Recruiting Industry-Sponsored Multidisciplinary Projects for Capstone Design

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Abstract

Through seven years of experience the administrators and faculty of the University of Florida's *Integrated Product and Process Design* (IPPD) program have become skilled at identifying industry sponsors and defining achievable projects for multidisciplinary teams of senior students. Each year the IPPD program hosts approximately 26 industrially-sponsored projects carried out by a group of over 150 students who are supervised by 23 faculty from different engineering disciplines. Since 1995, 186 sponsored projects have been identified, defined and undertaken. Over 1000 students from 10 academic disciplines have participated in the two-semester program. This paper outlines a framework for sponsor and project recruiting based upon eight years of successful execution. Industry praises the IPPD effort as an outstanding experiential education program, with benefits for students, faculty, and industry. Six years of student self-assessment results clearly demonstrate the program's educational objectives are being met.

Introduction[3]

Engineering faculty responsible for defining senior design projects are faced with a challenging task. There is an ongoing need for new projects that can be tackled by teams of undergraduate students. There are many project sourcing and support options, including such considerations as allowing participating students to seek out the projects from sponsoring faculty or companies, recycling previous projects, polling colleagues for ideas and sponsorship, and actively recruiting industrial sponsors. This paper will focus on a successful model for recruiting industrial project sponsorship and defining achievable multidisciplinary senior design projects.

The *Integrated Product and Process Design* (IPPD) program is an innovative undergraduate engineering education initiative first developed at the University of Florida in the academic year 1994 under the auspices of the Southeastern University and College Coalition for Engineering Education (SUCCEED) initiative that in turn is sponsored by the National Science Foundation. The pilot testing was done in the 1995 academic year, and since then the program has been offered as a two-semester course available to senior engineering and business students. The students work in five to seven member interdisciplinary teams, under the direction of one faculty member who acts as a technical coach. Each team also includes the participation of a liaison engineer representing an industrial sponsor, namely a private company, or a government institution or laboratory, who charters the design team with the task of designing and building authentic products and processes of financial or strategic value to the sponsor.

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[3] The following introductory and overview material is based upon references 1 and 2.

IPPD is fully institutionalized at the University of Florida, and the two-semester course serves as an optional substitute for a capstone design course and for a technical-elective course. Students gain practical experience in teamwork and communication, problem solving and engineering design, and develop leadership, management, and people skills. Teams and individuals are evaluated based on clearly defined project deliverables and on their performance in lectures and workshops.

This paper provides an overview of the IPPD program at the University of Florida, presents relevant lessons learned in the areas of project sponsor identification, sponsorship solicitation, project identification and project selection, and reflects on the results of six years of self-assessment activities[4].

Overview of the IPPD program

Course structure

The IPPD course is supported by four key principles: (1) multidisciplinary teams of five to seven students working on industry-sponsored design projects, mentored by a faculty coach and supported by an industry liaison engineer, (2) a structured development process based upon recognized industry best-practices and tailored to fit an 8-month development cycle, (3) use of industry-standard design tools (such as Pro/ENGINEER and Mentor Graphics), and (4) adherence to well-defined project management methods. The structured development process for hardware projects is illustrated in Figure 1. The design process is initiated with the formation of project teams. This step begins with team recruitment and project staffing. Once the multidisciplinary teams are formed, an overall project management structure is established and a leader, financial officer, recorder, and weekly meeting schedules are determined. The first deliverable is the generation of a name and logo for the team; thus formally establishing team identity.

The remainder of the structured development process encompasses two consecutive semesters of extensive work commitment by each team of students. The product and process design activities involving hardware deliverables are organized into five consecutive phases that follow the paradigm discussed by Ulrich and Eppinger [2000]: conceptual design, system level design, detailed product/process design, verification, and production. The product and process design for software deliverables has similar phase designations. Figure 1 shows a schematic representation of the development sequence followed for hardware projects. The end of each phase shown in the figure is given by the successful completion of a clearly defined deliverable or by meeting a major milestone. The structured development process culminates with the delivery of a working prototype to the industry sponsor.

The embodiment of the design process into the curriculum takes on the multi-faceted format of lectures, workshops, and team-teaching activities. The lectures, given twice a week by engineering faculty and by guest lecturers from industry and from the business school, are used to formally introduce each aspect of the design process via theory, examples, case studies, and in-class activities. The lectures are presented in a just-in-time fashion, such that upcoming deliverables are explained one or two weeks in advance. Each team holds weekly design workshops where they focus on the project details and the coach-assisted adaptation of the lecture topics to the specific project requirements. These workshops typically involve the participation of industry liaison engineers via teleconferencing. Additional support is provided to train students in the use of specific development tools and techniques. The IPPD program meets ABET requirements and feedback from project reviews provides a conduit for departmental curriculum improvements.

[4] The data presented in reference 2 is updated to the latest available information.

Student and faculty participation

The program currently involves faculty and students from nine engineering disciplines, as well as students majoring in business. At this time the undergraduate rolls include over 150 students who are coached by a group of 23 faculty. An annual fluctuation in the number of students involved from each discipline occurs depending on the expertise base required to execute the available projects, and on the level of interest that can be generated among the pool of available students. A typical team composition involves 5 to 7 students from appropriate disciplines, a faculty coach, and an industrial liaison engineer and his/her technical support staff. As is done in industry, the team composition is driven by the technical requirements of the project. Successful student recruiting culminates with enough students of each discipline to staff all the projects. There is some flexibility in the specification of the needed disciplines. For example, in selected projects aerospace engineering students are often considered as interchangeable with mechanical engineering students, and business students may be recruited in place of industrial engineering students.

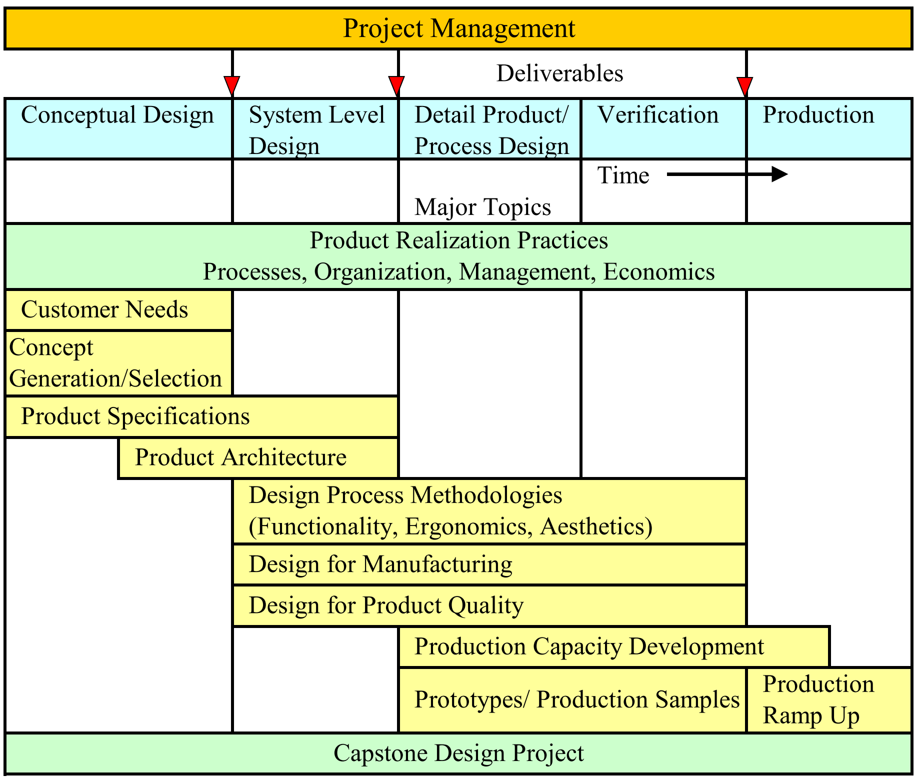


Figure 1. Integrated Product and Process Design Program structure for hardware-oriented process deliverables

Number of sponsors and projects

Since its inception in 1995, a total of 55 companies have sponsored 186 projects in the University of Florida IPPD program. Sponsors paid $15,000 for each project, plus supported the teams with liaison engineers (mentors). The program has reached a nominal annual operating level of approximately 26 projects and 23 sponsors. Approximately 2/3 of the sponsors are repeat participants from a previous year. Projects that are well defined at the start have the highest chance of successful completion. The sponsors that have successful projects, notwithstanding economic downturns, tend to repeat as sponsors. Therefore, the high repeat rate is tied to a successful project definition and scoping process.

Lessons learned

The framework employed to secure a steady stream of sponsored multidisciplinary senior design projects in the University of Florida's IPPD is composed of the following elements:

1. a disciplined network and process to identify and cultivate potential project sponsors

2. a year long cycle of project recruitment activities

3. a well defined, yet flexible set of project selection criteria

4. a structured project definition process

5. a simple letter of agreement to act as a contract.

This framework has been successfully utilized and developed over the past eight years, resulting in 186 design projects and over $2.7 million in industry support. These elements are explored in more detail in the following sections.

Finding sponsors

Networking cannot be overemphasized. A key to finding sponsors is to notify as many stakeholders as possible that you are looking for projects. Sometimes a simple conversation in the hall leads to a contact and eventually to a sponsored project. Executive-level contacts are best.

Potential sponsors are identified throughout the year by a variety of IPPD and College of Engineering stakeholders. Projects rarely launch unless senior/executive management are willing to commit the resources. Therefore, a critical success factor in finding a credible project sponsor lead is to have access to University resources that routinely interface with senior management at corporations that are interested in conducting research with the University or in giving major gifts. The two groups most active in this area on campus are the engineering deans and the directors of the University of Florida Foundation. The University also has an Engineering Advisory Council (EAC) composed of a variety of engineering executives from corporations and government agencies large and small, and further, each department within the college of engineering has an Industry Advisory Board (IAB). The EAC and IABs provide an excellent network of potential project sponsors.

Many faculty have corporate contacts through active research, former students, and consulting arrangements. It is important to ask your colleagues for leads.

Existing sponsors are also great sources for new sponsors. Sometimes this occurs within other divisions of the company or with key suppliers/partners.

Students occasionally provide contacts that eventually lead to sponsorship. In the current program year, a former IPPD student highly recommended the program to his management, which led to a sponsored project. In fact, this former student is the liaison engineer for his company's project. A currently enrolled IPPD student provided a lead to his father's company that resulted in a sponsored project. To avoid any conflict of interest, the student was not assigned to the project team for his father's company.

The campus Career Resource Center's (CRC) close interaction with the college of engineering and the IPPD program led to a sponsored project in the current program. A human resource manager set up a visit with the CRC and inquired about whom else to visit. The CRC recommended a visit to the dean's office to talk about cooping and internships, and a visit with the IPPD director. The follow-up from the HR manager led to interaction with the vice president of engineering and a visit at the company's headquarters. The IPPD program was presented to the VP's engineering team and several engineering groups fought over the chance to work with the students.

Activities such as career fairs and engineering fairs have yielded limited results. The engineers that come to the fairs are typically not high enough in the organization to secure commitment. Incidentally, the feedback we get from the students is that the recruiters quickly focus in on the IPPD experience listed on the student resumes.

Timing and execution

A yearlong set of activities results in approximately 26 fully committed, fully staffed projects annually. Table 1 provides a roadmap of activities and resources involved on a monthly basis. For clarification, the "Director" refers to the Administrator in charge of the IPPD program. This individual is ultimately responsible for the fiscal and academic success of the IPPD program. Therefore, the Director plays a central role in recruiting sponsors, projects, faculty and students to support the IPPD enterprise.

Table 1. Roadmap of monthly IPPD project recruitment activities

Month	Activities	Who
December	Develop marketing plan Assemble target address list Host potential sponsors at IPPD System Level Design Reviews	Director
January	Refine solicitation letters Send letters to target companies	Director
February	Follow up on initial mailings via telephone and email Secure executive commitment to sponsor projects Begin working with committed companies to define projects Network in to correct managerial and technical contacts on new sponsors; set up site visits Network at Engineering Advisory Council and Industrial Advisory Board meetings Estimate number of students needed by discipline	1. Director 2. key faculty most experienced in IPPD and scoping projects 3. Foundation, deans or other COE industry interfaces
March	Site visits to new companies	1. Director 2. key faculty most experienced in IPPD and scoping projects
April	Host potential sponsors at IPPD Final Design Review Hold industry feedback session at conclusion of the design review to share plans for the future and collect Industry comments Review project ideas with committed sponsors and faculty Begin locking in coach assignments	1. Director 2. key faculty most experienced in IPPD and scoping projects 3. project faculty coaches

Month	Activities	Who
	Site visits	
May	Review project ideas with committed sponsors and faculty Lock in coach assignments Site visits Review student recruiting by discipline	1. Director 2. key faculty most experienced in IPPD and scoping projects 3. project faculty coaches
June	Review project ideas with committed sponsors and faculty Juggle coach assignments Site visits	
July	Complete project recruitment Finalize project definition and collect project summary sheets Finalize faculty coach assignments Finalize student recruiting	1. Director 2. project faculty coaches
August	Send letters of agreement and project invoices	Director
September to November	Collect leads	Director

Project selection criteria

A set of project selection criteria are provided for the potential sponsors as an aide in defining appropriate design projects. For each project idea submitted, the IPPD Director and involved faculty weigh the proposed project against the following criteria:

- Project should meet a specific need for the sponsor company
- Company must name liaison engineer (2 to 4 hours per week)
- Project should not be of immediate concern (2 semester class spread out over 8 months)
- Discrete projects should involve design and manufacture. For example the project could involve:
    - a physical prototype for a new product or product derivative including the associated manufacturing processes.
    - the redesign of an existing product including a physical prototype and the associated manufacturing processes (redesign for cost, quality, performance, productivity, automation, etc.)
    - a physical prototype for a new or redesigned test equipment or manufacturing process
- Continuous process projects should involve design, modeling and analytical prototyping
- Discrete projects can have firmware content

- Projects may be purely software oriented; software projects requiring 2 or more disciplines to successfully execute are encouraged

- Project scope should be approximately 600 student hours

- Company provides educational grant of $20,000/project

- Project should not be classified or highly proprietary.

Projects that deviate too far from these criteria are generally not suitable for IPPD. In cases where the faculty coach has a high degree of expertise in the project area and is skilled at directing student teams, projects that do not fit the model can be successfully completed. Often, these projects are too "researchy" and do not lend themselves well to adaptation within a deliverable-based product development environment. These projects are often proposed by scientists and not by engineers.

Project definition

A project summary was developed to capture important information about the project. The sponsor company is requested to fill out this document. The summary sheet serves many purposes. First, it is a structured tool for developing a concise overview of the project and the identifying liaison engineer(s) and key technological project aspects. Second, it provides a guide for the IPPD Director to identify qualified faculty coaches for the project. Since the summary sheet is in a familiar format, it provides a common framework for evaluating the project against the selection criteria. Lastly, the document is used as a teaching tool for the multidisciplinary student design team. The document provides a context for the problem to be solved, introduces the team to jargon and special concerns of the sponsor company. The contents of the project summary sheet are documented in Table 2.

Table 2. Project summary sheet composition and description

Element	Description and comments
Project title	Defines the title of the project for the duration of program
Liaison engineer information	Contact information for the liaison engineer(s); requires the sponsor to name one or more people up front in the project definition phase; helps solidify commitment
Project background information	Puts the project into a context within the sponsor's business. This is particularly helpful for the student engineers—they may be familiar with the underlying project technology (i.e. wireless communications) but totally unfamiliar with the intended application (fire hydrant flow measurement).
Most important objectives of project	This is the statement of the qualitative customer needs and a description of the problem to be solved.
Design expectations	This addresses specific design deliverables and documentation standards (i.e. solid models will be delivered in Pro/ENGINEER or printed circuit board layout will be delivered in Mentor Graphics). This is important for project evaluation because it gives an early indication of special training requirements or design team skills

Element	Description and comments
	required.
Prototype expectations	Determines what types of prototypes are required—physical and/or analytical. For instance, a multilayered printed circuit board may be required to meet space constraints—perhaps for testing purposes, a dozen boards may be required. This provides an insight into the complexity of the prototypes and the resources required to produce the prototypes—will outsourcing be required? Can the company provide assistance in fabrication, assembly and testing?
Estimated cost of hardware	Hardware costs in excess of $1000 are the responsibility of the sponsor company. It is important to clarify budget issues early and obtain necessary commitments up front.
Estimated company time/effort Calendar months Engineering time Prototyping/modeling time Other time	The intent of this section is for the sponsor to define the company time and effort required if they were to undertake this project in-house. If the project requires more than 600 hours, then it is out of scope for IPPD. Alternatively, this section may be used strictly to estimate the amount of time they will invest in liaison engineering support. Either way, the time estimates are invaluable in estimating the project scope and amount of support the company plans to offer.
New technology requirements	If an emerging technology is required for this project, for instance incorporation of MEMS technology into composites health monitoring, then it should be identified here. Projects that require an invention to succeed are out of scope for IPPD. It is an unrealistic expectation that a group of undergraduates will be successful in inventing a new device or process within an 8-month timeframe.
Special information	Any other pertinent information. Could include information on availability of special software through the sponsor, a special testbed or a particular supplier that the sponsor wishes to utilize for the project.

Letter of agreement

Project commitments may be made via a personal visit, a telephone conference or through email. Once a project has been agreed upon, a project summary sheet received, and the sponsor approves of a faculty coach, a letter of agreement is sent to the sponsor. The letter contains the following elements:

- An agreement between the Industry Sponsor and the University of Florida
- A commitment from Industry for a $20,000 educational grant
- A pledge to exempt the sponsorship fee from indirect cost
- A statement that Industry owns the design

- An assurance that Industry does not hold the University responsible for final project success of or any product liability
- An offer to sign a non-disclosure agreement if required
- A commitment that Industry will provide liaison engineer support
- A promise that the University will review project progress regularly
- A project scope estimate of approximately 600 student engineering hours

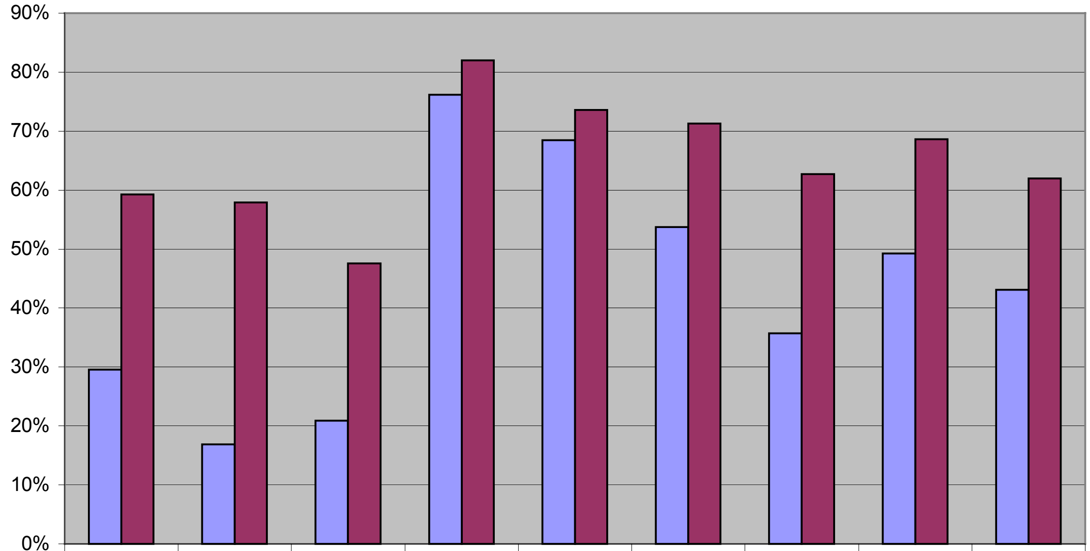
The letter is signed by the Dean of Engineering and the Director of Sponsored research and sent to the sponsoring executive for signature. An invoice for the project sponsorship fee accompanies the letter. Once the University receives an executed copy of the letter, the sponsorship fee can be received. This process works effectively in over two-thirds of the projects. In others, the sponsor sends a purchase order (P.O.) and once acceptable terms and conditions are agreed upon, the University will bill against the P.O.

Rarely has all the paperwork for the project been received prior to project launch in late August. Once the semester starts and the student team has formed, we have NEVER had a sponsor renege on a commitment. Waiting for all the terms and conditions to be satisfied and agreements signed prior to launch would have likely resulted in dropping half of the 186 projects undertaken to date.

Assessment results

The students complete self-assessments of educational objectives at the beginning and at the end of the course. The educational objectives include the following: (1) applying engineering knowledge in design, (2) understanding how to integrate product and process design, (3) understanding structured design methodology, (4) understanding principles of teamwork, (6) understanding principles of effective oral communication, (7) communicating effectively orally, (8) understanding principles of effective written presentations, and (9) communicating effectively in writing. Figure 2 shows the composite results compiled since the 1996-1997 academic year. Analysis of this data shows that in most of the nine categories, significantly more students report in the "very-good to excellent" rating categories (a rating of 4 to a rating of 5 on a 5-point Lichert scale) when comparing the pre-IPPD to the post-IPPD self-assessment results. More quantitatively, in seven categories the data reveals double-digit percentage increases from pre self-assessment to post self-assessment ratings of very good to excellent. In addition, over the same data-collection period, 92% of the post-assessment respondents agree or strongly agree they are confident to practice design in industry, and 90% of the respondents agree or strongly agree that the course improved their ability to conduct independent research.

Comparison of Pre and Post Self-Assessments of Educational Objectives
IPPD Program 1996 to 2001
592 Pre Assessment Respondents
428 Post Assessment Respondents



	1	2	3	4	5	6	7	8	9
Pre: very good to excellent	30%	17%	21%	76%	68%	54%	36%	49%	43%
Post: very good to excellent	59%	58%	48%	82%	74%	71%	63%	69%	62%

Educational Objective

(1) applying engineering knowledge in design, (2) understanding how to integrate product and process design, (3) understanding structured design methodology, (4) understanding principles of teamwork, (6) understanding principles of effective oral communication, (7) communicating effectively orally, (8) understanding principles of effective written presentations, and (9) communicating effectively in writing

Figure 3. Integrated Product and Process Design Program Educational Objectives from 1996 to 2001.

Conclusions

This paper describes some of the lessons learned during eight years of continuously improving the Integrated Product and Process Design courses at the University of Florida. The program is continually sustained with new sponsored projects. The projects are recruited utilizing a network of IPPD program stakeholders. Sponsorship leads are followed until projects are committed. Once committed, the project ideas are reviewed and written up in a project summary sheet. The projects are selected based upon a set of criteria. The process has worked effectively for 8 years.

Acknowledgements

The authors would like to acknowledge Heinz Fridrich, former IPPD Director, for his vision, perseverance and leadership in the creation and shepherding of the University of Florida's IPPD program. The following colleagues were also instrumental to the success and institutionalization of the IPPD program: the Original Task Force of S.X. Bai, R.B. Dickerson, A. Heggestad, K.S. Jones, M.E. Law, Y.W. Su, S. Svoronos (principal investigator), and J.C. Ziegert; the Implementation Task Force of W.R. Eisenstadt, S.S. Erenguc, R.

Narayanan, S. Svoronos, S. Tufekçi, E.D. Whitney, and J.C. Ziegert; Coaches J.R. Ambrose, M. Bermudez, G. Bosman, A.B. Brennan, T.F. Bullock, P.A. Chadik, J.N. Chung, O.D. Crisalle, W.W. Edmonson, N.G. Fitz-Coy, R.M. Fox, M.P. Frank, F. Gamble, K. Gugel, A. Helal, W.E. Lear, S.M. Legg, D.W. Mikolaitis, R. Newman, K.D.T. Ngo, T. Nishida, J. Peterson, K. Powers, K. Rambo, R.K. Stanfill, S.M. Thebaut, A.J. Vakharia, L. Vu-Quoc, G.J. Wiens and J.N. Wilson; the College Advisory Committee of R. Abbaschian, T.J. Anderson (Chair), D.J. Elzinga, W.G. Tiederman, and, M.A. Uman; S.I. Peek, J.H. Perkins and A.W. Sistrunk. Lastly, we acknowledge the unwavering support of Deans W.M. Phillips, M.J. Ohanian (retired) and P.P. Khargonekar. The IPPD program has received financial support from the SUCCEED coalition which is funded by the National Science Foundation grant C9727411.

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a. R. Keith Stanfill

Keith Stanfill joined the University of Florida in May 1999 and is the Director of the Integrated Product and Process Design program. Dr. Stanfill has over ten years' industrial experience with United Technologies, including 7 years with Pratt & Whitney and 3 years with Carrier Corporation. As an engineer at Pratt & Whitney, he designed gas turbine hardware for fighter aircraft—most recently the Joint Strike Fighter. At Carrier, he served on the New Product Development Council Steering Committee, facilitated Design for X (DFx) workshops internationally, developed business process linkages between new product development and lean manufacturing, and developed and implemented manufacturing systems software. He received his B.S., M.E., and Ph.D. in 1985, 1991 and 1995, respectively, all from the University of Florida Department of Mechanical Engineering. His interests include technology transfer, product development, design education and DFx. He is a registered professional engineer in the state of Florida and is a member of the American Society of Mechanical Engineers and the American Society of Engineering Education.

b. Oscar D. Crisalle

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