Project Title: Bioenergy and Biological Systems Engineering: An Educational Consortium for a Sustainable Agriculture

Project Academic Partners:

University of Illinois at Urbana-Champaign, Department of Agricultural and Biological Engineering
Purdue University, Department of Agricultural and Biological Engineering
Universidade de São Paulo – Pirassununga (Brazil-lead)
Universidade Federal de Viçosa (Brazil partner)

Project Internship Industry Partners:

John Deere Technology & Innovation Ctr, University of Illinois Research Park
Alfa Agroenergia S.A., Pirassununga/SP
GAIA Energia e Participações, S.A., São Paulo/SP
Perdigão Agroindustrial, S.A., Videira/SC
Pif Paf Alimentos S/A, Visconde do Rio Branco/MG

Summary of Consortium Proposal:

We seek to develop an educational consortium whose primary goals are to: 1) develop biological systems engineering curriculum; 2) further develop student and faculty exchange opportunities with key Brazilian Universities; and 3) create engineering internship opportunities with US and Brazilian agricultural industries. Our Consortium consists of two US and two Brazilian partners: University of Illinois at Urbana-Champaign (UIUC) is the US lead and Purdue University (PU) is the US partner; in Brazil, the University of São Paulo – Pirassununga (USP-FZEA) is the lead and Federal University of Viçosa (UFV) is the partner. The undergraduate Agricultural Engineering program at UIUC is ranked number one in the US for the third year in a row by US News and World Report, and the equivalent program at PU is ranked consistently in the top five in the US; both programs are supported by highly ranked colleges of engineering. Industrial partners from one USA and four Brazilian companies include agricultural machinery, bioenergy and food production sectors that have provided strong letters of support and commitment. Personnel in this project have substantial prior international education experience, including a successful previous US-Brazil FIPSE project for student exchange, a previous US-Europe Atlantis project on Biosystems engineering curriculum development,

leadership of the two USA partner departments, leadership of the Purdue University Global Engineering Program (https://engineering.purdue.edu/GEP/), participation in ACES Global Connect, Brazil May-mester courses in 2004, 2006 and 2008 and numerous projects, international sabbaticals, post-docs and work experiences, faculty-led student study programs, student exchanges and internships. We will send at least 24 US undergraduate and graduate students for at least one semester of formal exchange or international internship that earns full-time credit, and will receive a like number of Brazilian students. A listing of team assignments and biographical sketches of each team member is provided in the 'optional other attachments' to this proposal.

Core content: The key to the success of our Consortium is the opportunity to develop mutual curricula in the emerging arenas of bioenergy and biological systems engineering. Tremendous industry demand for engineers with training in bioenergy systems justifies the inclusion of this topic in the proposal. The Agricultural & Biological Engineering Departments (ABE) at both UIUC and PU has recently developed a Biological Engineering undergraduate program, with separate national accreditation (see below for history of the evolution of agricultural engineering to biological engineering). USP-FZEA has a strong agricultural and food engineering program and has recently been granted approval to develop the first Biosystems Engineering program in Brazil, using American but primarily European curricula as a model (PD Gates served as external advisor to USP on this task). UFV ranks as the top undergraduate Agricultural Engineering program in Brazil and in the top three departments overall in Brazil, and has been the lead partner in a previous FIPSE project. A shared vision for curriculum in Agricultural and Biological Engineering could be very beneficial by providing a novel and necessary focus, and by providing synergy for mutual course and curriculum development at each of the institutions.

Internships: Industry partners include Deere & Company, Inc. with a strong engineering research and development laboratory at the UIUC Research Park in Champaign IL; Perdigão Agroindustria SA and PifPaf SA (livestock/poultry companies); GAIA Energia e Participacoes SA, and Alfa Agroenergia SA, both involved in sugar cane processing and bioenergy production (ethanol, electricity cogeneration, lignocellulosic conversion technologies). Also, while not confirmed at time of this writing, other potential industry collaborators include COSAN, a sugar cane/ethanol plant near USP-FZEA, and in the U.S. Caterpillar Inc. and Archer Daniels Midland, each of which has a corporate research center located in the UIUC Research Park.

Project Based Study Visit: Complementary to this proposal, although not a part of our budget request, will be the development of an annual project-based study visit for US students and faculty to the Brazilian partners. Projects will be developed jointly by the Consortium's faculty partners, and led by a faculty team, and will serve as both a recruitment opportunity and student assessment tool. Each year the group will consist of approximately 10 students, ranging from freshmen to graduate students, with high aptitude for subsequent participation in the exchange or internship program. The project-based study visit will span several weeks in the month of May, and the students will earn credit for their efforts. Held in May of each year, PU Professor and co-PD Osvaldo Campanella has termed this a "May-mester" that will serve as the basis for our study visit.

Strategic Career Opportunities: Community service agencies face a future in which they must take advantage of technology to improve, coordinate, account for, and deliver the services they provide. They need the help of people with strong technical backgrounds. Undergraduate students face a future in which they will need more than solid expertise in their discipline to succeed. They will be expected to work with people of many different backgrounds to identify and achieve goals. They need educational experiences that can help them broaden their skills. The challenge is to bring these two groups together in a mutually beneficial way. In response to this challenge, Purdue University has created EPICS: Engineering Projects In Community Service. This has benefited students and the community (http://epics.ecn.purdue.edu/). This project will explore how this Purdue signature program can be used as a service learning model for the consortium.

External Evaluation: Dr. Conrad Heatwole, Virginia Tech, will serve as our external evaluator. He is PD of a current US-Brazil FIPSE/CAPES project in water resources engineering, has substantial background in international project management, and is thoroughly familiar with the required FIPSE evaluation criteria.

Development of Innovative Curricula, Teaching Materials, and Modules

Identity of the Profession: Agricultural Mechanization has been ranked as one of the greatest engineering achievements of the 20th century by the U.S. National Academy of Engineering. *Agricultural engineering* played a vital role in that transformation. Other traditional areas of agricultural engineering, such as soil and water, post-harvest and value-added processing, and structures and environment, have also made remarkable impacts to the agricultural production, the food industry, and environmental stewardship. Agricultural Engineering is transforming into a future bio-based engineering and technology mindset (*Biological Engineering* in US, *Biosystems Engineering* in EU and at USP-FZEA) and is defining a new culture that will guide our future for many years. This transformation is ongoing, and to understand it and provide guidance requires some background on the profession.

The profession of *agricultural engineering* in the US has its roots in "farm mechanics", and was a core component of the new Land Grant Universities established by the US Congress in 1862. The name of Agricultural Engineering was used as a job title by the City of New York in 1857; in 1905 the degree at Iowa Agriculture College (now Iowa State University) was changed from Agricultural Mechanics to Agricultural Engineering. Over the next two decades most Land Grant Universities renamed or developed Agricultural Engineering degree programs. For example, Purdue University established its Farm Mechanics Department in 1921, and renamed it to Agricultural Engineering in 1926, the same year that Brazilian partner Federal University of Viçosa was established (and indeed, modeled after Purdue); UFV began its Agricultural Engineering degree program the following year, while Purdue's undergraduate curriculum was adopted by the College of Engineering in 1946. At Illinois, the first Agricultural Mechanization degree was awarded in 1904; the department of Farm Mechanics was established in 1921, and renamed in 1932 with a formal curriculum in Agricultural Engineering. Thus, of our four partners, our Brazilian partner UFV claims the oldest named Agricultural Engineering degree program – 81 years old at the time of this writing; and USP-FZEA is the youngest, being established in 1992 as Food Engineering. The American Society of Agricultural and Biological Engineers (ASABE) celebrated its centennial in 2007.

To build on the past success and to further enhance the ability of the agricultural engineering discipline in its contribution to an evolving system including agriculture, food, environment, and energy, the discipline made a strategic decision to adopt a more holistic approach as depicted by its new name of "*Agricultural and Biological Engineering* (ABE)." In this vision, the Land Grant functions of teaching, research, and extension education and faculty responsibility of service (including economic development) will continue. The overarching mission is to "integrate life and engineering for enhancement of complex living systems." Engineering is a process of design under constraints. The task of design is to systematically and computationally assemble and integrate resources to achieve certain operational and performance goals. Traditionally, the role of engineering design in our discipline has been to enable and facilitate system operations that contain biological processes (this is the task of "bringing engineering to life"). Therefore, the biological processes and the knowledge of life (i.e. biological sciences) have been considered as design constraints. In our new vision, life and engineering sciences are developed, applied, and integrated for analysis and design of bio-based systems (the concept of "integrating life and engineering," i.e., using life sciences as resources for engineering work and vice versa). The overarching goal of agricultural and biological engineering work is to "enhance complex living systems" involving humans, plants, animals, and microorganisms within the context of agriculture, food, environment, energy, all of which are representative of biological systems.

Biological Engineering Curriculum: The US-EU Atlantis Action project "POMSEBES: Policy Oriented Measures in Support of the Evolving Biosystems Engineering Studies in USA-EU" (2006-4563-003-001 CPT CPTUSA) PD's included members of the current proposal. The final outcomes of the project are provided as an 'optional other attachment'. In summary, the group determined the following:

- *"The emerging **Biosystems Engineering discipline in** <the> **US (also known as Agricultural and Biological Engineering) and in Europe represents a broader biology-based evolution of the Agricultural Engineering discipline.** It … <is> not limited to agricultural production systems, with the exception of human ones. It integrates engineering science and design with applied biological, environmental and agricultural sciences and can be defined as 'the branch of engineering that prepares students to develop and apply engineering solutions to problems in biological systems'.*

- *The concept that Biosystems Engineering emphasizes 'integration of life and engineering', including both approaches, 'bringing engineering to life' and 'bringing life to engineering' should be promoted and disseminated;*
- ***A list of … learning outcomes and core competencies for students in Biosystems Engineering should be developed** to assist with the evolution and development of the discipline curriculum…;*
- *A systematic comparison among study programs in US and EU is proposed to be used…;*
- *Relationships between quality assurance issues of programs of study and learning outcomes or student's core competences should be encouraged. "*

Similar conclusions have been achieved by US academic administrative leaders in providing direction on the issue of Biological Engineering, its definition, and its relationship to Agricultural Engineering. Specifically, this group (ASABE ED-210) held a special meeting in July 2005 to discuss the impact of the current proliferation of academic department and program names. It was decided that the names of educational programs significantly impact five important issues: (1) curriculum and accreditation, (2) student interest and recruiting, (3) placement/industry recognition, (4) ranking and identity, and (5) professional engineer licensing and professional society membership. A list of action items were generated and discussed, including: (1) need for one common program name, (2) develop core elements and common competencies, (3) influence the change of the program names/definition, (4) avoid bioengineering as a name (which generally refers to the engineering within a medical context related specifically to human health), (5) name programs that are accredited under the ABET agricultural criteria as agricultural engineering and those programs accredited under the proposed biological engineering criteria as biological engineering, and (6) continue the discussion on names and how to influence local politics to achieve a common name. Before the conclusion of the meeting, a motion was passed that affirmed the goal that departments adopt agricultural engineering or biological engineering as their respective accredited undergraduate engineering program names. Our ACESys paradigm (see below) will provide a clear vision for future agricultural and biological engineering academic units and programs.

Such guidelines are being used within individual universities (predominantly Land Grant Universities, and Historically Black Universities and Colleges) for guidance on curriculum and program development, to the Accreditation Board for Engineering and Technology (ABET), and to the American Society of Agricultural and Biological Engineers (ASABE). The US members of this proposed Consortium include current and past academic heads, members of ASABE, and active educators engaged in the ABET accreditation review process. PD-Gates is an ASABE Board of Trustees member assigned to update the definitions of Agricultural Engineering and Biological Engineering for the ASABE Board and membership. From these many activities on definition of the curriculum, its development and its relationship to traditional agricultural engineering, we have built a team of faculty uniquely qualified to provide continued leadership that includes bringing both Brazilian and European perspectives to the process.

What distinguishes the Biological Engineering Specialization from the baseline Agricultural Engineering curriculum are the recommended electives listed in the graphic on Page 10 (similar list for USP-FZEA is provided as an 'Optional Project Narrative File'). It is noteworthy that we currently lack formal international experiences or internships as part of the degree requirements. This omission will be addressed as part of our project. The objective of this specialization within the curriculum is to provide a viable pathway to fulfill core engineering requirements while developing fundamentals skills in an area of interest in the biological sciences. A typical student will reach expertise in the biological sciences at the 200-300 level range without sacrificing free electives or exceeding the 128 credit graduation requirement (4260 hours at USP-FZEA). A student will need to utilize free elective courses towards rigorous biology courses to reach 400 level courses in an area of interest in biological sciences. Achieving this higher level of experience in biological sciences has been identified as a key to success in biological engineering and is the distinguishing characteristic in ABET accreditation separating Agricultural and Biological Engineering. Our challenge is to incorporate a meaningful international engineering experience also. By contrast, the Brazilian curriculum has an additional year, and the resultant timetable addresses the Biological Block (see 'Optional Project Narrative File', page 11).

Aside from the medical sciences, the types of biological systems now being considered vary widely in scale from molecules to ecosystems. The most commonly requested areas within this wide range include ecological, nanotechnology, food and bioprocess, and bioenvironmental engineering. With such topical breadth, a pedagogical focus on a set of core competencies will be the best way to prepare our students for future success in Biological Engineering. The **core competencies** for engineering of biological systems are termed *Automation*, *Culture*, *Environment*, *and Systems*. We term this our **ACESys concept**. Automation refers to machine capabilities of perception, reasoning, communication, and task execution. Culture refers to the biological organisms being utilized as a component in the engineered system including plants, animals, microorganisms, or humans. Environment refers to the surroundings provided to the biological organisms including air, water, soil, and controlled environments, which are often optimized to control the behavior of the culture. Systems refer to the skills of analysis and integration of all components in the engineered system for technical workability, economic viability, efficiency, environmental impact, operations, and management.

The ACESys concept is initiated in the first year with a new Biological Principles in Engineering (ABE 141) course. This course surveys examples of engineered biological systems and focuses on the principles for successful design. Colleagues at USP-FZEA also have two first year courses (Introduction to Biosystems Engineering, and Biochemistry in Biosystems Engineering). Students participating in this exchange program will be able to exchange these credits during study abroad experiences.

In the second year, a course on Environment (ABE 221) and a course on Automation and Systems (ABE 222) are provided; these are provided starting in semester 7 at USP-FZEA. Environment will introduce fundamental principles that will be utilized in later classes for engineering indoor and outdoor environments. Automation and Systems will begin the process of teaching perception and reasoning, both precursors to systems analysis and operations research. Follow-on courses listed under technical electives are under development in advances systems engineering and currently exist in automation. The principles of Automation and Environment are already well represented in the existing baseline Agricultural Engineering curriculum. It is anticipated that students interested in our more traditional approaches to Agricultural Engineering will also benefit from these courses.

A key new course to be developed will be Principles of Heat, Mass Transfer, and Momentum (ABE 341). This is a fundamental engineering course focusing on biological systems, and is called Transport Phenomena at USP-FZEA (Semester 4). Most Colleges of Engineering have several courses in Heat Transfer, Mass Transfer and Momentum, but few that treat them simultaneously. It is again interesting to note the synergy with USP-FZEA, PU, and UFV, each of which also incorporates these topics in their curriculum.

To ensure that enough fundamental biology learning is achieved by the students, the previous requirement of biological and natural science electives will increase to 13, including several compulsory courses. Some careful planning will be required on the part of the student, but clearly much more flexibility is available in this approach. Nine hours of technical electives in Biological Engineering are specified. Courses at USP-FZEA and UFV may augment the available list of electives we offer to our students via this program, and vice-versa. Non-auditable specializations can be constructed within this concentration in Biological Engineering for students interested in further detail. An example is Bioenergy, an emerging and critical area of Biological Engineering, as is described below.

Bioenergy Systems Curriculum: Energy and its sustainability have become important topics on most higher education campuses around the US and in Brazil. Infusing these topics into existing curricula and creating new opportunities for students to be able to gain relevant knowledge and skills are being strongly addressed by all four partners. For example, at USP-FZEA a block of energy-related courses comprising 150 hours (approx. 9 credit-hours) have been developed. These include production of alternative energy, distribution of electricity, energy efficiency and biofuels. At UIUC a graduate options program in Energy and Sustainability Engineering has been approved to begin in 2009 that includes a course concentration in biomass energy resources. Some courses for this concentration already exist at PU, UFV and UIUC such as Renewable Energy Systems, Processing of Grains for Fuel, and Processing of Biomass; some are available to advanced undergraduate students. The development of new courses such as Biomass Production Engineering, and Analysis of Bioproduction Systems for Workability and Sustainability will be taking place during 2009 and will be accessible to both undergraduate and graduate students. An undergraduate bioenergy systems specialization is under discussion for 2010 at UIUC. Significant opportunities in the bioenergy sector exist within all four partner institutions, with substantial student interest.

Foundational Mathematics and Science

These courses stress the basic mathematical and scientific principles upon which the engineering discipline is based.

Hours	Requirements
3	CHEM 102—General Chemistry I
1	CHEM 103—General Chemistry Lab I
3	CHEM 104—General Chemistry II
1	CHEM 105—General Chemistry Lab II
4	MATH 221—Calculus I
2	MATH 225—Introductory Matrix Theory
3	MATH 231—Calculus II
4	MATH 241—Calculus III
3	MATH 285—Intro Differential Equations
4	PHYS 211—University Physics: Mechanics
4	PHYS 212—University Physics: Elec & Mag
2	PHYS 213—Univ Physics: Thermal Physics
34	Total

Technical Electives

This elective course work must be completed to fulfill each Concentration. The subjects build upon the agricultural and biological engineering technical core.

Hours	Requirements
6	Biological and natural sciences electives chosen from a departmentally approved list of Biological and Natural Sciences Electives
15	Technical electives chosen from a departmentally approved list of Biological Engineering Electives
21	Total

Engineering Technical Core

These courses stress fundamental concepts and basic laboratory techniques that comprise the common intellectual understanding of agricultural and biological engineering and the background for the technical courses and electives in each student's concentration.

Hours	Requirements
4	ABE 221—Agric & Biological Engineering I
4	ABE 222—Agric & Biological Engineering II
2	ABE 430—Project Management
4	ABE 469-Capstone Design
3	CS 101—Intro Computing: Engineering & Sci
3	ECE 205—Elec & Electronic Circuits
3	GE 101—Engineering Graphics & Design
2-3	TAM 210—Introduction to Statics **or** TAM 211—Statics
3	TAM 212—Introductory Dynamics
28-29	Subtotal for all specializations and the concentration. See additional technical core requirements below.

For the Biological Engineering Concentration

Hours	Requirements
2	ABE 141—Biological Principles in Engineering
3	ABE 341—Heat/Mass Transfer & Momentum
4	CHBE 321—Thermodynamics
3	CHEM 232—Elementary Organic Chemistry I
4	MCB 150—Molec & Cellular Basis of Life
16	Subtotal
79-80	Total for the Biological Engineering Concentration

Strategic Research Initiatives: While the domains and core competencies described above help to frame and refine the definition for the discipline of Agricultural and Biological Engineering, one key contribution of the discipline is to effectively advance the systems level issues of economics, environment, energy, ecology, education, and efficiency (i.e. the 6 E's) of a bio-based economy. To effectively sustain the cyclic nature of this economy it is essential to improve its effectiveness and competitiveness, optimize its economic return, provide management capabilities, monitor and ensure intelligent and balanced use of resources, understand the governing constraints, enable creative productivity, interface with other economic sectors, identify value-added opportunities, and create new economic activities for wealth and job generation. The following technical areas are of particular importance in sustaining and advancing this very large and complex bio-based economic engine.

- Agricultural Automation – including machine intelligence of perception, reasoning & learning, communication, and task planning & execution.
- Bio-Energy and Bio-Products – including production of bio-fuel, bio-power, and bio-materials. Example research and development activities are ethanol production, bio-diesel properties and engine performance, biomass feedstock production for energy, and thermochemical conversion of biomass to crude oil.
- Sustainable Environment – including information and analytical tools, processes, simulation, mitigation technologies, and socioeconomic considerations.
- Biological Engineering – including biological nanotechnology, synthetic biology, whole-cell biosensors, metabolic engineering, and biological device design.
- Systems Informatics and Analysis – including complex design techniques, decision support, early reliability measurement techniques, holistic agro-ecosystem perspectives, carbon footprint analysis, multi-scale modeling, and sustainable development.

Development of Organizational Frameworks for Student Mobility

In this section we present the project design with focus on how we will integrate a semester of study abroad or internship into the undergraduate curriculum without significantly increasing student time to graduation. A key organizational framework that was successfully implemented in an earlier US-Brazil exchange was to develop student cohort groups, in which each class of Brazilian students is placed with US students who are intending to participate in the program; then prior to the start of the following semester the US students that travel to Brazil will meet up with their Brazilian colleagues, and will be placed into classes that include the Brazilian students that intend to participate the following year. In this way, a strong student identity is established for the exchange program, reinforcing cultural and language training and providing a social network that is critical to a sustainable exchange program.

Student Mobility Numbers and Duration: UIUC and PU will exchange 24 students for a semester of study or internship during years 2-4.. Separately, our Brazilian partners will exchange 24 students over the same time period. We intend to evenly distribute student numbers across all partners. For UIUC and PU students, the primary exchange format will be semester-long study, with a goal of creating internship opportunities for US students in the Brazilian industry partners. Similarly, the Brazilian students will be hosted by UIUC and PU in semester-long exchanges with a potential for follow-on opportunities for a few months in May-July with US industry partners on the UIUC campus.

Student Recruitment: Recruiting US engineering students for study abroad opportunities in Brazil presents some significant challenges. From previous exchange experiences we have learned that while language is a key barrier, the sequencing of semesters between the two hemispheres and the stringent engineering curriculum demands are even more of a challenge in designing an effective and successful exchange. UIUC and PU have excellent student support services for international education, including Portuguese language training, formal means of credit transfer, tuition agreements, housing and local arrangement programs, insurance and health benefits, and international programs in their respective engineering and agriculture colleges as well as at the University level.

At UIUC, the ABE Department has a full-time student services academic professional who will help to guide students into this Consortium. The College of Engineering (COE) and the College of Agricultural, Consumer and Environmental Sciences (ACES) have established International Offices. The College of Engineering's International Programs in Engineering (IPENG) includes a goal that 50% of graduating engineers have some form of international experience; currently it is about 18%, and will provide participation incentives via reduced tuition fees and earned credit for international exchange and international internships. Prof. Campanella's successful "May-mester" program to Brazil and Argentina will serve as a key recruiting and student evaluation component (although not charged to this project). The Dean of ACES is also providing financial incentives ($1,000) to students in the FIPSE program (see letter of support).

Academic Credit Recognition: To be completely successful, our US-Brazil Consortium for undergraduate engineering students must include academic credit recognition that demonstrates equivalency into the US program for purposes of engineering accreditation, and vice-versa for the Brazilian partners. To accomplish this, existing courses in each Brazilian curriculum (see USP-FZEA new curriculum 'Optional Project Narrative File') will be compared to the existing ABE courses and these courses will form the core of possible offerings. The process by which these courses will be formally recognized by each institution varies slightly, but is established and will be formalized as part of the specific Memoranda of Understanding documents to be developed during year 1 of the project.

The UIUC College of Engineering maintains a list of courses previously approved for study abroad (http://www.engr.uiuc.edu/international/experience/courses.htm), with equivalencies established, and this list will be expanded during our first year. In addition to the recognition of existing courses, our development effort will provide opportunities for the partnering institutions to develop courses and course content for our Biological Engineering curriculum. This will include courses that fit with UIUC and PU undergraduate programs (Agricultural and Natural Resources Engineering, Agricultural and Biological Engineering, Biological and Food Process Engineering, Agricultural Engineering) which are accredited under either Agricultural Engineering or Biological Engineering program criteria by ABET. Coordination of new course development will be done with faculty Undergraduate Coordinators and Undergraduate Course and Curriculum committees for both departments.

Fees: Reduced student tuition and fees are possible for UIUC College of Engineering students engaged in semester or longer study abroad, as part of the strategic plan to increase international experiences. During the 2008-09 academic year, for example, the tuition charge was roughly 20% of in-state tuition, and most other student fees were waived. Clearly, the framework to provide incentives for international study is in place. Please refer to the letter of support from UIUC International Programs in Engineering (IPENG).

Student Stipends: Each US student will receive up to $3,500 in mobility stipends from this project's funds. During Year 1 we will determine the best means of distribution. In a past FIPSE project we were able to directly deposit these funds into individual students' accounts, once they had purchased airfare and either made a tuition payment or arrived in the partner Brazilian institution. There may be more efficient methods at both UIUC and PU and we will explore these with the College and University International Programs officers. Additional student support for both US and Brazilian students is possible through research experiences while in the host country, and by some students engaged in formal internships.

Student Support and Services: UIUC and PU have excellent student support and services for international education. ACES has a strong interest and history of international programs, with a Global Connect International Programs (http://global.aces.uiuc.edu/), ACES Academy for Global Engagement, and ACES Study Abroad (http://students.aces.uiuc.edu/study_abroad). The UIUC College of Engineering International Programs in Engineering (IPENG) includes short term Discovery Study Tours, Summer Programs, and Semester or Academic Year Study Programs; the Study Abroad Office provides administrative support, assistance, and advice for travel health, safety and insurance (http://www.cte.uiuc.edu/dme/placement/student/otherFL.htm). PU's Global Engineering Program (http://engineering.purdue.edu/GEP) provides a wealth of student support and services, with linkages and exchanges with 29 other Universities and formal semester-long agreements with 52 programs. All PU engineering students are required to satisfy a Global Literacy requirement. Credit transfer, tuition and fees arrangements worked out in these programs shall apply to the proposed Brazilian exchange with USP-FZE and UFV.

Development of Adequate Language Preparation and Assessment

Portuguese language training for the US students will be required as part of the selection process. Training is available through several existing programs: UIUC College of Engineering's newly established spring semester intensive language course is being offered commencing in Spring 2009 (http://www.engr.uiuc.edu/international/index.htm), and an intensive Language Instruction Program (IFLIP) is offered to students and faculty each winter break (http://services.lang.uiuc.edu/forms/iflip.htm). Students with previous Portuguese language training may elect to take a proficiency test, administered by the Center for Teaching Excellence (http://www.cte.uiuc.edu/dme/placement/student/otherFL.htm). All US students will also be enrolled in intensive Portuguese language training during their study abroad, unless they are of exceptional skill, and with agreement of hosting partners.

Development of Internships

Internship opportunities are a key element of this Consortium, and will focus primarily on bio-energy related topics. Support from companies to create internship opportunities both locally and in Brazil has been sought and is reflected in the letters received from Deere & Company, Perdigão, Pif Paf, GAIA and Alfa Agroenergia. We will seek opportunities in which both US and Brazilian engineering students can participate.

Internships are a valuable opportunity for students to gain experience in an industry setting and for industry employers to identify potential recruits. The larger agricultural and construction machinery industries have well established internship programs to accommodate students for different periods of time, depending on student availability and needs. Students can opt to spend the equivalent of a whole semester or even a year working in an industry setting as part of a cooperative program, or they can choose to work in an internship during university vacations in the winter or summer. The most common US internship choice is during the three month summer break. A large number of students from the ABE Departments at the UIUC and PU end up working for companies such as Caterpillar, Deere & Company or Archer Daniels Midland (ADM) as these companies have their headquarters in Illinois and also have a number of their production facilities within Illinois. In addition the three companies mentioned have a presence in the UIUC Research Park that allows them to interact with students and faculty on campus not only during the winter and summer breaks but also during the semesters when they are able to work part time on industry-related projects at the research park facility.

A further important dimension concerning these companies is their extensive international operations, of which a number exist in Brazil. Creating opportunities for U.S. students to gain an international perspective through an internship in Brazil is very attractive to these companies (see for example the letter of support from John Deere & Company in 'Mandatory Other Attachments' file). A process of exchanging students between Brazil and the U.S. opens up the potential for students from both countries to work in teams on industry projects, thereby developing human capital that will strengthen the companies' ability to market their products internationally.

The linkages with Brazil envisioned in this proposal would allow students from Brazil to come to the US and participate in an internship. A team-based ("cohort") approach in which Brazilian and U.S. students work together on designated projects has been shown to be very effective as a way to encourage U.S. students to travel to Brazil and undertake a similar experience there, where the same Brazilian students that had visited the US can then assist the US students as they experience a foreign environment. The Purdue Director of Global Engineering Program (GEP) is co-PD Prof. Rabi Mohtar. GEP has several programs that will be adapted to the needs of this consortium to allow students from all institutions to work together on long-term service-learning projects and Global Design Teams, where US students will work with Brazilian counterparts on high impact international development projects. GEP will coordinate with the Purdue Office of Professional Practice at Purdue and UIUC for two way student research and industrial internships.

In spite of the importance placed on internships, especially by employers, the process of formally including this internship experience in the undergraduate degree program is not well articulated within any of the partner institutions' curricula. Students are encouraged to undertake a summer internship of approximately 2-3 months. This is the method currently used by some of our students; however, they are not encouraged to obtain formal credit towards their degree for this internship experience. The UIUC College of Engineering accommodates internships by allowing students to maintain their full-time student status provided they register for an Engineering Internship course and pay a reduced tuition fee, the latter often being covered by the employer. However, this approach has not been utilized in our curriculum, and especially not for an international internship experience. UIUC ACES, on the other hand, allows students to register for an International Internship course that comprises a supervised learning experience designed for ACES students registering for an academic term abroad and/or for non-degree exchange students enrolling for an academic term at UIUC.

There is thus a need to investigate the formal recognition of internship experience in the degree audit. By recognizing this need and generalizing it to our US and Brazilian partners, we have a unique opportunity for substantial curriculum reform that directly addresses some U.S. engineering students' concerns regarding international study, namely an extension of time to graduation. This form of recognition would help encourage students to undertake internships. Such an addition to the degree audit could also further facilitate study abroad internships. For Brazilian engineering exchange students at the either UIUC or PU for a semester, a formal Internship course is a logical choice if the students are able to undertake an internship with companies located in the Research Park. For summer (northern hemisphere) internships, the College of ACES International Internship course is the logical choice.

Strategies for Professional Certification, Licensure, and/or Accreditation

The US students that graduate from UIUC and PU have earned engineering degrees accredited by the agency, ABET. They are eligible to sit for the Fundamentals of Engineering exam, and are encouraged to do so. Once a graduate engineer who has passed the Fundamentals exam has worked with licensed engineers for four years, they are eligible to sit for their Professional Engineering (P.E.) license. These exams are administered by licensing boards in each state. Thus, any curricular modifications must satisfy all appropriate requirements of each department's Course and Curriculum (or equivalent) committee to ensure ABET requirements are met. Several co-PDs are members of these committees.

Use of new Web-based and other Computer-Based Technologies

Among the team members for the Consortium are several experts on instructional technologies, information technologies, web-based instruction, and related tools. A systems approach can be used to promote a sustainable consortium by taking advantage of Purdue's HUBzero™. The HUB technology, invented at Purdue, allows users to create dynamic web sites that connect a community in scientific research and educational activities. HUBzero™ sites combine powerful Web 2.0 concepts with a middleware that provides instant access to interactive simulation tools. These tools are not just Java applets, but real research codes that can access TeraGrid, the Open Science Grid, and other national Grid computing resources for extra cycles.

Many team members have prepared research proposals together over the course of the last decade and are always investigating new technology opportunities for instruction and collaboration. For example, several of the co-PDs at UIUC have recently evaluated social bookmarking software, Delicious (http://delicious.com), which is being considered by some faculty as part of international online instruction, along with a commercial package, Elluminate® (www.elluminate.com) for hosting instructional sessions. The team has been using various tools including a WIKI (http://biomass.age.uiuc.edu/index.php), powered by MediaWiki (http://www.mediawiki.org), the same software utilized for the well-known Wikipedia) for file sharing and Skype for video and voice conferencing during proposal preparation. To allow students to exchange ideas, Google Docs™ (http://www.google.com/docs) and other 'cloud computing' applications are quite useful for collaborative document preparation. Several of the co-PDs have extensive experience using these tools as well. The online collaborative WIKI developed by co-PD Rodriguez will be used for auxiliary course content, curriculum materials development and storage, and other ongoing work projects. In addition, co-PD Alan Hansen has experience utilizing [we-]blog technology to enable students to document their South African travels (http://ui2safrica2008.wordpress.com). The tools necessary for providing blogs allow free or low cost hosting on websites such as Blogger (http://www.blogger.com) or can be readily built in-house using tools such as Drupal (http://drupal.org).

Development of a Strong Project Evaluation Plan

As noted in the introduction, we have secured the expertise of Dr. Conrad Heatwole, Virginia Tech, to serve as our external evaluator for all four years of the project. He is the PD of a current US-Brazil FIPSE/CAPES project in water resources engineering, has substantial background in international project management, and is thoroughly familiar with the required

FIPSE evaluation criteria as well as the requirements of the ABET accreditation issues. We anticipate sharing evaluation plans and evaluation instruments as appropriate between the two projects. His CV and letter of agreement are included in the appended materials. During Year 1, Dr. Heatwole will work with project Director Gates to finalize the evaluation plan required within three months from grant commencement. Of specific focus will be developing evaluation instruments (formative and summative) for baseline data collection, project evaluation data collection and a documented means of change implementation. The Evaluation Plan will have a quantitative measurement matrix including the key components of the project (such as international person-credits earned at partner institutions, language mastering, and culture exchange). The Evaluation plan will be completed during Year 1. Dr. Heatwole will provide input to the detailed first year plan (see below). He will participate in annual FIPSE-CAPES meetings in US and Brazil as part of his own FIPSE project, and we will ensure that sufficient time is reserved during these annual meetings for our group's face-to-face communication. PD Gates currently has a research and extension contract (funded by USDA) with Virginia Tech and will be traveling there annually – thus an additional annual meeting between the evaluator and project director is possible.

Project outputs for annual evaluation and reporting will include number of faculty from each partner, development of appropriate MOUs, progress on curriculum development and collaboration, establishment of course equivalencies between partners, schedules, topics and faculty leaders for the May-mester program, means of interviewing and selecting US and Brazilian students for exchange, the method developed for identifying and evaluating international internships, the number of students involved in each component, evaluation of returning students' mastery of language and cultural aspects and engineering learning.

Outcomes of the four year project must be evaluated according to documented guidelines. Dr. Heatwole and his team have established some useful ideas regarding the scholarly evaluation of his FIPSE project and we intend to collaborate and build on these to expand the dataset. This includes questions of motivations and barriers for students in a semester study abroad, such as:

- *Is a short term experience (e.g. May-mester) a useful means of enhancing student interest and removing barriers to participation? And;*

- *For our group specifically, is the inclusion of international internships as a recommended component of a successful engineering degree program an incentive for more international participation by our students?*

These outcomes will be published in a scholarly article (American Society for Engineering Education) and presented at an annual professional meeting. We expect the collaborative curriculum development to be of interest to colleagues in other departments and universities.

Preparatory Phase: First Year of Project

Key activities needed to ensure a successful project have been identified. An abbreviated timeline for year 1 of the project is provided below (4-year timeline is included in a separate 'mandatory other attachments' file).

Activity description	***Date***
Project start date	July, 2009
Initiate specific cooperative exchange agreements among partners	July-August, 2009
Initiate recruitment plan for both US and Brazilian students	August-September, 2009
Develop student evaluation in anticipation of Year 2	August-December, 2009
First Project Directors meeting, in USA	October-November, 2009
Initiate student enrollment in winter break and spring semester language courses	November, 2009
US student selection for Year 2	December-January, 2010
Team meetings in Brazil	March, 2010
Procedures for course registration, documentation of program activities, visas	May, 2010
Annual Project-Based Study Tour (May-mester)	May-June, 2010
Prepare first group of US Students for Year 2 travel in July 2010	June, 2010
Annual progress evaluation	May-July, 2010
First year external evaluation	June, 2010
Approval for project continuation	July, 2010

Sustainability

Identification of possibilities for further exchange: If the first four years of the exchange program are successful, we hope new funding options may become available to allow its continuation. At the moment there are several foundations, as well as national and multi-national companies, developing activities in areas that are part of the scope of this consortium. These organizations may show interest in financing future student exchanges to develop work on specific subjects of their particular interest. We believe some multi-nationals, with interests both in USA and Brazil may support our proposed exchange program.