AC 2007-584: THE TURABO DECLARATION AND THE ENGINEERING EDUCATION CAPABILITY MATURITY MODEL: LACCEI INITIATIVES TO IMPROVE LATIN AMERICAN AND CARIBBEAN ENGINEERING PROGRAM ACCREDITATION AND RECOGNITION

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The Turabo Declaration and the Engineering Education Capability Maturity Model: LACCEI initiatives to improve Latin American and Caribbean engineering program accreditation and recognition

Abstract

The Latin American and Caribbean Consortium of Engineering Institutions (LACCEI) is a non-profit organization formed by institutions seeking to improve collaborations with and recognition of engineering programs in Latin America and the Caribbean (LAC). Two LACCEI initiatives seek to improve international recognition of Latin America and Caribbean engineering programs by increasing the number that attains internationally recognized accreditation. In 2004, the Accreditation Committee of LACCEI proposed a five-level model for educational program process assessment that measures the capability of an engineering education program to achieve repeatable results. This model, called the *Engineering Education Capability Maturity Model*, could be used as a blueprint for engineering programs to move systematically towards program accreditation, a program ranked level three has documented they produce "competent" engineers, one that attains level five produces "competitive" engineers. In 2006, LACCEI and the Organization of American States co-sponsored a workshop to formulate strategies to increase the number of accredited LAC engineering programs. In this workshop, the accrediting agencies that have signed the Washington Accord and have assessed programs in this region, regional engineering educational organizations, and engineering deans formed round tables to discuss regional challenges and strategies. The results, captured in a document called *The Turabo Declaration*, are discussed in this paper. LACCEI initiated an accord, called the *Engineering Collaboration for the Americas*, signed by six multinational organizations to advance and implement LAC engineering education initiatives. This paper disseminates and seeks feedback on the models and strategies evolving from these initiatives.

Introduction

Mobility in this global economy requires either the international recognition of engineering degrees, or undergoing an evaluation to deem the degree equivalent to an accredited degree. In the context of this paper, an accredited degree program is defined as one that has attained the approval of an internationally-recognized, national or extra-national quality assurance system that is independent from the system that offers the program and to which the degree granting system has voluntarily submitted the program for review.

Accords and agreements are allowing recognition of engineering degrees beyond national boundaries. Europe formed the Fédération Européene d'Associations Nationales d'Ingénieurs (FEANI) in 1951 to start standardizing the European Engineer (EUR ING) degree. In the Americas, the American Board for Engineering and Technology (ABET) and the Canadian Engineering Accreditation Board (CEAB) signed an agreement in 1979 to mutually recognized

programs accredited by these two organizations. In 1989, the Washington Accord was signed by eight countries to mutually recognized engineering degrees accredited by their national engineering program accrediting agencies, and other countries have since become signatories or provisional signatories, see Table 1. The Sydney and Dublin Accords, created in 2001 and 2002 respectively, did the same for the recognition of technical engineering degrees. In 1999 the Bologna Declaration was signed by 40 countries to create European Higher Education by 2010. In 2002, the Engineers Mobility Forum and the Technical Engineers Mobility Forum created the International Registry for Professional Engineers (IRoPE)[1] to facilitate global mobility, and requires a degree equivalent to an accredited degree. In 2004, the European Commission started the EUR-ACE[2,3] program to help establish a European Engineering Accreditation System.

Table 1. Signers of the Washington Accord to Recognize Engineering Programs

COUNTRY	SIGNERS OF WASHINGTON ACCORD
Australia	The Institution of Engineers, Australia (IEAust) Association of Professional Engineers, Scientists and Managers, Australia (APESMA)
Canada	Canadian Engineering Accreditation Board (CEAB) Canadian Council of Professional Engineers (CCPE)
Hong Kong	The Hong Kong Institution of Engineers (HKIE)
Ireland	The Institution of Engineers of Ireland (IEI)
Japan	Japan Accreditation Board for Engineering Education (JABEE)
New Zealand	The Institution of Professional Engineers, New Zealand (IPENZ)
South Africa	The Engineering Council of South Africa (ECSA)
United Kingdom	Engineering Council United Kingdom (ECUK)
United States of America	Engineering Credentials Evaluation International of the American Board of Engineering and Technology (ECEI of the ABET)
PROVISIONAL SIGNATORIES	
Germany	
Malaysia	
Singapore	

No Latin American nor Caribbean countries are represented in any of the agreements cited above, thus putting engineers educated in this region at a disadvantage in terms of mobility and competitiveness. This paper examines some of the efforts to strengthen engineering programs in the Latin American and Caribbean (LAC) region and to increase their recognition and accreditation. It focuses on initiatives by the Latin American and Caribbean Consortium of Engineering Institutions (LACCEI), a non-profit organization formed in 2002 by institutions seeking to improve collaborations with and recognition of engineering programs in this region.

Two LACCEI initiatives aim to improve international recognition of LAC engineering programs by increasing the number that attains internationally recognized accreditation. In 2004, the Accreditation Committee of LACCEI proposed a five-level model for educational program process assessment that measures the capability of an engineering education program to achieve repeatable results. This model, called the *Engineering Education Capability Maturity Model*, could be used as a blueprint for engineering programs to move systematically towards program accreditation. In 2006, LACCEI and the Organization of American States (OAS) co-sponsored a workshop in Puerto Rico to formulate strategies to improve the number of LAC engineering

programs accredited. The recommendations received at this workshop were gathered in a document called T*he Turabo Declaration*. In 2006, LACCEI initiated an agreement signed by six multinational organizations to advance LAC strategies. We present these initiates and conclude by seeking feedback and collaboration to advance these initiatives.

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In the next section, we examine the state of national engineering accreditation systems and engineering program degree recognition and accreditation in the LAC region.

State of Accreditation and Program Recognition in Latin America and the Caribbean

Degree recognition begins with an internationally-recognized national accrediting agency. The International Network for Quality Assurance Agencies in Higher Education (INQAAHE) [4] is the international organization that recognizes accrediting agencies. Only fourteen accrediting agencies from ten LAC countries are members of INQAAHE. As Table 2 shows, there are many countries in Latin American and the Caribbean that may not have accrediting agencies for higher education, or have not taken the necessary steps to get international recognition for their accrediting agencies. The agencies in Table 2, accredit institutions in general, although may accredit engineering programs also, such as Argentina´s CONEAU.

Table 2. Latin American and Caribbean Accrediting Agencies Members of INQAAHE[4]

COUNTRY	ACCREDITING AGENCY
Argentina	CONEAU - Comision Nacional de Evaluacion y Acreditacion Universitaria) – Argentinian Commission for Evaluation and Accreditation
Bahamas	Quality Assurance Unit. The Bahamas Ministry of Education
Chile	CNAP - Comision Nacional De Acreditacion De Pregrado - National Commision of Accreditation Consejo Superior de Education – High Council of Education
Colombia	Consejo Nacional de Acreditación – Colombian nacional Accreditation Council
Costa Rica	CCA - Consejo Centroamericano de Acreditación de la Educación Superior - Central American Council of Accreditation of Higher Education SINAES - Sistema Nacional de Acreditación de la Educación Superior – Nacional Higher Education Accreditation System
Guatemala	CSUCA - Consejo Superior Universitario Centroamericano – Central American University High Council
Jamaica	UCJ - The University Council of Jamaica NCTVET - National Council on Technical and Vocational Education and Training
México	CONAEVA - Comisión Nacional para la Evaluación de la Educación Superior – Nacional Council for the Evaluation of Higher Education COPAES - Consejo para la Acreditación de la Educación Superior - Higher Education Accreditation Council
Perú	(Associate Member) - Consorcio de Universidades – Consortium of Universities
Trinidad and Tobago	CORD - Committee on the Recognition of Degrees

Table 3 lists internationally-recognized engineering program accrediting agencies. Again the list does not include any agencies in the LAC region. This may indicate that in this region, many governments and universities still have not recognized the importance of separating the quality assurance system from the process of authorization or licensure of higher education institutions to offer academic programs or grant academic degrees. In general, the Latin America and the Caribbean national accreditation systems are general and not specialized in nature, offering mostly institutional accreditation and not program accreditation. This differs from the US accreditation system, where there are three separate levels of differentiation accreditation of engineering programs:

Table 3. Recognized National Accrediting Bodies for Engineering Programs

COUNTRY	ACCREDITING AGENCY
Australia	The Institution of Engineers, Australia – *Signatory Washington & Sydney Accords, APEC Engineers Register , Engineers Mobility Forum (IRoPE)*
Bangladesh	Institution of Engineers Bangladesh - *Provisional signatory to Engineers Mobility Forum (IRoPE)*
Canada	The Canadian Council of Professional Engineers - *Signatory Washington Accord, APEC Engineers Register, Engineers Mobility Forum (International Register of Professional Engineers).* The Canadian Council of Technicians and Technologists - *Signatory Sydney Accord. Provincial member organizations.*
France	Conseil National des Ingenieurs et des Scientifiques de France - *French prof. engineers org.* Commission des Titres D'Ingenieur - *French engineering courses accreditation body*
Germany	Accreditation Agency for Study Programs in Engineering, Informatics, Natural Sciences, and Mathematics (ASIIN) - *Provisional signatory to Washington Accord* Verein Deutscher Ingenieure (VDI) - *The Association of Engineers* Verband der Elektrotechnik Elektronik Informationstechnik (VDE)
Hong Kong-China	The Hong Kong Institution of Engineers - *Signatory Washington & Sydney Accords, APEC Engineers Register, Engineers Mobility Forum (International Register of Professional Engineers)*
India	National Board of Accreditation - *Indian technical subjects accreditation body* Institution of Engineers of India - *Provisional signatory [with Engineering Council India) to Engineers Mobility Forum (IRoPE)*
Indonesia	The Institution of Engineers, Indonesia - *Signatory to APEC Engineers Register*
Ireland	The Institution of Engineers of Ireland - *Signatory to Washington, Sydney & Dublin Accords, and Engineers Mobility Forum (IRoPE); member of FEANI*
Italy	Consiglio Nazionale Ingegneri - *Member of FEANI*
Japan	Japan Accreditation Board for Engineering Education - *Signatory Washington Accord* Institution of Professional Engineers Japan - *Signatory to APEC Engineers Register and Engineers Mobility Forum (IRoPE)*
Korea	Korean Professional Engineers Association - *Signatory to APEC Engineers Register and Engineers Mobility Forum (IRoPE)*
Malaysia	Board of Engineers Malaysia - *Provisional signatory to Washington Accord* Institution of Engineers Malaysia - *Professional engineering institution*
New Zealand	The Institution of Professional Engineers, New Zealand - *Signatory Washington & Sydney Accords, APEC Engineers Register, Engineers Mobility Forum (IRoPE)*
Pakistan	Pakistan Engineering Council
Russia	Russian Association for Engineering Education Accreditation Board
Singapore	Institution of Engineers Singapore - *Provisional signatory to Washington Accord* Professional Engineers Board - *Professional Engineers registration body*
South Africa	The Engineering Council of South Africa - *Signatory to Washington, Sydney & Dublin Accords, and Engineers Mobility Forum (IRoPE). Provincial Member Organizations*
Sri Lanka	Institution of Engineers Sri Lanka
Thailand	Thai Professional Engineering Board - *Signatory to APEC Engineers Register*
UK	Engineering Council of the United Kingdom (ECUK) - *Signatory Washington & Sydney Accords*
USA	The Accreditation Board for Engineering & Technology - *Signatory to Washington Accord* National Council of Examiners for Engineering and Surveying - *Licensure Exams, State Licensure Boards* United States Council for International Engineering Practice - *Signatory to APEC Engineers Register and Engineers Mobility Forum (IRoPE)*
OTHER ENGINEERING FEDERATION ORGANIZATIONS	
Europe	FEANI - *Pan-European Federation of National Engineering Associations (25 national members)* EurEta - *The European Higher Engineering and Technical Professionals Association* SEFI - *European Society for Engineering Education*
Outside Europe	APEC - *Asia Pacific Economic Cooperation* CEC - *Commonwealth Engineers Council* Washington Accord - *International mutual recognition agreement of accredited professional engineering programs* WFEO - *World Federation of Engineering Organisations*

Note: IRoPE = International Registry of Professional Engineers

1. The State generally authorizes or licenses institutions to offer the degree program.
2. The general accreditation of the institution is done by regional accreditation systems that are authorized by the Federal Department of Education.
3. The accreditation of a specialized engineering program is done by ABET.

In 1995, the economic bloc, called Mercosur[5], was created, originally involving Brazil, Argentina, Paraguay and Uruguay, and, currently, six associated nations: Bolivia, Chile, Colombia, Ecuador, Peru and Venezuela. It proposes to promote free exchange and mobility of goods, persons and capital among the nations in the block, and to advance greater political and cultural integration between its member nations and associated nations. Recently the member countries adopted that both the Spanish and the Portuguese languages will be taught in each of the four countries, to improve mobility and facilitate communications among professionals. This brings this region a step closer to globalization. In the future it will consider a wider integration in many levels, including similar educational systems. Mercosur created an experimental mechanism of professional title recognition, called MEXA (Mecanismo Experimental de Carreras, in English: Experimental Mechanism for Professional Programs), for recognizing degrees from academic programs in member countries and associates of Mercosur, in the fields of agronomy, engineering and medicine. Chile's accrediting agency, Comisión Nacional de Acreditación (CNAP) lists only five MEXA accredited programs, all in agronomy. No other information was found on the web on engineering programs that have attained MEXA accreditation. This lack of easily available online information limits the recognition of programs that have attained MEXA accreditation.

In the LAC region there are four accreditation councils:

- Consejo Andino (Andean Council): Colombia Venezuela, Peru, Ecuador and Bolivia
- Consejo Brasileño (Brazilial Council): Rio de Janeiro, Brasilia, Southern Brazil, Bahia, Minas Gerais
- CAPANA (Central America and Panama): Costa Rica, El Salvador, Guatemala, Honduras and Nicaragua
- CACEI (Consejo de Acreditación de la Enseñanza de Ingeniería; in English: Engineering Education Accreditation Council): Mexico

Argentina, Chile, Uruguay and the Caribbean are not represented by Councils.

Some Memoranda of Understanding have been signed by Latin American and Caribbean organizations and institutions with an interest toward substantial equivalences. In 2001, the *Declaración de Monte Alban*[6] was signed in Oaxaca, Mexico by representatives of engineering education in Argentina, Bolivia, Chile, Colombia, Costa Rica, El Salvador, Mexico, Paraguay, and Spain. They agreed on four points:

1. To develop compatible systems for engineering program accreditation.
2. To develop accreditation systems that would eventually mutually recognize each other, and would participate in the operation of those currently existing.
3. To seek recognition of "substantial equivalences" of their engineering quality assurance and accreditation systems, both the ones already existing and those under development, in order to improve engineering education, professional mobility, the interchange of information and experiences, and professional and academic knowledge.
4. To interchange experiences through consulting and mobility of peer evaluators.

In 2002, Mexico's Consejo de Acreditación de la Enseñanza de la Ingeniería (CACEI, in English: The Mexican Engineering Education Accreditation Council) signed with ABET and CEAB/CCPE a Memorandum of Understanding, titled the *Western Hemisphere Initiative*[7], where they agree to collaborate in building regional capacity in the western hemisphere that fosters the establishment of sustainable national quality assurance systems, and to promote mutual recognition of educational quality assurance systems among nations in the Western Hemisphere[7b]. Three countries (Mexico, Argentina and Peru) have signed Memorandum of Understanding with ABET to have ABET recognize the programs accredited by their respective national engineering accrediting bodies. Mexico's CACEI has accredited more than 285 engineering and science programs and 32 technical programs in Mexico. Argentina's CONEAU accredits both undergraduate and graduate engineering programs. Peru's ICASIT (Instituto de la Calidad en la Acreditación de las Carreras de Ingeniería y Tecnología; in English: Institute for Accreditation Quality of Engineering and Technology Degrees) accredited their first engineering program with the assistance of ABET in 2006. However, no information was found on the web listing the programs that these three agencies have accredited.

In 2003, UNESCO's International Institute for Higher Education in Latin America and the Caribbean (IESALC - Instituto Internacional para la Educación Superior en América Latina y el Caribe) helped establish the Ibero-American Network for the Evaluation and Accreditation of Quality of Higher Education (RIACES[8] - Red Iberoamericana para la Acreditación de la Calidad de la Educación Superior) to assist LAC nations with their evaluation and accreditation systems.

Engineering degrees from a country without a recognized national engineering accreditation system, or whose national engineering accreditation system has not signed the Washington Accord, can seek *Substantial Equivalency* to international-recognized accredited engineering programs. For an individual degree, the engineer pays a Washington Accord signatory for an evaluation. For an engineering program, the institution undergoes, through a Washington Accord signatory, a process similar to the accreditation process and obtains Substantial Equivalency. Table 4 lists LAC engineering programs that are deemed Substantially Equivalent or been accredited by ABET. It should be noted that universities in Puerto Rico for all intent and purposes are considered institutions of the United States, and therefore can attain ABET accreditation instead of Substantial Equivalence.

Table 5 shows those LAC engineering programs deemed Substantially Equivalent by CEAB. Note all seven programs listed are in Costa Rica. The Engineering Council UK (EC^{UK}) also has accredited LAC programs, such as the University of West Indies – Trinidad & Tobago, but a complete list of the EC^{UK} Substantially Equivalent engineering programs was not readily available online. A web search yielded only thirteen LAC institutions that had successfully attained Substantial Equivalence for engineering programs.

The next section describes two LACCEI initiatives that focus on increasing the number of LAC engineering programs that attain international recognition and accreditation.

Table 4. Latin American and Caribbean Engineering Programs Accredited* or deemed Substantially Equivalent by ABET

COUNTRY	INSTITUTION & PROGRAM [year of accreditation]
Chile	**Pontificia Universidad Católica de Chile**, Santiago, Chile Chemical Engineering [2003] Civil Engineering [2003] Computer Engineering [2003] Electrical Engineering [2003] Mechanical Engineering [2003]
México	**Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM)** **ITESM – Campus Monterrey,** Monterrey, México Chemical & Industrial Engineering [1992] Chemical & Systems Engineering [1992] Civil Engineering [1992] Computer Systems Engineering [2001] Electronics & Communications Engineering [1992] Industrial & Systems Engineering [1992] Mechanical & Electrical Engineering [1992] Mechanical & Industrial Engineering [1992] **ITESM – Campus Ciudad México,** México D.F., México Electronics & Communications Engineering [2003] Industrial & Systems Engineering [2003] Mechanical Engineering [2003] **ITESM – Campus Estado de M éxico,** México D.F., México Electronics & Communications Engineering [2002] Electronics & Computer Engineering [2002] Industrial & Systems Engineering [2002] Mechanical Engineering [2002] **ITESM – Campus Querétaro,** Querétaro, México Computer Systems Engineering [1993] Electronic Systems Engineering [1993] Electronics & Communications Engineering [1993] Industrial & Systems Engineering [1993] Mechanical & Industrial Engineering [1993] **ITESM – Campus San Luís Potosí,** San Luís Potosí, México Industrial and Systems Engineering [2004] **Universidad Autónoma de Nuevo León**, San Nicolás de los Garza, México Civil Engineering [2004]
Puerto Rico	**Universidad de Puerto Rico – Mayagüez**, Mayagüez, Puerto Rico Chemical Engineering [1970]* Civil Engineering [1960]* Computer Engineering [1994]* Electrical Engineering [1960]* Industrial Engineering [1970]* Mechanical Engineering [1960]* **Universidad del Turabo**, Gurabo, Puerto Rico Mechanical Engineering [2005]* **Universidad Politécnica de Puerto Rico**, San Juan, Puerto Rico Civil Engineering [1996]* Electrical Engineering [1996]* Environmental Engineering [2002]* Industrial Engineering [1996]* Mechanical Engineering [1996]*

Table 5. CEAB Substantial Equivalent Latin American and Caribbean Engineering Programs

COUNTRY	INSTITUTION AND PROGRAM [year of accreditation]
Costa Rica	**Universidad de Costa Rica** – San José Ingeniería Civil [1999] Ingenieria Industrial [2000] Ingeniería Eléctrica [2000] **Instituto Tecnológico de Costa Rica** - Cartago Ingeniería de Construcción [2001] Ingeniería Electronica [2004] Ingeniería de Industrial de Mantenimiento [2001] Ingeniería Industrial de Producción [2004]

LACCEI Initiatives for Recognition and Accreditation of LAC Engineering Programs

The Latin American and Caribbean Consortium of Engineering Institutions (LACCEI) is a non-profit organization formed in 2002 by institutions and organizations seeking to improve collaborations with and recognition of engineering programs in Latin America and the Caribbean. Two LACCEI initiatives seek to improve international recognition of Latin America and Caribbean engineering programs by increasing the number that attains internationally recognized accreditation. In 2004, the Accreditation Committee of LACCEI proposed a five-level model for educational program process assessment that measures the capability of an engineering education program to achieve repeatable results. This model, called the Engineering Education Capability Maturity Model, could be used as a blueprint for engineering programs to move systematically towards program accreditation. In 2006, LACCEI and the Organization of American States co-sponsored a workshop in Puerto Rico to formulate strategies to improve the number of LAC engineering programs accredited by international-recognized systems. In the following sections we describe the model and the results of the workshop in detail.

Engineering Education Capability Maturity Model

Current accreditation processes are binary, the program either gets accredited or not. A multi-level model to facilitate the process of going through accreditation and to help find peers could increase the number of LAC programs that sought accreditation. The proposed model is based on a five-level process improvement model proposed in 1995 at Carnegie Mellon University, called the Capability Maturity Model (CMM)[9]. The CMM measures an organization's *process capability*, i.e. the inherent ability of a process to produce planned results. As the process capability increases, the results become predictable and measurable, and the most significant causes of poor quality and productivity are controlled or eliminated. The multiple levels, success in implementation, acceptance and maturation of the CMM made it attractive for application to improve the process of preparing for engineering program accreditation.

In the CMM Model, shown in Figure 1, principles and practices that lead to better outcomes are organized in five levels, giving a path to incremental adoption of best practices, more process visibility and control, and improved outcomes. Each level forms a foundation from which to achieve the next level, so trying to skip maturity levels could be counterproductive. An organization can adopt specific process improvements at any time; however, processes without proper foundation fail under stress. Following the CMM framework tends to produce stability in process improvement since the required foundations have been successfully institutionalized.

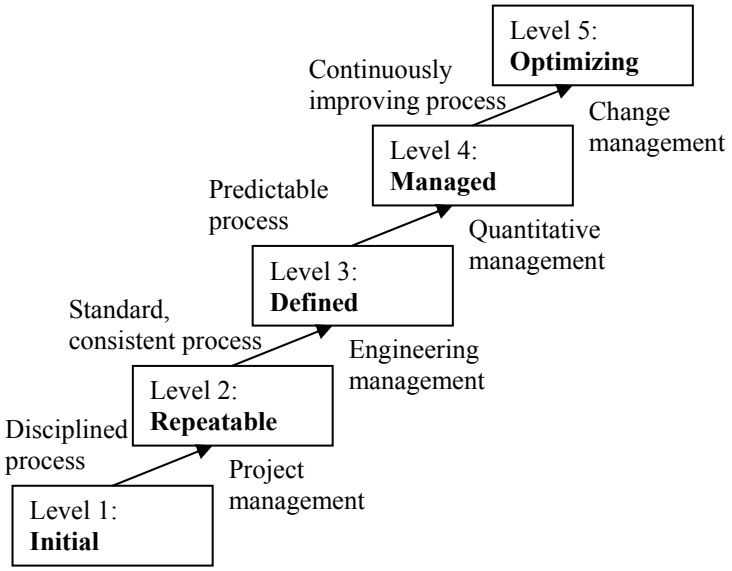

Figure 1: The Five Stages or Maturity Levels of the Capability Maturity Model[9]

Except for Level 1, each maturity level has the internal structure shown in Figure 2. A maturity level indicates a capability to perform a process with predictable results and is associated with a set of key process areas on which an organization should focus as part of its improvement effort in order to achieve their goals. Each key process area is organized into five sections called common features:

- *Commitment to perform* – the policies, leadership practices and actions that ensure that the establishment and continued use of the process
- *Ability to perform* –the practices that address resources, training, orientation, tools, and organizational structure that ensure that the organization is capable of implementing the process.
- *Activities performed* – the practices that address plans, procedures, the work performed, corrective action, and tracking.
- *Measurement and analysis* – the process measurement and analysis practices that ensure that procedures are in place to measure the process and analyze the measurements.
- *Verifying implementation* – the management reviews and audits practices that ensure that activities comply with the established process.

These common features specify the key practices described by activities or infrastructure, that when collectively addressed accomplish the goals of the key process area. An organization is satisfies a key process area when the process area is both implemented and institutionalized.

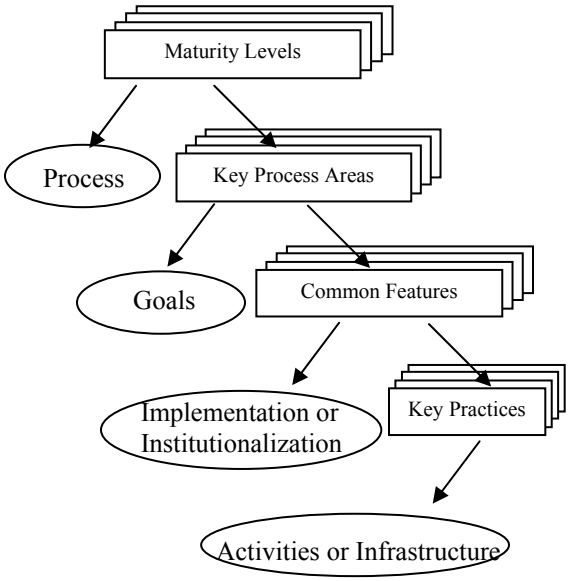

Figure 2. The Internal Structure of the Maturity Levels in Capability Maturity Model[9]

The proposed model, called *Engineering Education Capability Maturity Model* (EE-CMM) uses the same framework of the CMM when describing the capability maturity of an engineering or technology program using the same levels of process capability maturity described in Figure 1. The activities required to be documented for ABET accreditation were identified and mapped to the appropriate capability maturity level. The descriptions of each level were adapted to reflect the educational context and ABET accreditation requirements, resulting in the specialized EE-CMM.

Level 1: Initial – At this lowest level few processes are defined. Processes are adhoc and mostly reactive. Productivity and quality vary. Success depends on individual effort. Current levels of quality and productivity of peer programs/institutions are not known. To advance to the next level, the institution needs to identify and analyze peer programs, define its mission, goals, and objectives, and impose more structure and control on the process to enable more meaningful measurement.

Level 2: Repeatable – The institution has developed policies for managing the educational programs and procedures to implement those policies. Disciplined processes are established to identify the inputs and outputs of the process, the constraints and the resources used to produce the final product. Basic project management practices are used to track cost, retention and productivity and compare them with peer institutions. There is some discipline among faculty in documenting course syllabi, goals, objectives, learning outcomes, results and feedback, so that successful course delivery can be repeated. A strong curriculum for each degree program includes engineering sciences, humanities, social sciences, communication skills and an appropriate professional component. The institutional requirement for achieving Level 2 is that there are policies that guide the degree programs in establishing the appropriate management processes, their program planning and tracking are stable and earlier successes can be repeated.

The program's process is effectively controlled by a program management system, following realistic plans based on the performance in previous terms. The key process areas at Level 2 are:

- Degree program and course management
- Quality assurance
- Management of adjunct faculty
- Program/course tracking and oversight
- Program planning
- Identification of peer institutions

Level 3: Defined – The educational process for both management and educational activities is documented, standardized, and integrated into a standard process for the institution. Mission, goals and objectives are published in the catalog and posted. All programs use an approved, tailored version of the institution's standard process for developing and maintaining degree programs and courses. Includes all characteristics for Level 2.

- Document faculty credentials
- Publish learning outcomes in course syllabi
- Document strategies to attain learning outcomes
- Publish mission statement for University and College of Engineering
- Publish programs educational objectives for program in the catalog
- Institutionalized processes
- Peer review of proposed programs/courses
- Integrated program management
- Training program
- Involve constituencies in reviewing/updating educational objectives

Level 4: Managed – Detailed measures of the educational program and courses are collected and used to quantitatively understand and control both the process and the programs. Includes Level 3 characteristics.

- Implement feedback and assessment processes to determine if intended outcomes are achieved
- Quality management
- Quantitative process management
- Comparison with peer institutions
- Sufficient staff allocation/ compensation
- Strong institutional support and good facilities
- Involve constituencies in outcomes evaluation

Level 5: Optimizing – Continuous process improvement is enabled by quantitative feedback from the process and from testing innovative ideas and technologies. Includes all characteristics of Level 4.

- Process change management
- Technology change management
- Total faculty involvement
- Defect prevention: Student retention management, graduation rate management
- Feedback results in changes in program

These five levels and the key process areas that have been identified with each level are a beginning towards building an Engineering Education Capability Maturity Model[10-11]. Accreditation agencies, such as ABET tend to accredit institutions that are at level 5 in our model. The proposed model gives institutions that have not been accredited a framework that could yield the necessary process definition, implementation, assessment and improvement to eventually attain accreditation. The model provides a common language to discuss progress in process improvement and a logical progression in achieving higher capability maturity levels.

Once the engineering program has attained Level 5 then the program is ready to undergo accreditation and "substantial equivalency" evaluation.

The EE-CMM model was presented at the Engineering for the Americas Symposium in Lima, Peru in October 2005[10]. This Summit was co-sponsored by the Organization for American States and Engineering for the Americas (EftA). There were some discussions of the possibility of using the EE-CMM as an alternative multi-level accreditation standard, e.g., deeming a program as "competent" when it reaches Level 3 and deeming it as "competitive" when it reaches Level 5. Some felt strongly against using it in this manner, others felt this would be helpful in countries where no engineering program is accredited to help students find programs that meet at least minimal acceptable levels. Most thought it was very appropriate for self-evaluation and to assist in moving towards accreditation. One Caribbean engineering institution decided to adopt the EE-CMM to work towards ABET accreditation. The Caribbean delegation at the Engineering for the Americas Symposium voiced a strong desire to begin designing an engineering accreditation system for their region, and offered to organize a workshop in conjunction with the LACCEI conference in June 2006. The Organization of American States offered to co-sponsor the workshop. Thus the second LACCEI initiative began.

The Turabo Declaration

In 2006, LACCEI and the Organization of American States co-sponsored the workshop in San Juan, Puerto Rico, as part of LACCEI's conference. The workshop organizers were Dr. Clement Sankat, Dean of Engineering at the University of West Indies – Trinidad Tobago; Dr. Roberto Lorán, Vice Rector of the Universidad del Turabo – Puerto Rico; and Dr. Maria Larrondo Petrie, Executive Vice President of LACCEI. Dr. Saul Hahn of the OAS Department of Science and Technology opened the workshop presenting the OAS perspective and the importance of engineering for economic and social development. This was followed by a panel of representatives from recognized accrediting agencies that have accredited or evaluated engineering programs in the LAC region for Substantial Equivalence: ABET, CEAB, EC^{UK}, and CACEI. A panel of LAC organizations of engineering directors presented challenges and experiences: ASIBEI (Ibero America), ANFEI (Mexico), ACOFI (Colombia), CONFINI (Peru). The participants and panelists then broke into regional Round Tables to discus strategies to advance engineering program recognition and accreditation in the LAC region. Fifty participants representing thirteen countries participated: Argentina, Canada, Colombia, Dominican Republic, Ecuador, Honduras, Jamaica, Mexico, Peru, Puerto Rico, Spain, Trinidad Tobago, United States, and Venezuela. Each table was given five questions to guide their discussions:

1. Is the ABET model (or other existing accreditation model) adequate for the engineering programs in the Latin America and the Caribbean region?
2. What would be the added value of the Latin America and the Caribbean region having its own accreditation organization?
3. What would be the next steps in developing an accreditation system for Latin America and the Caribbean?
4. Do we wish to develop an accreditation system for Latin America and the Caribbean?

The consensus was that wholesale adoption of accreditation (ABET) would not be appropriate. Instead, best practices should be implemented, and differences rationalized. For example,

consider the experience in Argentina: it is the only mandatory process in Latin America (so far as is known). It started with a self-evaluation, which was initially optional. Budgeting was based on objectives, rather than historical trends. Early data showed poor use of national scientific funding; the process triggered changes in personnel to improve this. A model was developed to track and finance students.

The participants agreed on the following list of observations.

1. There are national systems and nationally external ones.
2. There are optional systems, and mandatory ones.
3. There are systems that accredit institutions and others that accredit programs.
4. Some systems emphasize individual certification; others emphasize institutional improvement.
5. There is both developmental and punitive use of accreditation information; local laws often govern this.
6. There may be conflict between a local/national accrediting agency, and a regional/international one.
7. There is a possibility of resistance to foreign scrutiny.
8. There is consensus that accreditation should allow mobility. There are various mechanisms for this, including signatory status of the Washington Accord.
9. There are two alternatives for achieving global recognition:
    a. Develop a national/regional accreditation system, and then sign an accord,
    b. Adopt an existing accreditation system (e.g. British or American)
10. There is a possibility of incest in national accreditation systems, especially in small countries.
11. There is a certain degree of difficulty in joining consortia such as the Washington Accord; even more so for individual countries.
12. Various groups need to be educated on these issues.

After a day of discussion, a document called *The Turabo Declaration*[12] was created that summarized the conclusions of the participants:

> "Whereas there is a need for Quality, Consistency and Mobility among Engineers educated in the Region, we recommend to LACCEI the appointment of a Task Force to draft a first principles document of a *Latin American and Caribbean Engineering Accreditation Agency (LACCEAA)*. Some first principles for design of this:
>
> a. Engineering Mobility (to be defined)
> b. Draw from best practices and current activities of all mature accreditation agencies
> c. Develop guiding principles of engineering education in the region, including sufficient flexibility of the guiding principles to accommodate the needs of individual nations in the region, enhancing but not suppressing their existing national accreditation systems.
>
> The Task Force shall formulate a strategic plan and milestones for the establishment of this new Regional Accreditation Agency."

The declaration was presented to the LACCEI Extended Governing Board and the LACCEI conference participants. The recommendation to create a new regional accrediting agency for Latin America and the Caribbean was found to be controversial and required further discussion and inclusion of more stakeholders.

LACCEI also determined that collaboration agreements were needed with multi-national and national organizations to undertake this effort and fund initiatives of this magnitude and importance. To this end, the third initiative was started.

Engineering Collaboration for the Americas

LACCEI organized a multilateral Engineering Collaboration for the Americas agreement in Rio de Janeiro on October 2006 that was signed by seven multi-national organizations: the newly created International Federation of Engineering Education Societies (IFEES), the Organization of American States (OAS), the American Society of Engineering Education (ASEE), Engineering for the Americas (EftA), the Asociación Iberoamericana de Instituciones de Enseñanza de Ingeniería (ASIBEI), Ibero-American Science and Technology Education Consortium (ISTEC) and LACCEI. The document formed a partnership to work toward the following agreed upon goals:

- to promote the professional educational and research development of world class engineers,
- to enhance engineering education and to support engineering academia under global quality assurance and program accreditation processes,
- to promote and develop continuing education programs, extension services, and lifelong learning activities to support lifelong productivity enhancement to strengthen enterprise competitiveness,
- to work toward meeting world demand for global engineers committed to solving problems of society,
- to build bridges for networking and resource sharing between industry, professionals, governments, academia and the civil society to meet the challenges for developing global engineers to impact worldwide economic development,
- to promote sustainability values and proactive actions on behalf of forthcoming generations,
- to envision and carry out collaborative efforts and activities for the benefit of all,
- to help enhance social, political and professional equity, justice and welfare and provide opportunities for those underrepresented in the global engineering community,
- to promote job creation and alleviate poverty,
- to jointly seek funding to support all activities related to engineering, and
- to broadly disseminate worldwide the agreement and attract other interested partners into this partnership.

Figure 3 shows a picture of the signers of the agreement. LACCEI also plans to invite national engineering educational organizations in Latin America and the Caribbean to sign a similar agreement and join in the discussions at the next Accreditation and Program Recognition Workshop.

Figure 3. Signers of the Engineering Collaboration for the Americas Agreement in October 2006 in Rio de Janeiro: Claudio Borri - President of IFEES, Dan Marcek - Chairman of EftA, Javier Páez Saavedra - President of ASIBEI, Jorge Ivan Vélez Arocho - President of LACCEI, Michel Bergeron - Director of OAS Science and Technology, Ramiro Jordán -Vice President of ISTEC, and Ronald Barr - Past President of ASEE.

Conclusions and Future Directions

Three LACCEI initiatives have been presented. Two seek to improve engineering program accreditation and program recognition in the Latin American and Caribbean region. The third builds strategic partnerships and collaboration to create momentum to implement initiatives in the region

The first initiative is to develop a five-level Engineering Education Capability Maturity Model (EE-CMM), designed to facilitate and organize the process of seeking accreditation by mapping the activities required for ABET accreditation to the appropriate level of capability maturity needed to implement and sustain the activities. A self-evaluation maps an engineering program to one of five levels of educational process maturity and gives a clear blueprint of what is needed to reach the next level. A program at level five is ready to attempt accreditation. A program at level three has documented that it produces "competent" engineers. One at level five would have also shown that it continually improves it processes to produce "competitive" engineers. At its current stage of development, the EE-CMM is mapped only to ABET accreditation standards. Other accreditation systems that have been used to accredit programs in this region need to have their requirements mapped to the EE-CMM, resulting in different versions for different accrediting bodies, but all having a common infrastructure with the levels providing a means for comparison. Before it can be implemented, the model needs to be expanded to fully specify each level, including more detailed activities and implementation. One engineering institution in the Caribbean that will be preparing for ABET Substantial Equivalency has volunteered to use the EE-CMM to guide its accreditation preparation process. Engineering programs can use the model for self-assessment and to track their progress towards accreditation. It was suggested that the capability maturity levels can be used to define a multi-tier accreditation system, e.g. deeming those that reach level 3 as being "competent" engineering programs and those that reach level 5 "competitive" engineering programs, but this may be controversial. If used, best practices of moving through each level can be documented and disseminated as part of the framework. Institutional and faculty commitment, in terms of effort and budget, are easier to

obtain to pursue smaller incremental steps toward accreditation than to pursue the monumental task of accreditation or substantial equivalence. The model will hopefully facilitate moving towards an engineering program accreditation mechanism to recognize and license engineers throughout Latin American and the Caribbean, the Americas and, ultimately, globally. Comments and assistance in developing a more detailed and complete model is sought, as well as mapping it to other accreditation systems besides ABET.

The second initiative began with a workshop that began exploring whether it is feasible and desirable to create an engineering program accrediting agency for the Latin American and Caribbean region that could eventually sign the Washington Accord. LACCEI will hold a second Engineering Program Recognition and Accreditation Workshop in 2007, again co-sponsored by the Organization of American States, to continue the dialogue and expand the list of participants:

- All agencies that evaluate engineering programs in the region. In addition to ABET, CEAB, CACEI, and EC^{UK}; LACCEI will invite RIACES, MEXA, CONEAU, ICASIT, SINAES, and any others in the LAC region.
- All organizations of engineering directors in the region and other engineering education societies that represent each country in the region will be invited.

The LACCEI Accreditation Committee needs to incorporate into its two accreditation initiatives, ideas being proposed by existing projects that seek to form regional engineering accreditation, such as MEXA – the Mercosur Experimental Accreditation Project, and the European Commission's EUR-ACE Project. The EUR-ACE draft framework describes good practices for accreditation and includes the expected outcomes of engineer ING qualifications at the Bologna First (Bachelors) and Second (Masters) Cycle levels. Europe intends to use EUR-ACE as a template to which existing national systems can be matched and on which countries currently without accreditation systems can create a national system. In Europe countries that have no national engineering accreditation system, the EUR-ACE framework and outcomes provide a template that new agencies can follow with the expectation of recognition within Europe. Where national accreditation systems exist and their practices and outcomes comply with the EUR-ACE framework, recognition within Europe will be facilitated. Although Latin American and the Caribbean face different challenges than Europe, it would be very useful to consider what is being proposed and how it may need to be adapted for the LAC region, especially since many LAC institutions traditionally have followed European models of education.

To progress on the ideas in the EE-CMM and The Turabo Declaration, LACCEI recognized that a deeper collaboration with other organizations was needed. This led to the third initiative: The Engineering Collaboration for the Americas agreement, signed by 7 multinational organizations to advance initiatives and efforts in the Western Hemisphere and globally. LACCEI also plans to sign agreements with national Latin American and Caribbean engineering organizations this year. This needs to be followed up with an action plan in order for the vision to become a reality.

LACCEI welcomes comments and collaboration in these initiatives.

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