criteria. Of all programs in the SE Centric category only 11, or 23%, exist at the basic level. In the Domain Centric SE program category, 39% are at the basic level. It is evident from this that Systems Engineering is developing mainly at the advanced level, especially in the SE Centric category. The INCOSE formal application, submitted to ABET more than one year ago, proposes to develop and implement criteria for both basic and advanced level SE accreditation.

ABET leaves it to the academic institution to choose the degree level at which it will seek program accreditation; that is, to declare whether the first professional degree for entry into the profession is to be at the basic or the advanced level. However, it is the policy and practice of most academic institutions to submit only basic or undergraduate programs for ABET accreditation. Herein is the opportunity for INCOSE to make available an independent professional assessment and certification of the scope and quality of academic programs at all degree levels. And, to do so worldwide.

Considering INCOSE Academic Certification

Although INCOSE is seeking participating body status within ABET, it is anticipated that it will become increasingly important for INCOSE to provide certification in addition to, and beyond, ABET accreditation. Some highlights are summarized in this section. For more detail see Fabrycky, W. J., *INCOSE Academic Certification: Participating in and Going Beyond ABET*, Fellows Edition of INCOSE Insight, Vol. 8, Issue 2, March 2006.

Emerging INCOSE as an Academic Leader. Attainment of participating body status within ABET, if pursued alone, will make INCOSE a good follower within academia, but not an outstanding leader. ABET accreditation is necessary but not sufficient for the effective advancement of systems engineering worldwide. INCOSE is, by design, international in its outlook and its mission.

This same propensity that compels most institutions to seek formal peer approval for basic academic programs in the form of programmatic accreditation through ABET will likely support the concept of INCOSE academic certification to cover the ABET void. The systems engineering "voice" of government, industry, and even academia will grow increasingly stronger as INCOSE continues to emerge as the lead international society for the SE body of systematic knowledge and professional practice.

The vision of INCOSE academic certification is predicated on the proposition that SE should continue to expand rapidly as a first professional degree at the graduate level. Professional graduate study in SE should be encouraged and recognized from an INCOSE perspective. Thus, academic certification is the suggested approach to emerge INCOSE as an academic leader internationally.

Preparing for Academic Certification. INCOSE is fortunate to have two distinguished groups of highly qualified individuals to call upon to enable and sustain academic certification, if and when deployed. The first is the population of INCOSE Fellows, now comprised of 50 persons. Many of these have been and continue to be engaged with SE academic programs, some in cooperation with INCOSE chapters. To view these remarkable INCOSE members, please go to *About INCOSE*, then to the *Hall of Leaders*, and then to *Fellows* on the INCOSE web site at www.incose.org.

The second group now being organized is Omega Alpha, the Systems Engineering Honor Society. Chartered in 2006, this Association is being established internationally to identify, recognize, and honor distinguished individuals who have a demonstrated record and a continuing commitment to advance Systems Engineering in academia. For an overview of the goals and objectives of Omega Alpha, please go to www.omegalpha.org

Conclusions and Recommendations

To be credible, INCOSE initiatives intended to influence systems engineering in academia must be based on an understanding of degree program structures and their administrative settings. Therefore, it is recommended that the partition of SE academic programs into SE Centric and Domain Centric SE categories be adopted as a guide when developing relations with academia, with the engineering domain societies, and with ABET. Conflict avoidance should be the goal.

Even though the population of SE Centric programs at the basic level is small, and although most academic institutions will not offer their graduate degree programs for ABET accreditation, it is essential that INCOSE continue to seek ABET participating body status. It is through attainment of this status that INCOSE will gain increased influence within academia as well as in the established community of engineering societies.

Domain Centric SE programs outnumber SE Centric programs by a factor of two. However, an INCOSE focus primarily on the SE Centric category is essential to remove the perceived threat to the inherent domains of established professional engineering societies. In any event, INCOSE does not have the resources to commit to the expense of accreditation for both the SEC and the DCSE academic populations.

Finally, and importantly, INCOSE participation in the accreditation processes of ABET is necessary but not sufficient for three reasons: 1) ABET is unlikely to embrace the full potential of Systems Engineering as promulgated by INCOSE, 2) Only a fraction of the degree programs in SE will likely be offered for ABET accreditation by academic institutions, and 3) The jurisdiction and influence of ABET is principally centered in the United States, whereas SE and INCOSE are steadily expanding worldwide. Therefore, it is recommended that INCOSE take steps to evaluate the feasibility and potential for academic program certification as suggested herein.

“INCOSE Academic Certification: Participating in and Going Beyond ABET”, Vol. 8, Issue 2, March 2006.

Fabrycky, W. J. and E. A. McCrae, “Systems Engineering Degree Programs in the United States”, *Proceedings, 15th Annual International Symposium*, INCOSE 2005, Rochester, NY, July 12, 2005.

Biography

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