

## **AC 2008-296: INTEGRATION OF INDUSTRY PARTNERS INTO A CAPSTONE DESIGN PROGRAM**

### **Stephen Laguette, University of California-Santa Barbara**

Stephen Laguette received his BS, MS in Mechanical Engineering from UCLA. His career has included executive R&D management positions with a number of medical device companies. He has been responsible for the creation of complex medical devices with over fifteen US patents issued in a variety of surgical fields including General Surgery, Plastic Surgery, Urology, Neurosurgery, ENT, Voice Restoration, and Ophthalmology. As the Director of Device Research for a major ophthalmic medical device company, he directed all research activities, the identification of new technologies, and the review of new business opportunities for the corporation. His responsibilities included transitioning projects into development and potential commercialization. He identified and successfully created research programs with leading academic institutions and formed strategic alliances with other high technology companies. He is currently a Lecturer at the University of California, Santa Barbara in the Department of Mechanical Engineering and the Technology Management Program in the College of Engineering. He remains active in the field of medical devices as a consultant for new ventures and investment firms.

# **Integration of Industry Partners into a Capstone Design Program**

## **Abstract**

In September 2004, the University of California, Santa Barbara, Department of Mechanical Engineering initiated a Capstone Design course requirement for senior mechanical engineering students. The course has transitioned from a three unit course typically taken in the final Spring quarter of the curriculum to a two unit course taken each quarter of the academic year for a total of six units. Students work in teams under the direction of a faculty advisor to tackle a mechanical engineering design project. Engineering communication, such as reports and oral presentations are covered. The course emphasizes a practical, hands-on experience, and integrates analytical and design skills acquired in the companion ME courses. The course objectives are (1) design problem solving, creative thinking, project planning and teamwork through a challenging design and build project; (2) to provide experience in fundamental engineering reporting and communication including project plans, design reviews, and project reports. A Capstone Design program has now been developed and has become an integral and important component of the mechanical engineering curriculum. This program now allows the students to address more significant and practical design projects.

The ME Capstone Design Program added an Industry Partner Program for the 2005/06 student projects. This program was successfully started with the generous gifts and support from local companies. The Industry Partner program has now grown to include participation with major corporations in a variety of industries and technologies. This program has facilitated a positive and constructive entrance for a company to become involved with university and to establish beneficial relationships with the faculty and students.

The students now have the opportunity to work on a practical design project and to interact with outside engineers. The industry partner has the ability to work directly with some of our brightest and most capable students. This program has facilitated a source of funding and a breadth of meaningful and practical projects for the students to address.

This paper will address the development and integration of an Industry Partner program into an ME Capstone Design program. Issues such as recruitment, selection of appropriate projects, project communication and reporting, and intellectual property will be discussed. Examples of past and current projects will be presented.

## **Introduction**

The transition and development of a Capstone Design program at the University of California, Santa Barbara, Department of Mechanical Engineering has previously been reported [6].

The cornerstone of the program is a required course for all senior Mechanical Engineering students that is taken in the final year for two units each quarter. This course was created to provide the students an experience of working as a project team to address a practical and significant design and build project. The importance of working as a team is emphasized with individual roles and responsibilities.

Students work in teams of three to five under the direction of a faculty advisor to tackle an engineering design project. Engineering communication, such as reports and oral presentations are covered. We emphasize a practical, hands-on experience, and integrate analytical and design skills.

The ME Capstone Design Projects include the following types of projects:

- 1) **Industry Partner** projects are supported by gifts to the program. Students have an opportunity to work on practical design projects and to interact with outside engineers.
- 2) **Research Partner** projects are supported by research or University funding to support current University research projects. Students have an opportunity to work with leading international researchers, graduate students, and research laboratories.
- 3) **Student Organizations and Design Competitions** include the SAMPE and SAE design competitions. Our student teams have successfully competed and have won several prestigious awards.
- 4) **Student and Faculty Created Projects** include creative and challenging projects with an entrepreneurial perspective.

This paper is intended to address the development and integration of an Industry Partner program into the Capstone Design program. It is important to note that the intent of Capstone Design program is to reflect the technical excellence and expertise of the department while providing a variety of project types and challenges for the students. The Industry Partner program and projects are an important component of program but are not intended to be the sole source of the projects for student consideration.

### **Capstone Design Projects Course Objectives**

The senior design projects are developed with the support of local industry, interested faculty, student organizations, and interested students. The projects reflect the academic integrity and excellence of the Mechanical Engineering department. A committed faculty and Industrial Advisory Board are instrumental in this process.

It is important to provide a broad selection of projects in terms of technical considerations, fields of interest, student and faculty interests. Students select their projects and create their project teams from a list of projects that are provided prior to the start of the Fall quarter. Typically, more proposed projects are listed than will be needed.

Although there is a broad selection of projects, common course deliverables and expected completion dates provide a structured format for the student efforts and faculty evaluations.

### **Industry Partner Program**

In September 2004, the curriculum transitioned from a three unit design course typically taken in the final Spring quarter of the senior year to a Capstone design course taken each quarter of the senior year for a total of six units. There were many challenges presented by this transition. Two significant challenges included:

- (1) generating meaningful and challenging projects for the students to consider and
- (2) providing adequate funding to undertake and complete these challenging design and build projects

The initial Capstone projects that were generated in 2004 were similar in scope and challenges to those projects that had been previously developed for a quarter long course. These projects were limited in scope and limited in number.

Additionally, little planning and budgeting had been conducted to provide adequate funding and resources to transition to practical and meaningful projects to be conducted over an entire academic year. Little consideration had been given to the desired types of projects and the costs associated with transitioning from simple proof-of-concept projects to more complete projects with functional performance.

As a means to generate a selection of more practical and meaningful projects, an Industry Partner program was initiated for the 2005/06 academic year. The use of industry partnered projects within a capstone design program has been previously reported [1-5]. There are pros and cons with industry partnered projects that must be thoroughly considered and understood. There must be a careful review in the context of the desired educational objectives [3].

The clear objective of the Industry Partner program for our department is to generate a set of practical and meaningful projects in an industrial-type real world environment for student consideration. Students should also have the ability to select projects with different interests and objectives.

The principal pros and cons that were considered:

Pros:

- Generate more practical and meaningful projects
- Contribute funding for the projects and the growth of the program
- Student interaction with a company and practicing engineers
- Provides students an experience in a specific industry
- Assists in placement of students

#### Cons:

- Intellectual Property issues must be carefully addressed with the university
- Intellectual Property issues must be carefully addressed with company in the types of projects to be considered
- Administrative procedures must be developed and managed
- Faculty support and interest may be limited
- Industrial relationships must be continuously cultivated and maintained and are time consuming

Prior to initiating the Industry Partner program, a meeting was conducted with the Office of Technology and Industry Alliances of the university to understand the limitations, constraints and requirements of such a program in terms of intellectual property. In general terms, the companies must not provide funding on a fee-for-service basis. The companies are requested to provide funds as unrestricted grants, gifts, or donations to the department. The companies may not restrict the public disclosure of the project in terms of the academic deliverables and course requirements such as project presentations, design reviews, and technical reports. Further discussion of intellectual property issues will be addressed later in the paper.

We request an unrestricted gift of \$5,000 by the company to the department once the proposed project has been selected by the students and project team is formed. A review of similar industry partnered programs [1-5] indicates that gift amounts ranging from \$2,000 to \$20,000 are common. We have selected \$5,000 to encourage company involvement with minimal expense. This has provided adequate funds to support the projects and the design program at present. All partnered projects have been completely supported through prototyping, testing and project completion by the gift amount. There are no additional fees or requests for funding from the Industry Partner.

#### **Recruitment**

The graduating senior class for our department is typically between 80 to 100 students. The Capstone projects are undertaken by project teams with three to five senior ME students. Our typical number of Capstone projects and teams is about twenty. As stated previously, it is desired to provide a variety of project types. It was proposed prior to initiating the Industry Partner program that this would be an important component but would not be the sole source for projects and program funding.

It was proposed that we would limit the number of projects and Industry Partners to four of the nineteen projects for our first year of the program (2005/06). It was thought that this number would be easily manageable in terms of company recruitment, projects management, and would improve the probability of success for the program and success of the projects both for the students and companies.

The initial recruitment of companies was limited to our local area. This would provide easy and immediate access for meetings and visits both at the university and company site. Our area is typical of areas with a major university in that there are several high-tech

new ventures and several small to mid-size companies with manufacturing. Our area has been quite fertile regarding medical device new ventures and companies. In addition, the aerospace industry is dominant in terms of employment with a division of one of the major corporations.

With a clear understanding of how and why the Industry Partner program would benefit the department, the students, and the design program, the benefits of the program were characterized from the company perspective. Companies may be interested in developing and establishing a relationship in the program for the following reasons and concerns:

- currently involved or past involvement with research projects
- a desire to develop relationships and contacts for future research projects
- selective recruitment of new engineers
- address low priority projects with minimal expense and resources
- must not impact intellectual property concerns

It was clear from the beginning that the success of the program would require a good relationship between the university and company and that these relationships must be mutually beneficial. Companies that have a good working relationship (or a desire to develop a relationship) with the department and university would be excellent candidates for recruitment into the program. Initial company recruitment was limited to a network of current and past working relationships. We successfully introduced in 2005/06 two aerospace oriented projects and two medical device oriented projects through this network.

An increase in the size of the senior class the next year (2006/07) resulted in the total number of projects increasing from nineteen to twenty-three. It was desired to increase the number of Industry Partner projects from four to seven projects. It should be understood that the recruiting process is a year-long process. The recruiting process for 2006/07 began in 2005/06 by identifying prospective partners and inviting their attendance and review of project presentations, design reviews and the year-end poster competition. Prospective partners have the opportunity to witness and appreciate the efforts, accomplishments, and the limitations of the student project teams. Representatives of prospective partners are invited to act as judges for the annual poster competition that is conducted at the completion of all Capstone projects in June.

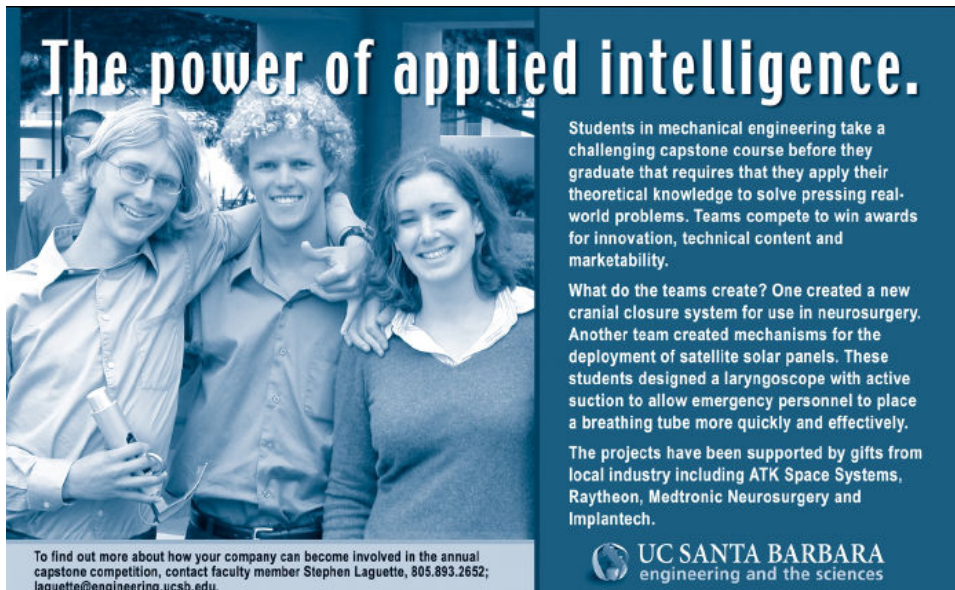
We were fortunate that for 2006/07 that three of the four previous year partners desired to continue their relationship. This necessitated the recruitment of an additional four companies into the Industry Partner program. Recruitment efforts were successful in adding two more medical device companies and two companies involved with novel high-tech test equipment and services.

For the current year 2007/08, we have ninety-seven students and a total of twenty Capstone project teams. It was decided to limit to no more than ten Industry Partner projects for student consideration. Again successful outcomes resulted and continued company interest resulted in four continuing companies. Including interested continuing partners, we had fifteen prospective partners and proposed projects. This year we

expanded recruitment efforts beyond our geographic area and have included a major aerospace and a major medical device corporation. Project selection criteria and intellectual property concerns eliminated five companies from student consideration prior to the start of the course. Of the ten proposed Industry Partner projects for student consideration, eight projects were selected based upon student interest.

Within three years, the Industry Partner program has successfully integrated and recruited continuing and prospective companies into a Capstone design program that can be selective in terms of the types of projects selected and student interest. It is desired to continue recruitment efforts and to maintain the established relationships for next years 20008/09 projects. At present we are planning on limiting the number of projects for student consideration again to ten proposed projects. Based upon the size of next year's senior class, it is estimated that we should have approximately twenty projects going forward.

Recruitment of prospective companies is assisted through efforts with the College of Engineering through the use of an advertisement (Fig. 1) that was created for placement in the college newsletter. In addition, our Industry Partners and the program are acknowledged at college events involving industry attendance during the year.



**The power of applied intelligence.**

Students in mechanical engineering take a challenging capstone course before they graduate that requires that they apply their theoretical knowledge to solve pressing real-world problems. Teams compete to win awards for innovation, technical content and marketability.

What do the teams create? One created a new cranial closure system for use in neurosurgery. Another team created mechanisms for the deployment of satellite solar panels. These students designed a laryngoscope with active suction to allow emergency personnel to place a breathing tube more quickly and effectively.

The projects have been supported by gifts from local industry including ATK Space Systems, Raytheon, Medtronic Neurosurgery and Implantech.

To find out more about how your company can become involved in the annual capstone competition, contact faculty member Stephen Laguette, 805.893.2652; [laguette@engineering.ucsb.edu](mailto:laguette@engineering.ucsb.edu).

**UC SANTA BARBARA**  
engineering and the sciences

Figure 1. Advertisement of Design Program

### **Intellectual Property**

Concerns regarding intellectual property should be addressed prior to establishing a project selection criteria. As noted previously, based upon discussion with the Office of Technology and Industry Alliances, funding must be provided through unrestricted

grants, gifts or donations at our university. There must be no commitment such as a fee-for-service agreement or contract. Additionally at our university, the undergraduates are considered to “own” their individual intellectual property. Any agreements that are needed by the company are addressed between the company and the student. There are no agreements or contracts between the company and the university or department.

Typical agreements that are desired by the companies involved in the program include confidentiality and invention assignment. Students are advised that selection of an Industry Partner project may involve a requirement to sign a Confidential Disclosure Agreement and Inventions Assignment Agreement. Students are advised that if there are concerns with signing such agreements that they may select other available projects for consideration.

Companies involved in the program that have required these agreements typically use the same agreements that are used for student interns. In general terms, these agreements will require that should company confidential or proprietary information be disclosed to the students in the course of the project that this information shall not be publicly disclosed. Additionally in the course of the project, should the student efforts on the project result in a possible invention that this will be assigned to the company.

There are concerns by some companies, typically involving aerospace or the military, that US citizenship is required. The students are advised that the company has stated this requirement when the project is listed for student consideration. The company does have the right to restrict entrance to their facilities and the disclosure of information. However, no restrictions must be placed by the university regarding US citizenship to be involved on the project. To date, no non-US citizen students have requested these specific projects.

It is our experience that the best way to address confidentiality and invention assignment concerns is through project selection rather than relying upon agreements. During the recruitment process and initial relationship discussions with prospective partners, the companies are advised to generate and propose projects that will not require their disclosure of confidential or proprietary information. Additionally, the companies are advised to generate and propose projects that have already been protected through company intellectual property.

Lastly, any agreements that may be required for the students to consider and sign are reviewed for acceptability prior to being listed for student consideration. Under no circumstances, should any agreements be considered that restrict the students from conducting and completing their academic responsibilities and course deliverables such as project presentations, design review and reports.

### **Project Selection**

Prospective companies are selected and recruited to participate in the program that have an established relationship or desire a relationship with the department and the university. It is important that these companies are involved with technologies, products, or services



that are of interest and within the expertise of the department. To be successful, the relationships that are created and maintained must be mutually beneficial. There must be proper support and motivation from individuals at the company as well as the department in terms of faculty interest and support.

Once it has been determined that there is a good fit with the company and the department in terms of objectives, discussions regarding specific projects may now become more meaningful. Prospective partners are advised to consider projects that are low priority in terms of need and are not currently being addressed by the company. Projects must also fit our academic calendar and course deliverable dates. Generally, the project should start in September and end in June. The project should be completed within a budget of the gift amount of \$5,000. Lastly, should the project not be completed successfully that there will be no significant expectations or impact upon the company.

As stated previously, projects should be considered that do not require the disclosure or use of company confidential or proprietary information. There should also not be any expectations regarding the generation of new intellectual property. Ideally the project scope is already addressed and protected by existing company intellectual property. For example, this would include patent applications and issued patents.

At present the Capstone projects are undertaken by undergraduate mechanical engineering students. We have not yet incorporated an interdisciplinary program to involve the other departments. The projects should be feasible for completion under these limitations. Projects should have an emphasis in mechanical engineering design. Projects that require significant computer programming or electronics without company support are avoided.

We have found that it may require several discussions and iterations with a prospective partner to develop a suitable list of projects for consideration. Ideally a set of three to five projects are proposed by the company for consideration and discussion. A meeting is held with the responsible individuals of the company. The pros and cons and the technical challenges of the project are discussed. A single project is selected and is proposed by the company to be considered for student selection.

The selected projects have included the following types:

- novel test equipment and methods
- accessory products
- improved manufacturing processes and equipment
- product improvements

It is our recommendation that projects should be avoided that are expected to generate new products. Typically these types of projects have company expectations and intellectual property issues that should be avoided.

As mentioned previously, the students participate in the final selection of the projects that will be undertaken as Capstone projects and have alternative non-Industry Partner project

types for their consideration. These Industry Partner projects tend to attract students for the following reasons:

- interest in the company
- interest in the technology or industry
- more practical projects

The project selection process purposely results in practical projects that should not generate new intellectual property. We have found that students that desire less structured and more creative challenges will select the Research Partnered or Faculty/Student Generated projects.

### **Project Communication and Reporting**

All successful projects require good communication. It is essential that communications with the Industry Partner meet their expectations. Early discussion with prospective companies should identify expected communications. The ideal situation is for the company to assign an engineer to the project for student interaction. The frequency of communication should also be established in terms of company expectations. Some companies will desire close contact (i.e. weekly) to provide guidance and assistance as the project progresses. Some companies will desire minimal communication (i.e. only course presentations) and may regard frequent interaction as a distraction. It is important to clarify and agree upon the methods of communication, frequency, and points of contact.

The academic course deliverables are the same for all projects types

#### Fall Quarter Activities

- Project selection, Formation of Teams
- Development of Concepts and Designs
- Development of Project Plans
- Development of Product Design Specifications
- Project Presentation

#### Winter Quarter Activities

- Design Development activities
- Prototyping, Analyses, Testing and Evaluation
- Preliminary Design Review
- Engineering Project Report

#### Spring Quarter Activities

- Design Development Activities
- Prototyping, Analyses, Testing and Evaluation
- Complete Project Binder

- Completion of Design Project
- Final Report or Poster

Company representatives are invited to attend the Fall quarter Project Presentations, the Winter quarter Design Review and the Spring quarter Poster Competition. These events are also used as an opportunity to invite prospective partners to attend in anticipation of future involvement. The partners are invited to interact with the students during the Fall and Winter meetings. They do not participate directly in academic grading but discussions are conducted post-event in terms of feedback and meeting expectations.

The inclusion of company and industry involvement and participation in these events has added a positive influence upon the students in terms of their preparation. This includes the non-Industry Partnered projects as well. The companies enjoy the interaction with students and faculty and reinforces successful relationships.

All project teams are expected to prepare and maintain a project binder that includes meeting minutes, copies of presentations, review, reports, design output such as drawings, test reports, and analyses. The final binders at project completion are delivered to the partners at the completion of the projects with all prototypes, samples, or end products.

### **Past and Current Projects**

The first year (2005/06) of the Industry Partner program included the following projects:

- a hinge design and system for satellite deployment use
- an improved neurosurgical medical device
- a sophisticated test system for cryogenic testing of materials
- an integrated manufacturing system for a medical device

These projects were relatively successful in terms of meeting the student accomplishments, course requirements, and company expectations.

The least successful project was the integrated manufacturing system. Upon review, the company was not located locally and required a one hour drive each way for the students, required the integration of electronics and software, and may have been beyond the scope of the students. It was mutually decided that we would not pursue another student project at this time.

We were successful in retaining three of the four partners for 2006/07 and integrated four additional partners for the following projects:

- a test system to assess deployable spacecraft structures
- a test system to assess materials at cryogenic temperatures
- a test system for sophisticated calibration requirements
- an improved neurosurgical medical device
- an improved respiratory therapy medical device

- a light source for medical applications
- a head restraint system for automotive safety

The projects for 2007/08 include three previous partners with an addition of five new companies for the following projects:

- a test system to assess deployable spacecraft structures
- a test system for calibration requirements
- an improved neurosurgical medical device
- a test system for impact testing
- an integrated test system for medical device demonstration purposes
- an integrated test system for medical device performance testing
- a joint design for composite tubes
- a cleaning system for medical device use



Figure 3. Improved medical device

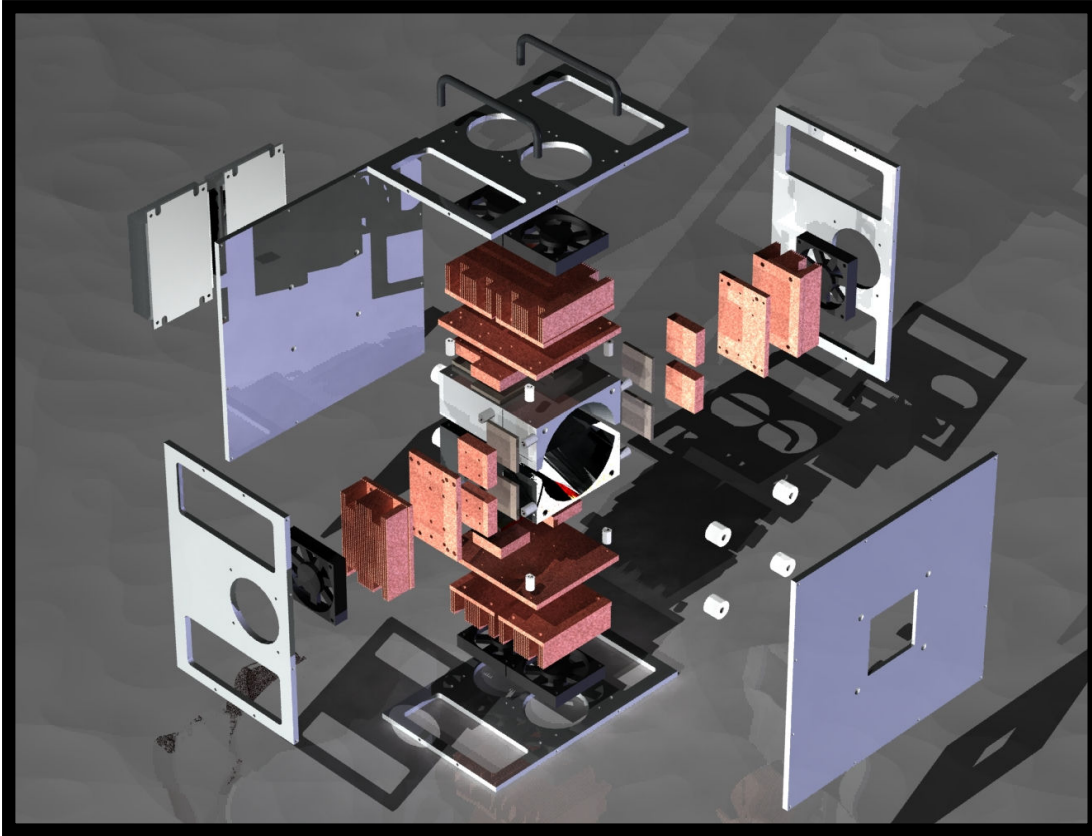


Figure 4. Design and assembly of test equipment

## Conclusions

The success of an Industry Partner program within a Capstone Design program is dependent upon the goals or objectives that are established.

The clear objective of the Industry Partner program for our department is to generate a set of practical and meaningful projects in an industrial-type real world environment for student consideration. Students should also have the ability to select projects with different interests and objectives. This has clearly been accomplished.

We have improved and enhanced the academic excellence and integrity of the program. We have raised over \$95,000 through company gifts in three years that has been used to support these projects and the entire design program. We provide an easy entrance for interested companies to become involved with university. The program serves to maintain and establish mutually beneficial relationships.

At our university the students may select an Industry Partnered project as one of four different project types. When compared against Research Partnered projects and Student and Faculty Created projects, the Industry Partnered student project teams have tended to be more successful in completing their project goals and successful design completion.

There has been a positive and practical influence upon the student teams to set clear and objective design requirements at the start of the projects. This has resulted in clear and practical objectives with a greater probability of success. Additionally, the students have benefited from the frequent and direct interaction with experienced engineers and managers to better ensure success. The educational results as compared with non-industry projects will be the subject of a future paper.

## **Acknowledgements**

The author also wishes to thank past and present Industry Partners in the program including Medtronic, Boston Scientific, Raytheon, Northrop Grumman, ATK Space Systems, Implants, Conmed Linvatec, Inogen, SE-IR, Biomechanics Institute, BEI Encoders, and Helix Medical. Their support and contributions have been instrumental to success of the Industry Partner program and the Capstone design program at our university.

## **Bibliography**

1. Conn A.F and W.N. Sharpe Jr. *An Industry-Sponsored Capstone Design Course*. Presented at the 1993 ASME Design Education Conference, March 24-26, 1993.
2. Wigal, C.M. et al. *Capstone Design Course with Industry Collaboration*. Presented at the 2001 ASEE Southeast Section Conference.
3. Magleby, S.P. et al. *Selecting Appropriate Industrial Projects for Capstone Design Projects*. Int. J. Engng Ed, Vol 17, Nos 4 and 5, pp. 400-405, 2001.
4. Stanfill, R. K. and O.D. Crisalle. *Recruiting Industry-Sponsored Multidisciplinary Projects for Capstone Design*. Presented at the 2003 ASEE Southeast Section Conference.
5. Otieno, A. and C. Mirman. *Engineering Technology Capstone Experience- An Industry Based Partnership*. Int. J. of Modern Engineering, Vol 3, No 2, Spring 2003.
6. Laguette, S.W. *Development of a Capstone Design Program for Undergraduate Mechanical Engineering*. Presented at the ASEE Annual Conference June 24-27, 2007.