

## **REU Supplemental Request: 13-542**

This proposal seeks supplemental funding (NSF Award # IIP-1339009) to support an undergraduate to participate in the Research Experiences for Undergraduate's program (NSF13-542). An opportunity has been identified that will provide an REU student a meaningful and productive research experience. The student will provide data collection/analysis support for one of MU's most productive and engaged CELDi research collaborations.

### **1. Prospective student's involvement in the research project**

The student will be involved in a project in collaboration with Bayer CropScience (and builds off of some of the concepts from another CELDi project that was conducted by MU with The Boeing Company – a result of the synergy that has developed among the MU CELDi members). The primary sponsor is headquartered at the Kansas City, MO location and addresses their global seed treatment business. However, the project will include individuals from Shakopee, MN; Taiwan, Australia and Brazil. This high level of integration provides the student with an excellent introduction to highly distributed, team- based problem-solving.

Bayer's CropScience division is in need of an approach to assess different scenarios in order to find the optimal way to distribute spare parts as well as position / send repair technicians. In order to address this problem the MU team is developing a suite of decision-support tool that includes both data visualization and optimization tools to support the design of a spare part distribution network. This network consists of DC location, inventory allocation, repair technician location, and repair technician allocation.

Key questions to be addressed include: How to identify the number of repair technicians? Where should technicians be located? Where should DCs be located to support both customer service / demand and technical response time? Using the developed models, we will determine the optimal repair DC / technician locations.

The overall project objective will be obtained via the following sub-objectives:

- 1) Analyze current state-of-the-art on distribution network covering problems.
- 2) Collect and analyze both global crop demand patterns and Bayer's current customer network.
- 3) Develop new network covering models that account for Bayer's unique decision criteria.
- 4) Conduct model validation analysis based on historical practice and results obtained from the developed model.
- 5) Conduct trade-off analysis based on differing levels of establishing network DC locations versus investment budget levels and technician coverage area.

The prospective REU student will be primarily involved in sub-objectives 1 and 2, but will also provide support for sub-objectives 4 and 5. In sub-objective 1 the student will search the literature and characterize both the types of models that have been developed and provide a critical analysis of which aspects of prior models would be useful to this project. In sub-objective 2 the student will work on both collecting global crop demand patterns and formatting the Bayer data so that it is in a usable form. In sub-objectives, 4 and 5 the student will assist the research team in conducting both a model validation analysis and a trade-off analysis per the company's requirements.

## **2. PI experience involving undergraduates in research**

MU and this project's PI have an established history of involving undergraduate students in research. MU hosts an undergraduate research forum each May that is attended by all undergraduates (over 500) participating in research at MU (<http://undergradresearch.missouri.edu/>). The PI has already involved over eighteen undergraduate students in CELDi based research over the past six years. This REU supplement will enhance the ability to involve students in undergraduate research and provides additional opportunities for valuable research experience for undergraduate students, which complements the MU engineering curriculum. An MU student recently won another CELDi Outstanding Undergraduate Research Award, which highlights our ability to both incorporate outstanding students into CELDi research projects, in addition to their ability to contribute to the success of their projects.

MU CELDi has been awarded 5 REU supplements since 2009. The following will briefly note the accomplishments of the students that obtained funding.

### **Design and Analysis of Supply Chains with respect to Energy Issues**

Students Supported: Kelsey Kotur (2009-10), Adam Rubemeyer (2010-2011)

Modeled a representative Boeing supply chain to determine the relevant trade-offs with respect to energy issues and evaluated current state-of-the-art supply chain models. Determined the trade-offs between costs and service levels when energy is considered in supply chain design.

### **Logistics of Using Underground Pipelines for Freight Transportation**

Student Supported: Nicole Smith (2009-10)

Explored the feasibility of using underground pipelines for transporting various types of freight that are normally transported by truck. The student was involved in developing simulation models to explore different approaches to load and unload underground freight pipelines.

### **Design of Reverse Logistics Networks in a PBL Environment**

Student Supported: Donald Schmidt (2011-2012)

Developed models for reverse logistics network design in a performance based logistics environment in order to determine the location of repair/distribution facilities to support minimization of component repair time and cost with respect to location capability/capacity and export constraints.

### **Analysis of Emerging Trends in Logistics**

Student Supported: Jennifer Bergman (2012-2013), Graham French (2013-2014), Veronica Rueda Rey (2013-2014)

In response to an identified need by the CELDi Industrial Advisory Board, the undergraduate students reviewed selected logistics industry trend documents and provided executive summaries tailored to the needs of CELDi industrial members - supporting CELDi's desire to increase value for industry members.

### **Repair Prioritization with respect to Inventory Requirements**

Student Supported: Molly Laird (2015-2016)

Developed a tactical tool to provide short-term repair recommendations while considering the future impact on issue effectiveness and aircraft availability. The model determines which part types should be repaired, how many of each part type should be repaired and when should the parts be repaired. Boeing hired this undergraduate REU researcher to work as an intern this summer to further solidify the applicability of the project results.

### **3. Mentoring that student(s) will receive**

The students will be mentored on several different levels. Each CELDi research team consists of 2 faculty, 1-2 graduate students, and 1-2 undergraduate students. This allows for students to have faculty mentoring throughout the experience that includes how to conduct a literature review, use of data analysis tools, development of optimization models, and presentation skills. The students also have graduate student mentoring that usually consists of how to use state-of-the-art modeling tools. Finally, they obtain peer-to-peer undergraduate mentoring. The MU research team meets weekly with our industrial collaborator via conference call. Therefore, the students obtain indirect mentoring / input from industry as well. At the semi-annual CELDi Research Symposiums, there are also industry mentoring sessions where the students are paired with an industry mentor that provides career development perspective for the students.

### **4. Process and criteria for selecting the student(s)**

One REU student for Fall 2016 – Spring 2017 has been identified (Brett Pawlak), but another student will also be selected to start at the beginning of the semester. These REU student(s) will be selected among the most capable at MU with preference given with respect to the NSF commitment to diversity. The past eight MU CELDi REU students all graduated with honors, were leaders amongst their classmates and are now contributing to the engineering profession. Five of the eight were female, of which one was African-American and the other Hispanic.