ABSTRACT
Engineering educational projects with regional industry have influenced creation of Florida’s First Coast Manufacturing Innovation Partnership. The development of the joint industry-academia collaboration has the primary goals of project-centered innovations for technology transfer, training the regional workforce with relevance to industry, and sustainability of technology transfer through creation of high-technology jobs. By providing an experiential education in manufacturing systems automation and design in undergraduate engineering curriculum, engineering students are better prepared upon entering the workforce. Projects comprising the development of the Manufacturing Innovation Partnership are outlined which describe project-centered engineering education in design and manufacturing systems engineering.

KEYWORDS: Industry, manufacturing, automation, mechatronics, robotics, engineering education.

1. INTRODUCTION
Joint industry-academia projects with regional industry have influenced creation of Florida’s First Coast Manufacturing Innovation Partnership (MIP). Several joint industry-academia projects between a newly established Mechanical Engineering Program at the University of North Florida (UNF) and regional industry have established a foundation for the MIP [1-3]. Industrial projects have been organized between the UNF and regional industrial manufacturing companies to provide students with experiential learning to supplement their degree curriculum requirements.

2. MANUFACTURING INNOVATION PARTNERSHIP (MIP)
The Manufacturing Innovation Partnership Program exists with two primary objectives. One of these is to develop a shared design and manufacturing center providing resources for the local manufacturing and design companies to aid in the economic and technical development of the Northeast Florida Region, also referred to as Florida’s First Coast. The other objective is to improve the technical education and preparation of the future workforce in the region. Project-centered innovations for technology transfer, training the regional workforce with relevance to industry, and sustainability of technology transfer through creation of high-technology jobs serve to satisfy this objective.

The focus of the MIP Program is to create an environment that fosters innovations in current and new products, processes, and/or systems through project-centered manufacturing and design activities of mutual benefit to regional industry and academia. The outcomes of the project-centered activities are in the areas of design and manufacturing that increase the competitiveness of the partner company through innovation. The companies gain access to knowledge from academia and from knowledge created by the design and manufacturing resource center in an intellectual capacity not otherwise readily available within the region. This broader impact is a
more competitive, prosperous company in the region in a stronger position to create high-technology jobs. In turn, the experiential education gained by the student participants in the MIP Program create another broader impact of a more scientifically and technologically literate workforce trained with relevance to industry. A mentorship facet of the program is another broader impact to attract and retain engineering students for the future.

The fundamental idea is that technology tools for innovation in advanced design, for example, computer aided engineering including finite element modeling, analysis, and rapid prototyping; and manufacturing, for example, modular robotics, advanced manufacturing process development, automation, manufacturing systems modeling, dynamic systems and controls, and production simulation be used in support of projects in partnership with regional industrial companies. The rationale of the joint industry and academic projects accomplished in the MIP Program require the integration of research and education and the technical need by the partnering company. The vision is that a critical level of innovation for the region is achieved as the ultimate outcome for the projects while also accomplishing a distinguishing educational background for the engineering graduates.

Florida’s First Coast is centered around Jacksonville, which has as a population of close to 1.2 million and a growth rate of over 21% between 1990 and 2000. The Jacksonville metropolitan area is the 46th largest in the US with very proactive economic development organizations. The region has the potential to grow into a major industrial region with access to global markets through its deep-water port. The MIP Program serves as a catalyst for innovation fueling the growth, job creation, and overall improvement to the quality of life in the region. Florida’s First Coast is one of the fastest growing in the nation and has received recent acclaim as a top location for new and emerging businesses and industries to relocate or expand. The development of resources is particularly important to this region of the nation that needs an expanded supporting infrastructure for technology and innovation. The importance to manufacturing in the economy is crucial. Every individual and industry depends on manufactured goods. This sector continues to account for 14% of US GDP and 11% of total US employment [4].

With the rapid development of new manufacturing industry, it is necessary to also create resource facilities for these burgeoning industries. To help the local industry grow, shared resources among the local industry and academia are envisioned through the Florida’s First Coast Manufacturing Innovation Partnership Program. Many of these companies emerging are small and may not currently have resources for fully staffed engineering departments. Smaller companies also may not be able to afford the equipment and tools necessary to successfully survive and thrive in a quickly changing market. In some cases larger companies outsource engineering services to smaller companies to reduce their overhead expenditures.

The MIP Program serves as an advanced manufacturing and design infrastructure in the region. One way to help grow the regional industry base is to develop a resource support facility in the area of engineering design and manufacturing. The Florida’s First Coast Manufacturing Innovation Partnership Program serves as a catalyst for the high technology growth sector of the region while also enhancing the development of scientifically and technologically literate engineering workforce. The projects performed under the auspices of the MIP Program provide in-depth engineering for new engineers entering the workforce.

3. MIP PROJECTS AND PARTNERSHIPS

Students have teamed as Undergraduate Research Assistants (URAs) on several engineering project-centered industry-academia collaborations to accomplish machinery and system design for regional industry. Several of the initial projects are outlined below. The rationale of the joint industry and academic projects accomplished in the MIP Program requires the integration of research and education and the technical need by the partnering company. The innovations for the partnering companies of the region are achieved as the ultimate outcome of the projects while also providing students the educational background creating a more scientifically and
technologically literate workforce trained with relevance to industry. The industrial companies are key partners for innovation. Industry provides the requirements and the needs for the innovation. Industry clearly has needs. Smaller companies lack resources to meet those needs, while larger companies are continuing to try to do more with less, also creating a resource imbalance. The projects span from those for small local start-up companies to large multi-national corporations located in the region.

3.1 Predator Products
A series of projects in research and development of billiard products in terms of design of systems and machines between UNF and Predator Products, a world leading design and manufacturing company of pool cues in Jacksonville, has occurred and projects continue to be developed with this partnering company. Predator Products is a global leader in design and manufacturing of high-performance pool cues. Several projects have been enthusiastically performed by URAs included the design of a pool-playing robot [5-7], test devices for pool cue performance [8-11], while another project is underway in pool cue design analysis.

UNF Mechanical Engineering and Predator Products, Inc. (Predator) have jointly developed ongoing robotics and automation projects in collaboration [8]. One of these is a Break Device [9] machine to measure accuracy in force in break shots. Among other R&D interests at Predator in the area of robotics and automation is a Jump Cue Testing Machine which has also been designed and built [10-11]. The Jump-Cue Tester is currently being used by Predator in the design and evaluation of their jump-cue product.

The Predator Z series shaft has been studied using finite element modeling and analysis. An off-the-shelf software resource has been utilized for finite element analyses. Several types of shots have been analyzed using orthotropic materials under cue ball velocity conditions; a straight shot, a maximum English (offset to produce spin) shot and shots between these two have been studied. Some of the activities performed by the URAs for the cue design project are CAD modeling, material research and application, mapped meshing, load analysis and investigating boundary conditions and phenomena associated with pool shots.

3.2 Dura Automotive
A die cutting system tool has been analyzed and upgraded at Dura Automotive. Dura Automotive is an OEM supplier of automotive components. At their Jacksonville site, Dura Automotive produces thin stamped parts such as gaskets and washers from a variety of materials such as plastic and rubber. The Undergraduate Research Assistants (URAs) from Mechanical Engineering analyzed a set of components (20+ unique part numbers) for production on one of the plant’s punch press machines. The geometry of the parts were known from part drawings, however, not all materials were consistently applied by vendors, thus the project involved identifying the materials and vendors for the base material to make the parts. Some of the production parts use common material. The raw material was received in a possible variety of widths, thus this was another production variable to define and refine through contact with vendors. The desired production rates for the parts were known and the desired frequency of production for each part number was also known. Labor and tooling costs were known, and material costs were determined. The layout of the parts for processing in the tool was designed within the scope of the project. The URAs also designed and implemented the dies with the punch press tool. Through analysis of the data, a make vs. buy cost analysis has been performed within the scope of this work for Dura Automotive to help determine in-house production and utilization of the punch press tool.

3.3 Armor Holdings, Inc.
The scope of project activity in law enforcement products has occurred in a cooperative design and automation project between UNF and Armor Holdings, Inc., a global leading design and manufacturing company of security and law enforcement related equipment supplies. One of Armor Holding’s products developed and manufactured at their Jacksonville site, is a
drug-testing kit. Production of this kit is a high-volume, monotonous, labor-intensive task to produce the kits in a variety of configurations for use by law enforcement. Furthermore the assembly task is hazardous, due to some of the chemical reactive agents in the kits. Also, the operators may experience the effects of carpal tunnel syndrome due to prolonged manual assembly operations. A multi-disciplinary team (Mechanical Engineering and Electrical Engineering) of URAs has analyzed the assembly of the company’s drug-testing kit and redesigned the assembly for automation [12]. The first phase of the project has been to address an automated approach to the assembly of ampules inserted into tubes which are contained in kits. Initially various design for automation solutions to the current design were proposed. One of these has been adopted by the company and a system has been designed to automate this portion of the assembly process. A variety of ampules are assembled into tubes consisting of one to three slots, or sleeve openings to form the primary component for the kits. Each of the variety of ampules contains a specific chemical agent, that when released and reacting with a substance may determine the substance matter. There is a high volume of and multiple tube/ampule assemblies required in the products, leading this application to high-volume production automation [13]. The UNF URAs are currently implementing the automated system.

3.4 Jaguar Security

The MIP has partnered with Jaguar Security, Inc., a minority-owned, start-up security business in downtown Jacksonville. The UNF is developing a wireless Personal Digital Assistant (PDA) based security system to keep track of cargo. Using the wireless PDA, security logs that were once written down onto paper are replaced by a computerized system. This computerized system is able to keep track of cargo efficiently and provide detailed reports through a database system. The system is also developed with the intention of expansion to include inventory should Jaguar Security decide to implement this in the future. Some of the activities that URAs have performed for the project are requirements and specifications, system design, network infrastructure components and recommendations, development of the database.

3.5 Ronco Machine

An engineering research automation project is in-process between UNF and The Ronco Group of St. Augustine, a company that primarily serves the international paper processing industry [14]. The scope of the project is to address an automated approach to the adaptation of an existing core winder machine to an upgraded gift wrap feature that requires higher volumes of production with greater precision. An existing core winding machine design exists in The Ronco Group’s product line with limited capabilities. The design of the new machine accomplishes core winding at a sufficient rate and precision to produce products to satisfy a wider variety of industry needs. The goal of the project is to increase the production rate and allow flexibility to produce cores for a wider industry segment, not only gift wrap, but also other types of cores; aluminum foil, plastic wrap, wax paper, etc. Multiple cutting heads are required to meet the increased production rate requirements. Also, due to the target applications, greater precision is required. MIP URAs have designed a system accomplish higher production rates, and with greater precision.

3.6 Shands Health Systems

This research project is in the field of biomedical engineering with applications in structural biomechanics. The technical objectives are to perform an unbiased study of the mechanical material properties of bone cement and to perform a comparative analysis between the cements. Previous studies on bone cement have been performed by bone cement manufacturers and by researchers sponsored by the manufacturers. This results in a risk of introducing bias in the testing procedure and results. The proposed project has been posed by one of the orthopedic surgeons at Shands Health Research Center in Jacksonville. The investigation which includes making molds for the testing of various bone cement specimens is being performed by one of the orthopedic residents from Shands and URAs. The investigation proposed is likely to result in publishable data in the future.
3.7 W. Lorentz Surgical, Inc.

This is a cooperative project between the UNF and W. Lorentz Surgical, Inc., a design and manufacturing company of surgical instruments and supplies. The scope of this project has been the research and design of an adjustable stop for a skull tap product offered by W. Lorentz Surgical, Inc. The skull tap is an instrument used primarily in craniofacial and maxillofacial surgery for the tapping and drilling of threaded holes into the skull of a patient. Screws would later be inserted into these holes to aid in surgery. An adjustable stop slides over the tap and can be locked into place so that the tap will only drill a certain predefined distance. Grooves are cut into the tap itself to assist in locking. The current stop utilizes ball bearings that slide into these grooves and are held into place by a sleeve. Locking the tap requires screwing the sleeve so that it moves up the stop assembly and holds the ball bearings in place. This requires two handed operation. One criterion for this project was to enable one handed operation on the new design. Some of the activities that the URAs have performed while designing the tap stop are, design conceptualization, design criteria, integrating design with manufacturing capabilities, design, finite element analysis, and testing of prototypes.

4. CONCLUSION

Several collaborative industry-academia projects have been described that have provided a basis for the MIP Program. The initialization of the mechanical engineering program at UNF and the engagement with regional industry on project-centered, experiential education has led to the development of Florida’s First Coast Manufacturing Innovation Partnership. The MIP serves to expand the scope of project-centered partnerships described by the initial projects while also expanding experiential education beyond the classroom setting [15]. Once additional project-centered partnerships are established, each project is monitored on a project basis and on a partner basis. Monitoring is ongoing while the project is being carried out and after implementation for metrics of success. Additionally, several more regional manufacturing companies are joining the joint industry-academia MIP Program.

The teaming of academia with the industrial partners generates outcomes aligned with the goals in the near term and in the long term. The results of the project-centered activities create innovations to current and new products, processes, and/or systems of benefit for the engineering design and manufacturing companies of the region while providing experiential education for students. The innovations increase the competitiveness of the companies. As new opportunities are identified, the MIP Program plan accommodates incorporating ongoing research into the MIP program with additional projects. Also, in many cases it is likely that collaborative research between industry and academia can attract additional funding contributing to the long-term sustainability of Florida’s First Coast Manufacturing Innovation Partnership and training of the engineering workforce.

5. ACKNOWLEDGEMENTS

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6. REFERENCES


