# A Senior Project Done in Collaboration with Industry

**Robert Lynn Mueller**
**The Pennsylvania State University**
**New Kensington Campus**

## Abstract

Many baccalaureate-engineering curriculums require that their students complete a project course prior to graduation. This project is usually taken in the senior year and is to utilize the engineering principles encompassed in the student's education. While this is definitely a worthwhile requirement, it is sometimes difficult to find meaningful projects. The advantages to real-world engineering problem as a project are many-fold but getting these projects is not always easy. This paper discusses a real-world senior project done at Penn State University New Kensington in collaboration with local industry. By way of this project, this paper discusses the advantages of real-world projects, suggests ways to find corporate partners to participate, and also provides some suggestions on ways to ensure success.

## Introduction

The senior project is a capstone project course taken in the final term of the 4-year Bachelor of Science in Electromechanical Engineering Technology degree offered at Penn State University New Kensington (PSUNK). The objectives of the course are to train the students in project management, communication skills (both written and oral), budgeting, application of engineering skills, and team building. Each project team consists of 2 students (or 3 only if the course has an odd number of students) and the students are allowed to pick their own teams. The team is usually responsible for selecting its project with the condition that the project must contain at least 3 fundamental components: measurements from an electromechanical system, control decisions based on those measurements, and then the control of electromechanical elements to achieve some design criteria.

Other papers have been published on capstone projects done in conjunction with industry [1-3]. But these papers deal with projects that have the students solving engineering problems and not with the actual manufacture of an item that fulfils the 3 fundamental components outlined above. The author in [3] does discuss some good ideas for establishing long-term commitments from industry for accepting students on a regular basis.

To accomplish the administrative objectives of the course, the project team must provide biweekly written and oral progress reports on project design updates, schedule, and budget. At the end of the term, each project team is required to write a group project report detailing the project's design and budget. A formal demonstration of the project is also required.

Additionally, each student also writes a journal-style paper regarding one particular technical aspect of the project.

Obviously, picking the project can be one of the more difficult parts of the course. Finding a meaningful project can be very difficult but a project that is done in collaboration with industry could solve this problem. Not only do the students have a meaningful project, but it also exposes students to real-world engineering. It allows them to accomplish the objectives of the course while at the same time they have the benefit of working with practicing engineers in the workplace. The difficulty is finding these projects and then successfully implementing them.

This paper discusses how a senior project was successfully found and implemented at PSUNK.

## Steps Taken to Bring About the Project:

Industrial Automation & Control, Inc (IAC) is a local process control systems integrator that has hired some of our graduates. IAC was contacted to see if they had any projects that would satisfy our senior project requirements. They advised us that they had one potential project with HH Smith, a manufacturer of electrical components located in Meadville, PA (about 90 miles from our campus). HH Smith wanted to automate the process used for manufacturing banana jacks but it wasn't economical for IAC to invest the time and materials just to see if the process could be economically automated. But with the prospect of reducing engineering costs by using students, the project became more viable. IAC volunteered to provide the control and instrumentation hardware. Opto 22 Corporation, a long-time supporter of Penn StateUniversity, donated the PLC controller. Since the project was going to require machined parts, Lu-Mac, a machine shop located in nearby Ford City, PA, was approached and they agreed to provide machining services and materials for any special parts. HH Smith was also able to contribute some parts from obsolete manufacturing processes. And, of course, all parties were very willing to provide appropriate engineering guidance.

## Current Manual Manufacturing Process:

The first step in the manufacture of a banana jack is to place the clip portion over one end of the stud portion as shown in Figure 1. The assembly is then placed into a jig where a force is applied to both ends of the assembly. This causes the collar in the middle of the stud to encase the end of the clip, thus forming an assembled banana jack.

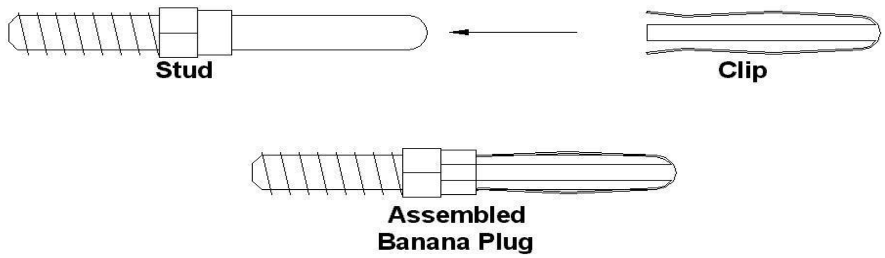


Figure 1. Banana jack component parts

The current manufacturing process consists of a human assembler placing the clip over the end of the stud. This assembly is then placed into a jig on the right side of the circular index table shown in Figure 2. The index table rotates and the assembly eventually gets to a crimping station (on the left side of the table as shown in Figure 2) where the assembly is crimped so that the clip is permanently attached to the stud. It is then extracted from the jig and dropped into a trough that goes to a bin for finished parts.

**New Automated Manufacturing Process:**

The automated banana jack assembly mechanism is shown in Figure 3. Protective shields have been removed and the operator's panel is not shown. The studs and clips are aligned and sorted using vibrating bowl feeders. The studs are placed in the vibrating bowl feeder shown in the right side of the figure and the clips are placed in the vibrating bowl feeder shown in the left side. The vibration of the bowl feeders causes the clips and studs to move upward along the track on the outward wall of the bowl. Along the track, the parts are oriented uniformly. The clips are oriented nose-first using a trip wire (incorrectly oriented pieces fall back into the bottom of the bowl). The studs are oriented by allowing their nose to swing down and progress along the track with the thread sides first. The pieces exit the bowl feeders onto a slide (one for clips and one for studs). At the end of each slide there is a low-pressure pneumatic ram that pushes the piece onto the final assembly mechanism. The final assembly is a two-step procedure: the first step has pneumatic rams that push one clip and one stud into the compression jig; the second step uses the same pneumatic rams, but at much higher force, to compress the stud's collar around the end of the clip inside the compression jig.

The process is controlled by a PLC controller model SNAP-LCSX donated by Opto 22 Corporation. This controller has a variety of analog and digital modules as well as special purpose modules. The controller is supported by the Factory Floor suite of development software that contains many features that are not normally found in many other PLCs and are not covered in our PLC course. Understanding these other features served as an additional learning component for the students. Factory Floor consists of four tightly integrated components (as follows):

1. OptoControl combines a graphical flowchart programming language with an integrated real-time debugger. The combination of simple flowcharting programming, a multitasking operating system and an English-based instruction set results in a language that makes control code easy to develop, easy to diagnose and maintain, and virtually self-documenting.

2. OptoDisplay is a 32-bit Windows-based HMI, that gives operators, technicians, and engineers the information they need at a glance.

3. OptoServer is the client-server application component of Factory Floor that gathers and serves requested data between the Opto 22 controller and OPC (OLE for Process Control) clients, enabling integration with Microsoft products, third-party packages, and/or user-developed custom applications.

4. OptoConnect allows bi-directional transfer of data between an Opto 22 controller and a Microsoft Access or Microsoft SQL Server database. This allows transfer of data between all levels of the business enterprise and the factory floor.

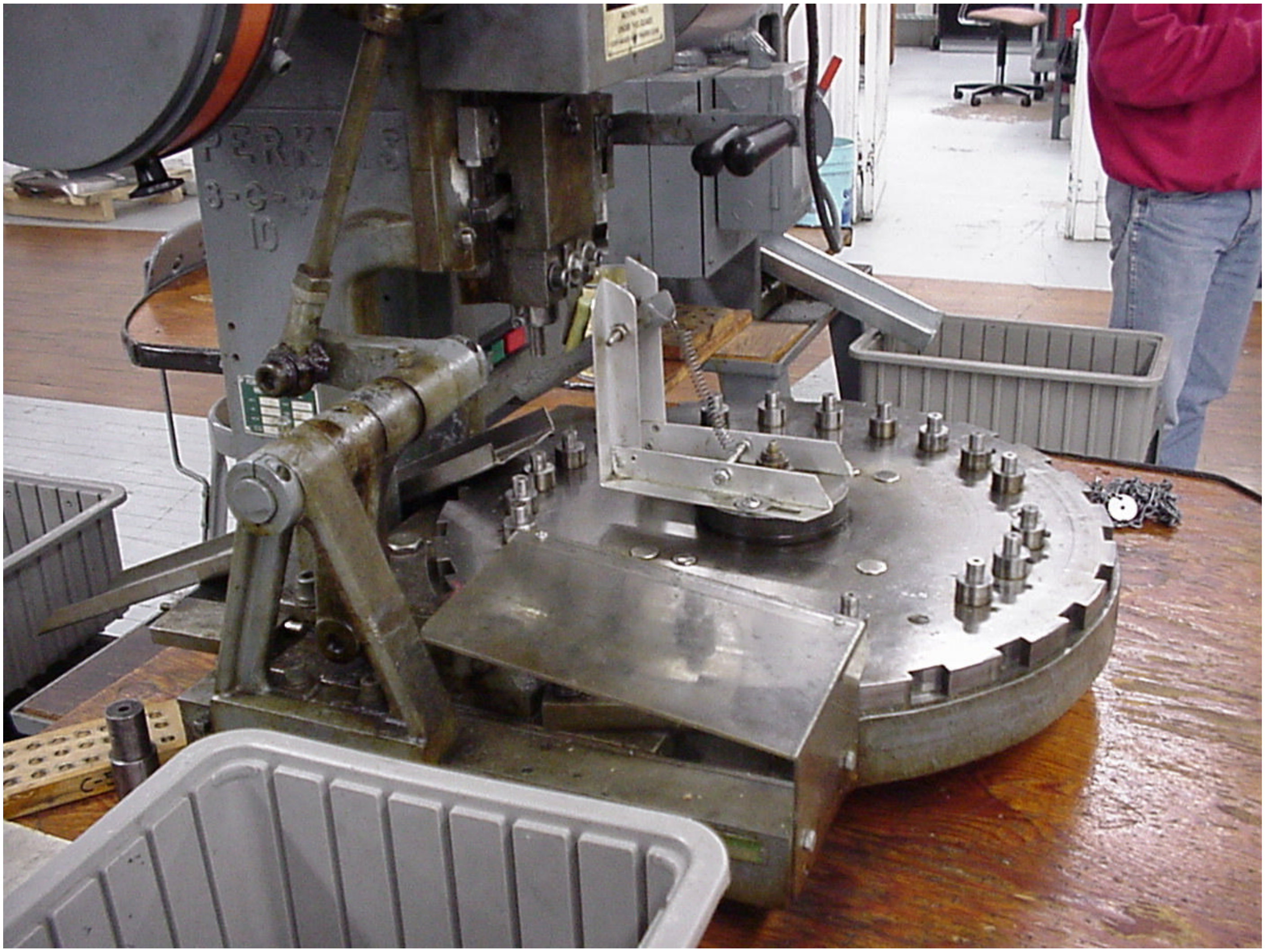

Figure 2. Index table.

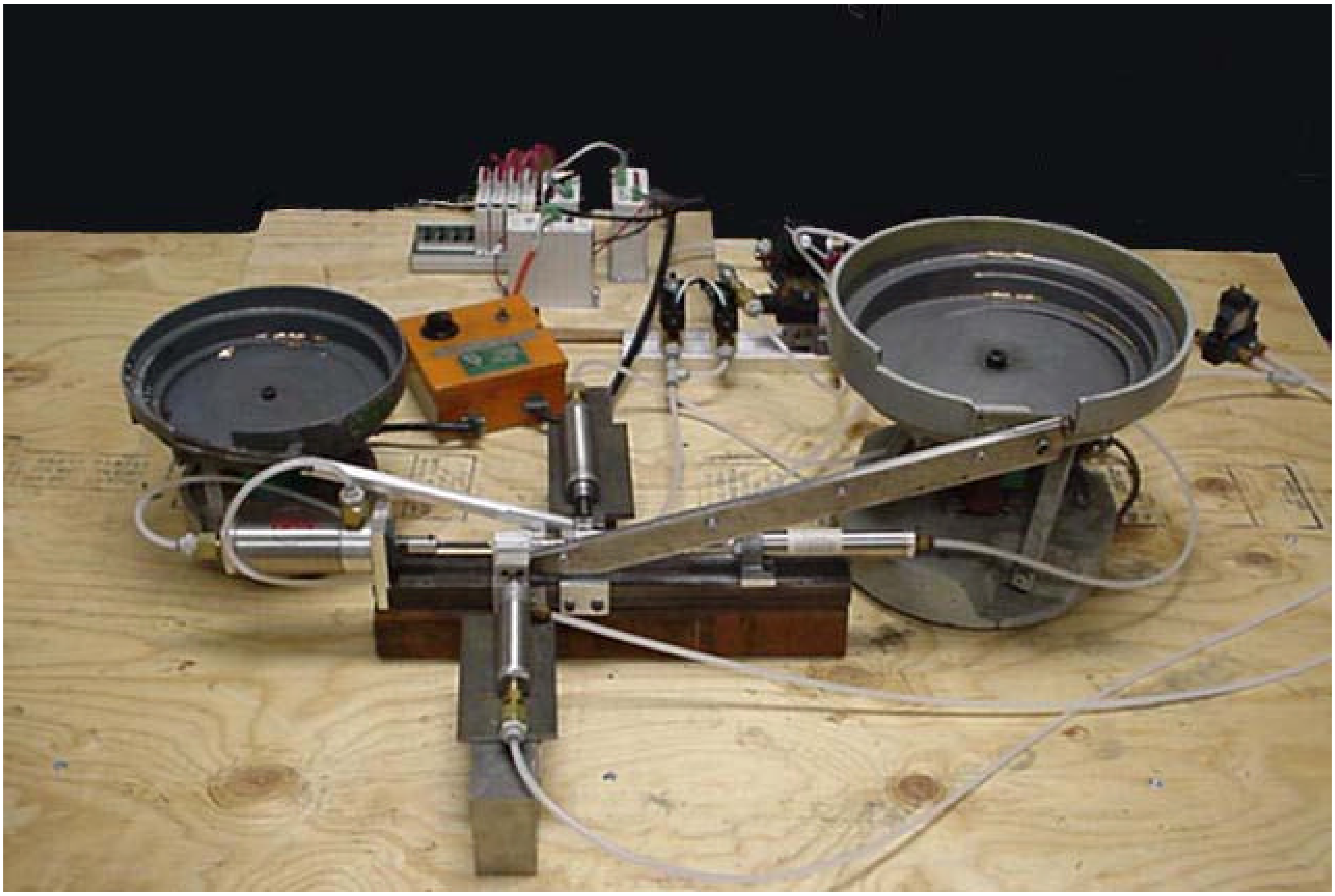

Figure 3. Automated Process

**Learning Points for Students:**

This project accomplished all of the normal objectives of the course as outlined in the introduction of this paper. However, there were many addition learning points that were achieved because the project was done in collaboration with industry.

Many times senior projects are constructed and then drawings for the final report are done to match what was built. When working in industry, the drawings must be done first. This forces the students to produce usable drawings that must take into consideration what can and cannot be manufactured. Also, the operator and maintenance documentation that is required in industry is usually not addressed in the classroom.

While most senior projects result in the application of classroom equations to an engineering application, there is no substitute for the application of classroom equations to a real-world application.

An economic justification of the final product must be done. This also includes the “what-it-costs versus what-it’s-worth” decision. That is, if the product provides a large savings to the customer, then there is cause to consider charging the customer more than it costs to construct the product.

The normal senior project is demonstrated in the lab and then it is forgotten. However, the industry-based project is put into service after the demonstration. This brings other considerations to bear. The first is that the product must be designed for easy maintenance after it is placed into operation. It also makes it necessary to address product liability concerns. That is, the project must be designed in such a way so that it is not possible for the operator or maintenance personnel to be injured by the project.

**Aspects That Made the Project Successful:**

The selection of this project was made easy because of close relations with local engineering firms. This provided a good source for this type of project. Other potential sources include members of the campus’ Industrial Advisory Committee. Another source could come from companies that routinely hire your students. Employers of former students may also provide a source. In addition, possibly some of these companies may have relationships with other firms that might be able to provide a project and/or the project resources that you are required.

Finding large national or international firms that are willing to support university projects with engineering services and/or equipment. Opto 22 was more than willing to supply the PLC and it only took a letter to request it.

Once all of the necessary companies have been identified, select one company to be the lead. For this project a systems integrator worked very well because of the type of project. The project functioned as though the students were working for the lead company. Under the lead companies guidance, it was the students’ responsibility to keep all suppliers and the customer informed of the project’s progress. Using a lead company may also help relieve university of any liability.

Keep in touch with the industrial partners. This will help ward off any potential problems plus it will let you fine tune procedures for future projects. It also enhances the possibility of reusing the company.

It is strongly recommend that you use your best students. Note that the best student is not necessarily the one with the best GPA when it comes to designing something that will be constructed. Lab courses are a good place to identify the students that are good with their hands. Work ethic is another consideration. Some students do the minimum amount required to just get by while other students are over-achievers. Placing weak students on a project increases the risk of an unsuccessful project and thereby ruin any future collaborative projects. It also has the potential risk of placing a bad image in industry on all of the program's graduates.

Respect needs to be given to the clients' confidentiality. Items that are to remain confidential need to be outlined at the beginning of the project. For example, some aspects of this project involving manufacturing costs and reject rates could not be publicly disclosed. This is a good lesson for the students to gain an understanding of the purposes of confidentiality.

And lastly, don't forget to send thank-you notes to all industrial partners thanking them for their cooperation and support of the program.

**Conclusion:**

This paper has discussed a senior project done in collaboration with industry. It has discussed how the project was successfully found and implemented. It has also suggested potential sources for these types of projects as well as outlining items for ensuring their successful implementation.

**Acknowledgements:**

The author would like to thank John McCaully, President of Industrial Automation & Control, Inc; Opto 22 Corporation; Bill Key, President of Lu-Mac, Inc; Kris Gamble, plant manager of H. H. Smith; and newly graduated engineers Nick McSparrin and George Mandalay.

**Bibliography:**

1. Conrad, William R. and Holt, Tracie L., "Industrial Capstone Projects," 1995 ASEE Annual Conference Proceedings, Vol. 2, pp. 2423-2424, June 1995.
2. Renken, Kevin J. and Balmer, Robert T., "Student-Solicited Industrial Case Study Projects in a Senior Mechanical Engineering Experimentation Course," 1995 Annual Conference Proceedings, Vol. 2, pp. 2115-2212, June 1995.
3. Werstler, David E., "Capstone Course: Projects in Industry," 1995 Annual Conference Proceedings, Vol. 2, pp. 2437-2244, June 1995.

ROBERT LYNN MUELLER
Robert Lynn Mueller is an assistant professor of Electro-Mechanical Engineering at the New Kensington Campus of the Pennsylvania State University. He received his B.S. in Electrical Engineering from Wichita State University and his Ph.D. in Electrical Engineering from the University of Pittsburgh. Dr. Mueller spent 30 years working with industrial control systems before joining Penn State and still continues to work as a consultant providing advice regarding industrial automation.