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University Coursework as an Alternative to a Professional Certification Exam

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Abstract

The International Council on Systems Engineering (INCOSE) offers three levels of individual credentialing, two of which require participants to pass a standardized test, as shown in Figure 1. While the standardized test is an efficient way to test participants' knowledge of systems engineering, the newly introduced INCOSE's Academic Equivalency (AcEq) Program provides an alternate path to becoming certified systems engineer. AcEq allows participants to qualify for INCOSE certification through university coursework in lieu of the standardized test. The standard test is offered only in English and is a timed, multiple-choice test. AcEq assessments may be offered in any language, any assessment format, and need not be timed. INCOSE sets the requirements for a university to apply for its courses to be recognized with AcEq. Once AcEq is recognized, students who do well in those courses are credited with having met the knowledge requirement. The students must still apply for certification through the standard path.

The process of applying for AcEq involves a university documenting how their course (or courses) assess students against INCOSE's testing objectives. Describing how they assess knowledge is challenging for faculty members who are more accustomed to documenting teaching and content delivery. INCOSE does not require that universities teach the content within the recognized course(s). This allows for thesis or final project courses, often taught to a wide range of undergraduate students, to qualify for AcEq.

Academic Equivalency was designed to offer an alternate path for assessment in languages other than English, in countries outside the United States and Western Europe. Despite that intent, fourteen of the fifteen academic equivalencies are in the United States. The champions of these programs typically pursue AcEq as a way to provide structure to their courses. It should be noted that only a small portion of AcEq-qualifying students pursue and retain their INCOSE certification after graduation; this in part is due to some of the qualifying students being international students or local students fresh out of college.

INCOSE and systems engineering faculty members find value in having standardized content presented to future engineers. Success is not measured only in certifications but also in exposure to systems engineering knowledge needed to meet the increasing demands of engineers capable of working or executing on complex engineering projects.

Keywords: INCOSE, Certification, Coursework, Academic Equivalency

Introduction

The key point of this paper is to highlight the benefit of using university coursework to fulfill the knowledge requirement of professional certification. We examine universities offering industrial and systems engineering programs around the globe, with focus on those offering introductory courses in systems engineering within the context of INCOSE systems engineering competency framework, and who are participating members of INCOSE Acajdemic Equivalency program. With the Academic Equivalency program, university students enrolled in this program and wish to become INCOSE certified systems engineer can demonstrate their subject matter competency in systems engineering via university coursework. For each university program who wishes to pursue this alternate path, there are administrative and technical requirements to be met. Figure 2 and 3 show the breakdown of the administrative requirement and technical requirements.

In light of the demand by stakeholders from academia (to provide alternate certification paths for the students), and organization(to provide systems engineering training and education for their employees), INCOSE Certification implemented this course-based assessment to create a pipeline of competent systems engineers.

Certifications provide a recognizable level of skills and knowledge with an outcome of increased professional stature, while also providing an intangible asset to an employer, potential employer or client. These certifications also allow quicker entry into new job assignments or responsibilities [4]. This paper describes the need for university coursework, systems engineering skills, alternate certification pathway, and certified systems engineers.
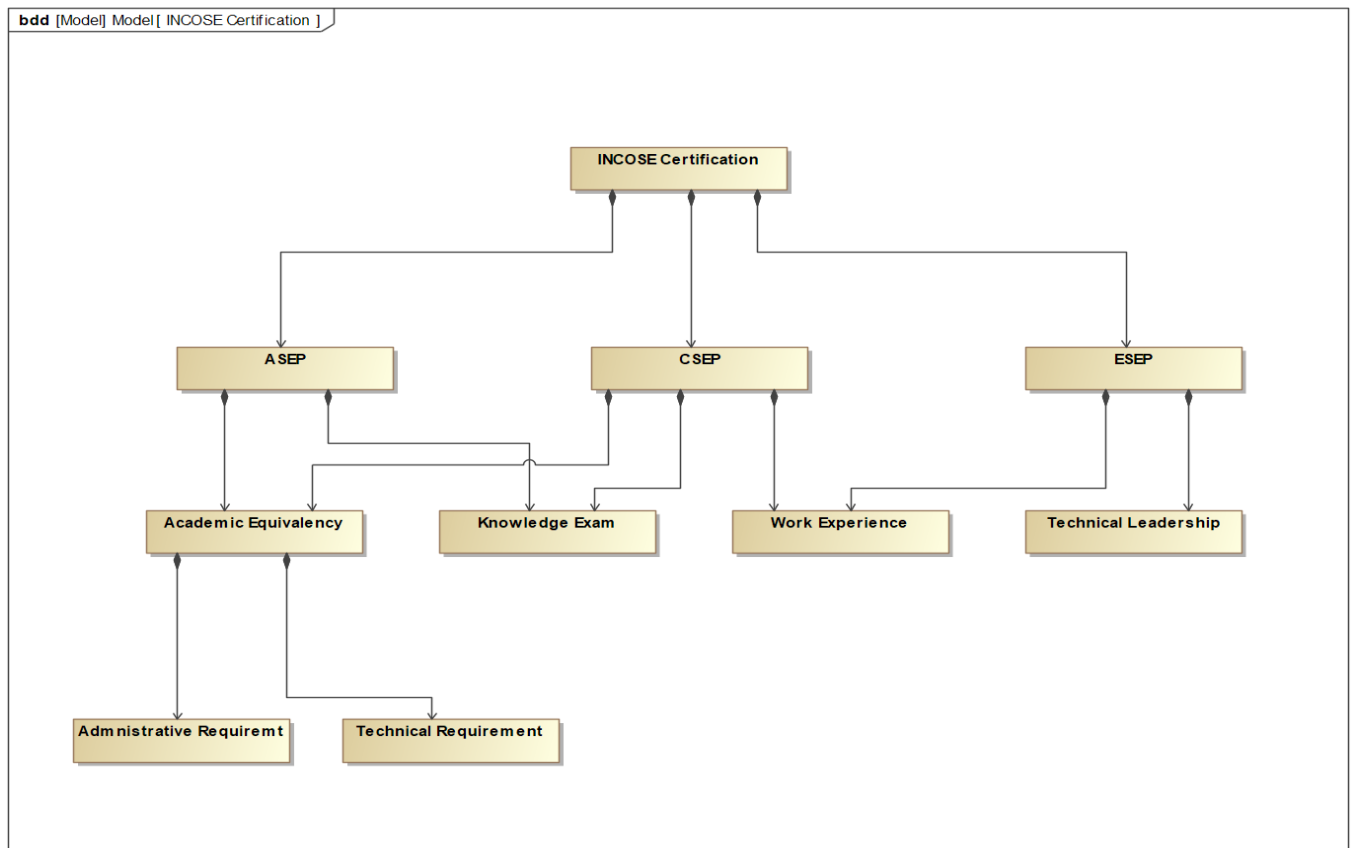

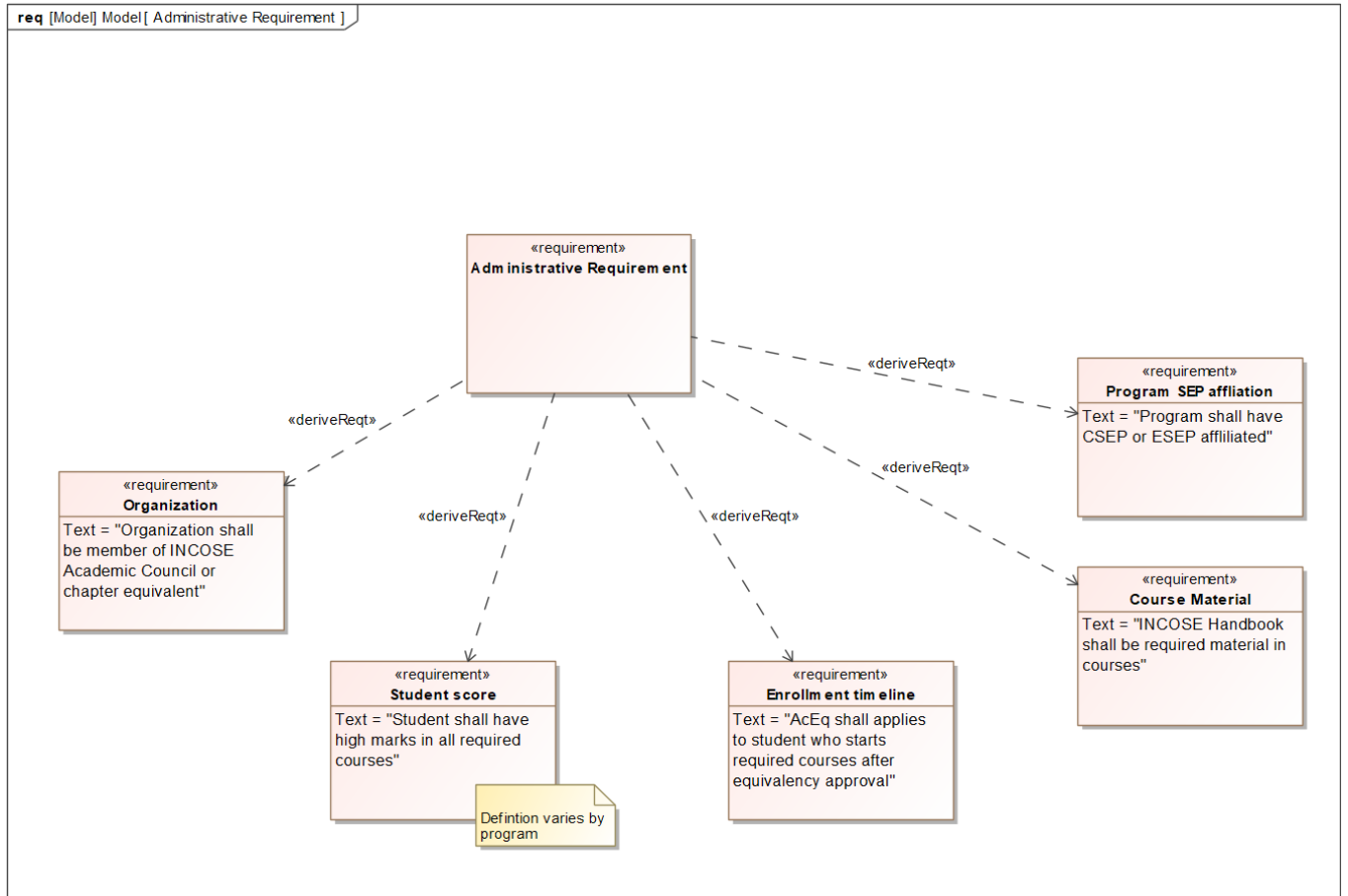Figure 1: INCOSE Certification Path and Requirements

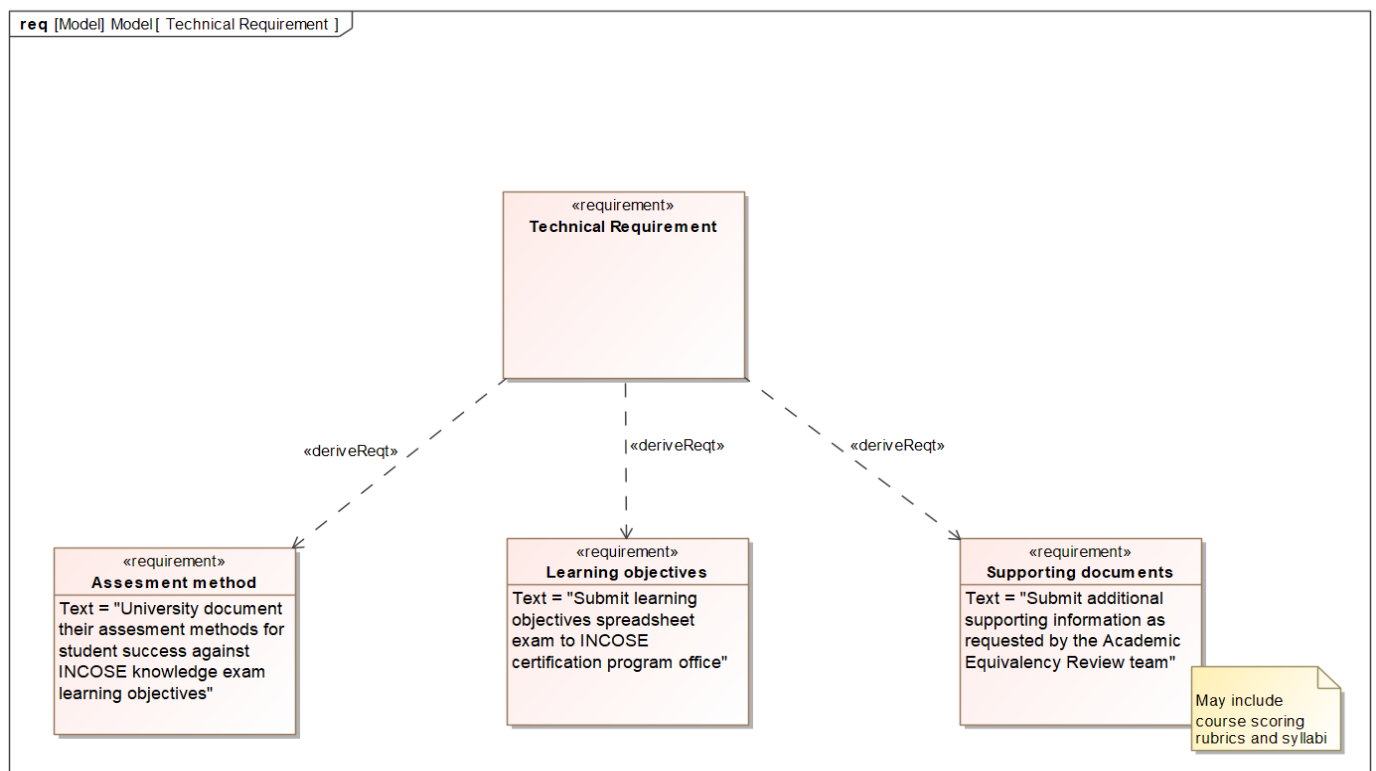Figure 2: Academic Equivalency administrative requirement

Figure 3: Academic Equivalency technical requirement

Why certifications matter

Professional certifications are a way to confirm and communicate an individual's abilities and interests. Holding a certification means both that an individual can pass an assessment (usually a test) and that they cared enough to attempt it. Professional assessment is so commonly used that the Association of Test Publishers (ATP) and Institute for Credentialing Excellence (ICE) hold multiple, international conferences and meetings annually to bring together certification program managers from the fields of accounting, dentistry, personal training, and water treatment, among many others [5].

Certification is particularly valuable when it can clearly distinguish something that was previously unclear. The distinction must be of value, which is why professional societies often host certifications. They are the parties that value the subtleties of their field the most.

The most valuable certifications cut across corporate and geographic boundaries. These are primary ways in which certifications differ from universities.

The relationship between certifications and university coursework

To understand the difference between certification and university coursework, it is useful to define terms. A publication from the Institute for Credentialing Excellence offers this distinction:

"Whereas the focus of an assessment-based certificate program is on education/training, the focus of professional/personnel certification is on the assessment of participants. Moreover, the assessment is independent of a specific class, course or other education/training program and also independent of any provider of classes, courses, or programs" [3]

In this paper, we will recognize a certification as coming from a professional society in contrast with coursework, a certificate, and a degree as coming from a university. The important distinction is that a certification program usually does not include education or training, only assessment. If it does include education or training, they are optional. A university program may produce a certificate and always includes education. This exclusion of education and training within a certification program are required to comply with ISO 17024 [8]. The distinction of what is assessed versus what is taught is important for INCOSE's Academic Equivalency, which will be described further in this paper.

The subject of systems engineering and its younger relation, Model-Based Systems Engineering (MBSE), has been taught both through theoretical, university-based education and through applied, job-focused training. There are currently 310 systems and industrial engineering programs in the Worldwide Directory of Systems Engineering and Industrial Engineering Programs [11]. While this number is high, there is lack of standardization across systems engineering education [9]. This is not inherently a problem but does mean that students with systems engineering degrees from different institutions may not have the same understanding of systems engineering principles or terms.

INCOSE's Certification Program, which is focused purely on assessment and excludes training and education from its scope, prioritizes common understanding for its participants. Its body of knowledge, the INCOSE Systems Engineering Handbook, is the basis of all knowledge assessments for certification.

Time scale of change

INCOSE's Systems Engineering Handbook Fifth Edition (SEH5E) will be published in the middle of 2023. The INCOSE Certification Program will pivot to recognize SEH5E within a month of that publication. This is enabled by the collaborative relationship between the SEH5E editors and the INCOSE Certification Program Office, allowing knowledge assessment developers to access a draft of the handbook prior to its publication. Because the certification program focuses only on assessment, there is much less content to update and that update can be done quickly.

INCOSE does not formally endorse or supervise training providers. However, it does have relationships with universities that teach courses based on the INCOSE Systems Engineering Handbook. When considering how much time to allow for universities to transition to SEH5E, the timeline is in years, rather than weeks or months. The time to update the handbook and to update education and training materials is much longer than the time to update just the assessment. The handbook was last updated in 2015, both times aligning with ISO 15288 [10].

Other shortfalls in a certification program

Certification programs are designed to be standardized, fair, and efficient. "The most efficient way to [measure baseline knowledge] is through a computer-delivered and computer-scored exam" [12]. These characteristics are sometimes in conflict, as a diverse audience may need different treatment to be equitable. This is a primary role of a certification program manager, to find the balance between opportunities for equity and risks of inequity and assessment security. The solution offered later in this paper addresses alternatives to the 2-hour, multiple-choice test offered only in English.

An international certification program is different even from an international education program in the lack of an established relationship and norms with the participants. A university is a bounded system with an ongoing relationship. This allows for the university to have, for instance, remote proctoring systems that compare a student's appearance across multiple exams. INCOSE's relationship with candidates is shorter, with less of a commitment for someone to initiate that relationship. This makes INCOSE more susceptible to attempts at cheating and with lesser consequences to those who are caught.

"The INCOSE Certification Program has an increasingly diverse set of stakeholders. Some elements of that diversity include the geographic regions from which candidates come and the languages they speak. Diversity also includes the type of systems on which individuals work and their job titles" [12]. With approximately ¼ of INCOSE candidates coming from countries where English is not the primary language [7], INCOSE has developed alternate assessment methods that do not rely on the English language. Many non-native- English-speakers still choose to participate in the English language assessments and application process, however, and INCOSE accepts responsibility to make its materials (including instructions, application forms, and marketing materials) accessible to language translation tools.

The assessment-only nature of a certification program can be seen as a shortfall for those who do not feel prepared to be successful in the assessment based on their prior education and work experience [2]. Training and education programs have developed in response to INCOSE's Certification Program, filling in this market demand.

What a system of systems certification program looks like

The INCOSE Certification Program controls its requirements but does not directly oversee all of the activities of communicating or assessing against those requirements. Its constituent parts contribute toward the objectives of the Certification Program but are not necessarily aware or intentional about those contributions. The constituent systems all have objectives or their own. In these ways, the Certification Program is a system of systems. As can be seen in Figure 4, the certification system interfaces with other systems to work effectively.

The system of systems structure makes the INCOSE Certification Program modular. This modularity makes it easier for the program to respond to changes that do not affect all parts. It also allows for differentiation for various stakeholder groups, addressing the equity and security concerns. One example of this modularity is in the variety of ways in which the knowledge exam is administered. The exam is offered as a workshop at INCOSE conferences; as a stand-alone event hosted in a board room or in a university classroom; and online with remote, video proctors. In most in-person offerings, all instructions are given in English. In China, however, candidate instructions are delivered in Chinese. All candidates with a mother language other than English are allowed extra time and a translation dictionary.

As shown in Figure 5, beyond the exam options listed above, offered by INCOSE Central, the knowledge requirement can be met through other assessment means. Candidates in Germany can take a combined training and assessment course fully in German; candidates from the US military can get knowledge credit for their coursework from the Defense Acquisition University (DAU); and candidates at 14 recognized universities can prove their knowledge through whatever assessments their university has had approved by INCOSE. Many of these assessments are projects where they apply systems engineering principles to a real-world situation. These students do not have to take multiple-choice tests if their professors choose to assess them in another way, and there is no requirement that the university assessments be performed in English. INCOSE's program of giving credit for coursework is called Academic Equivalency.
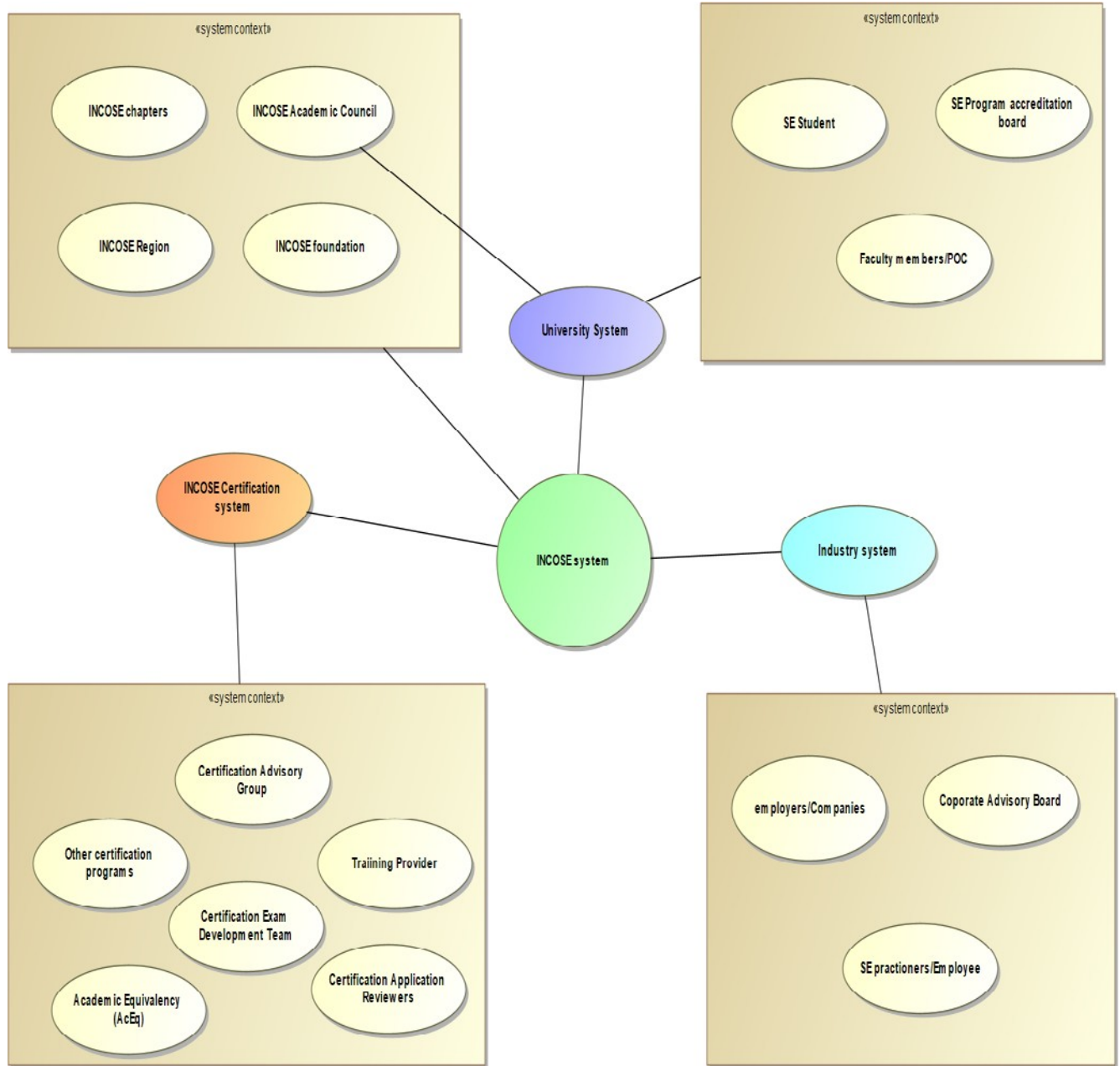
Figure 4: System of systems and constituents relationship with certification capability

Opportunities of decentralized certifications

Just as universities can accept transfer credits or AP scores as a substitute for a course, so can a certification program accept alternative assessment methods than its own. According to the Institute for Credentialing Excellence, "Any generally accepted assessment method may be utilized for conducting the summative assessment" [3]. With Academic Equivalency, universities can work with their community to determine the best method of assessment. Further, because INCOSE only looks at the assessment and not at the lecture or other teaching methods or content (other than requiring the INCOSE SE Handbook to

be part of the course materials), courses may focus on projects and topics most relevant to their students. Several academic equivalency programs are offered for courses tailored to a specific employer or industry. The courses do not have to be in a systems engineering department nor does INCOSE put restrictions on the instructors.

INCOSE's academic equivalency was created for the purpose of equity – particularly to offer knowledge assessment in languages other than English and with cultural adjustments for non-Western countries. It was a surprise, then, that every application to the program received so far has been from native English-speaking country, with only one outside the US (Australia), as can be seen in Figure 5. Most of the assessments at the universities are still tests and quizzes. The motivation at the university level does not seem to be for the sake of students, although many students have reported choosing the university coursework so that they can avoid the pressure of a single, two-hour exam with no more study guide than knowing that all content comes from the INCOSE SE Handbook.
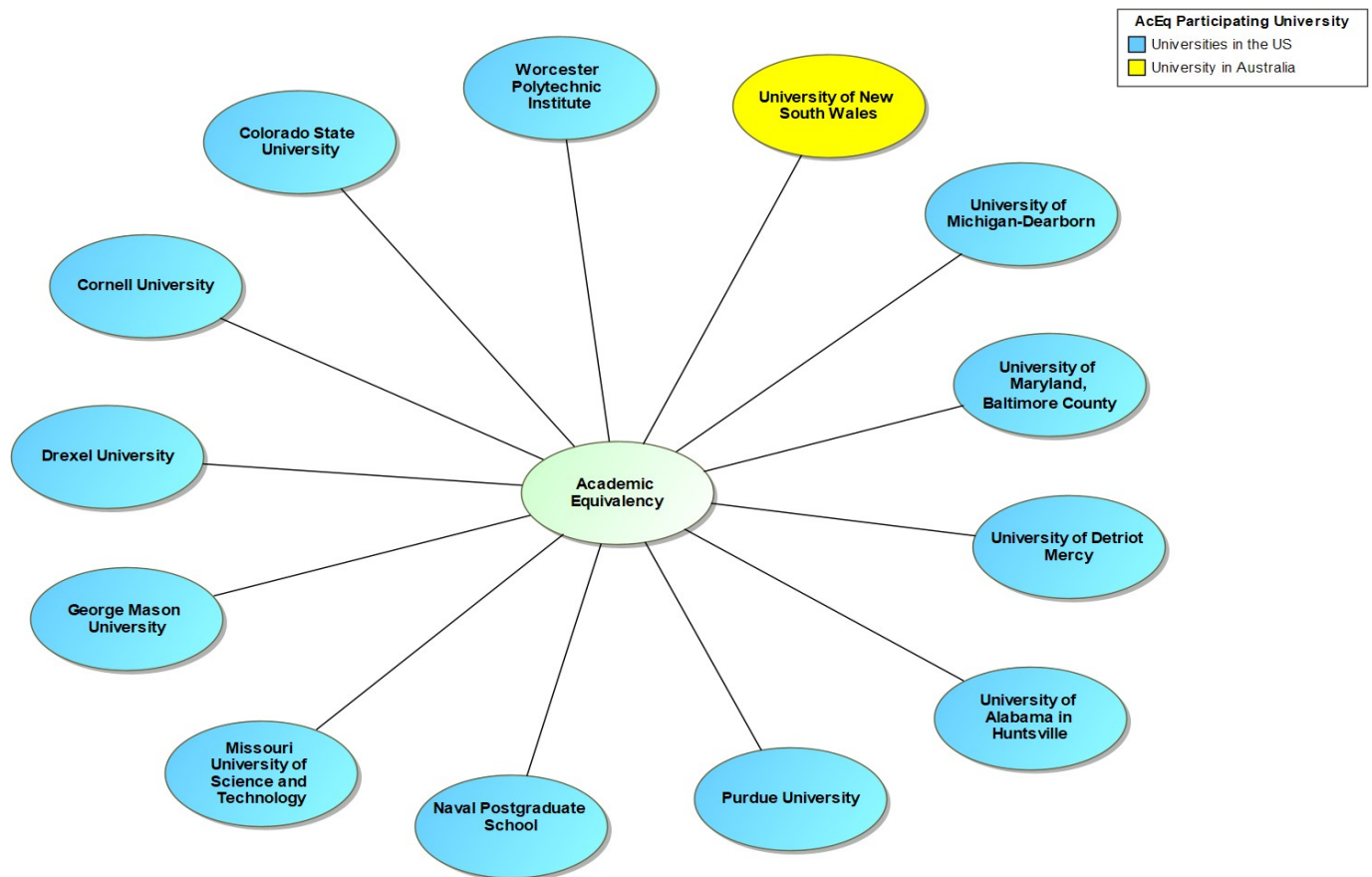
Figure 5: Universities with Academic Equivalency agreement

Anecdotal reports to the INCOSE Certification Program Office suggest that industry is increasingly asking local universities to offer academic equivalency as a way to educate their workforce in a way that is consistent with global expectations for their career field. Just as certification provides consistency of assessment, academic equivalency offers an endorsement

that a course will cover a standard set of topics. Academic Equivalency is given to a course or set of courses, not to a degree, a university, or a professor.

INCOSE's Certification Program is affected in both positive and negative ways by being a system of systems (SoS). It benefits from constituent systems that are appropriate for subsets of stakeholders. Emergent behaviors of the SoS such as training programs and internal corporate activities offer the benefits of making certification more easily achieved and more valuable [6].

Drawbacks of decentralized certifications

The common resistance offered by professors when they are asked about Academic Equivalency is that it will be too much work. It does not require submission of assignments or sample works. Three professors have found the process worthwhile enough that they submitted a second course (or set of courses) for equivalency after their first was approved.

Another concern raised by the existence of the academic equivalency program is the influence that INCOSE has over a course once academic equivalency is approved. Dr. Beth Wilson, ESEP, of Worcester Polytechnic Institute describes her configuration management process as putting a star on the slides and exam questions that can't change. Other instructors of the academic equivalency course are advised to change other materials and textbooks as they wish. If they do make changes to the starred content, the university must reach out to notify INCOSE. Unless they have eliminated a necessary assignment, such a change will be immediately approved.

The final concern related to decentralized certifications, including academic equivalency, is the transfer of data across parties. This is a risk, just as any third party raises concerns about data security. The primary mitigation INCOSE applies for this risk is to reduce the information transferred between parties. INCOSE asks that the university keep student grades to itself. The only information transferred from a university to INCOSE is a list of students who have met the academic equivalency requirement. These students must have achieved a minimum score in the recognized course(s), but that score is used as a filter and is not transferred with the student names.

Success to date

In its first three years of operation, from 2019 through 2021, over 1100 students qualified for INCOSE Certification through university coursework [1]. Although these universities are mostly in the US, students have come from around the globe. By 2025, INCOSE expects academic equivalency to be the primary way in which candidates from Africa and South America gain INCOSE Certification. INCOSE certification is driving the addition of standardized systems engineering texts and concepts in university courses, to the benefit of industry. As the INCOSE motto states, academic equivalency is driving "a better world through a systems approach."

Future Direction

The INCOSE Foundation – a non-profit arm of INCOSE – has a Global Membership Initiative to expand the benefits of INCOSE membership and systems engineering awareness into Africa and South America. Academic Equivalency is one of the key parts of this initiative. Several of INCOSE's US-based Academic Equivalency university champions have offered educational materials or consulting advice to new universities that are just starting their systems engineering programs. Across different countries, cultures, and domains, these universities see little competition and significant benefit from sharing materials and experiences. Their students will benefit from the common terms and explanations they will all be required to learn, though they are likely to be taught in different ways, customized at each university.

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