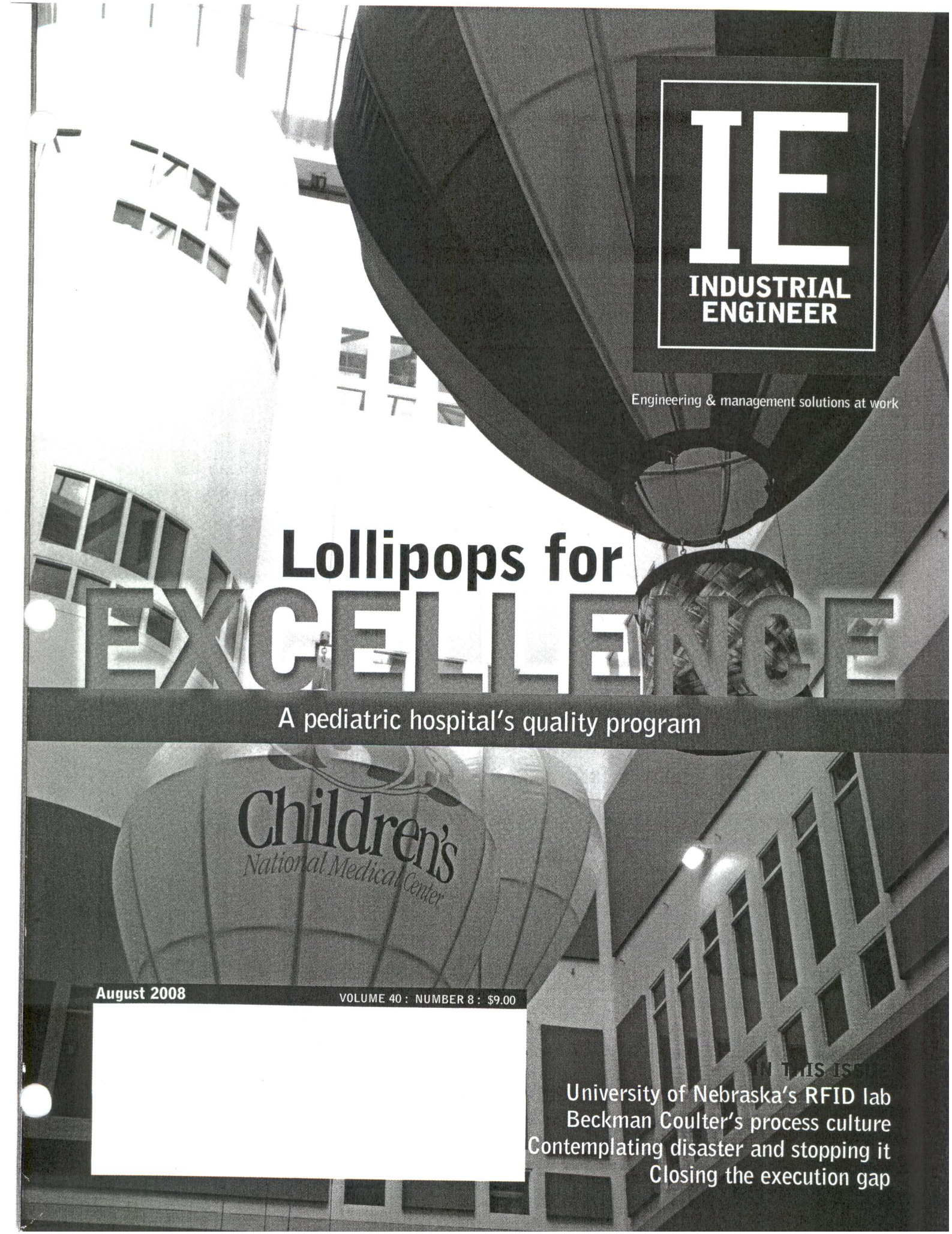

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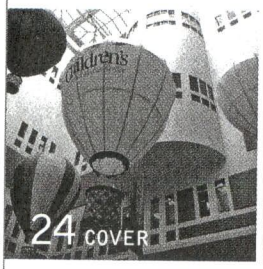

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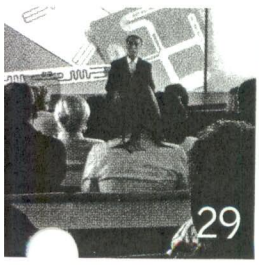

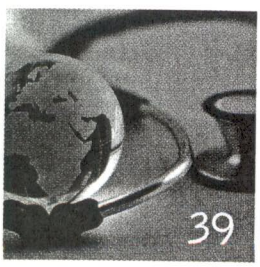

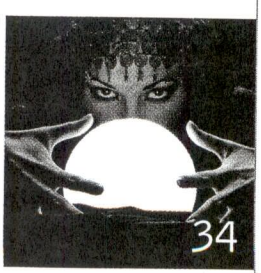

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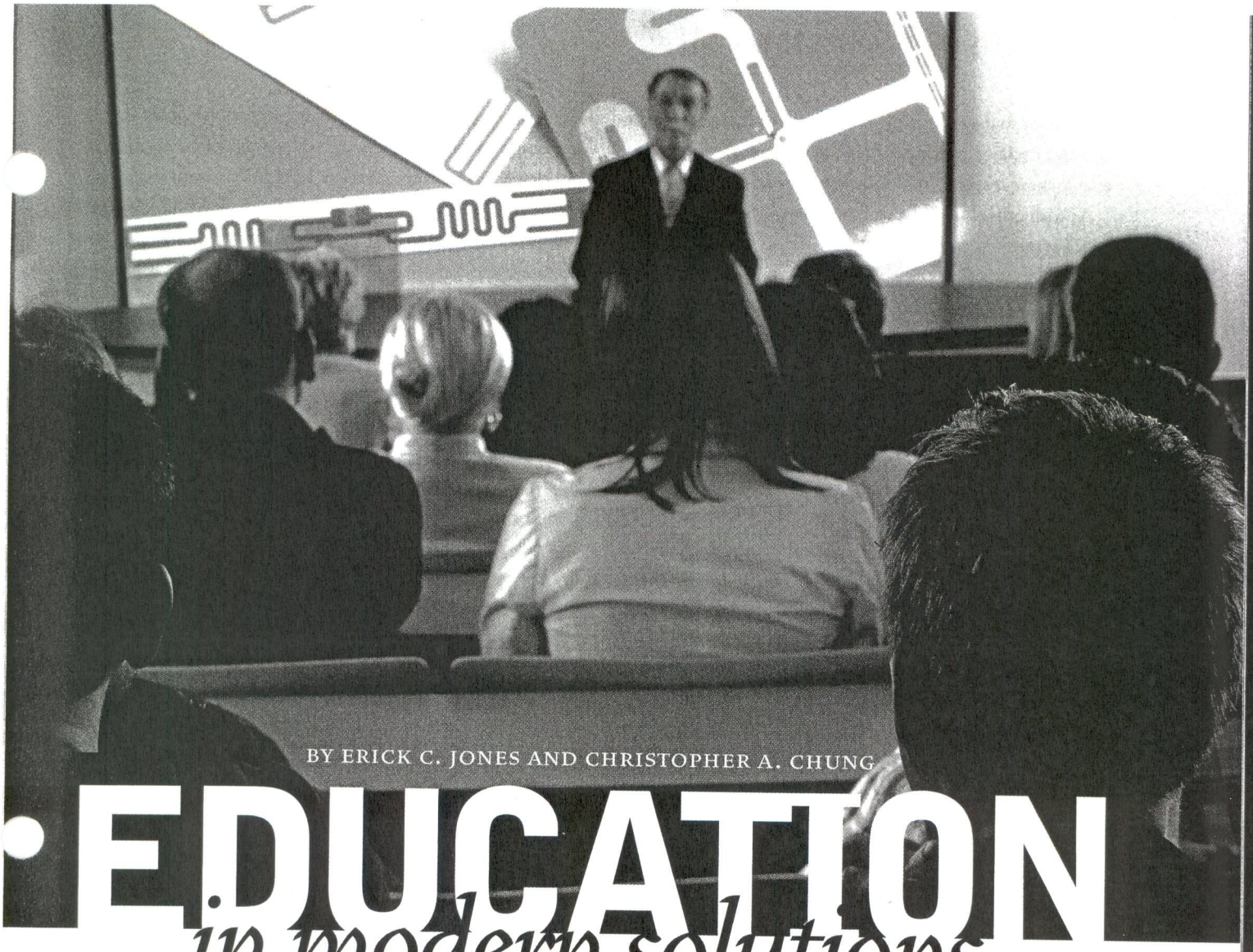
In furtherance of this mission, we adhere to the following objectives:

- To present accurate reporting and analysis of the most prevalent industrial engineering topics
- To serve as a career development resource to students and professionals
- To maintain high editorial standards, journalistic integrity, and credibility
- To support the mission of IIE in its service to members and the industrial engineering profession



BY ERICK C. JONES AND CHRISTOPHER A. CHUNG

EDUCATION *in modern solutions*

RFID is a must in the industrial engineering curriculum

Radio frequency identification (RFID) technology is fast becoming one of the most important technologies that industrial engineering students need to master. Due to mandates in the supply chain from various retail industry and government agencies, it has become crucial that new graduates understand the different technologies and the best ways to implement them. RFID is an emerging technology that demands adequate training in the technology from traditional educational outlets.

IE professionals are in a unique position to lead the RFID industrial revolution. Their education in project management, engineering economy and production planning and inventory control provides the necessary components to integrate all of the hardware and software inherent in RFID systems successfully. The objective of this article is to provide a road map for industrial engineering faculty to introduce RFID technology into their educational and training curricula. IE professionals can also use this approach to integrate RFID technology into their operations successfully. This road map includes: a basic introduction to RFID technologies, educational approaches showing how RFID tools modernize and apply to IE principles and the demonstration of current research and applications.

The fundamental idea is that IEs are in a key position to use RFID technologies to reduce cost, improve productivity and create higher efficiencies in the supply chain. IE principles connecting inventory control through production plan-

ning, labor management through scientific management and effective decision making through operations research should enable these results across industry to be achieved.

As with other types of automatic identification systems, an RFID system requires a number of interrelated components including a set of tags, one or more antennas, and a reader. A basic RFID system is illustrated in Figure 1.

Tags are the devices attached to the items or material the RFID system is intended to track. The tags may be placed directly on individual items such as consumer goods, or on shipping containers or pallets that hold multiple items. Tags come in assorted shapes and sizes. They may be classified as simple *passive* tags or more sophisticated *active* tags. Passive tags do not contain an internal power source while active tags do, which allows for greater range and capabilities. Each tag possesses an individual identification number. More sophisticated tags may also record and transmit environment and location data as well. When activated by the RFID antenna/reader, the RFID tag transmits the identification number along with any other data it may contain.

The RFID reader device creates an electromagnetic signal that is transmitted to the RFID tags through one or more antennas. Under normal operation, the reader continuously transmits the electromagnetic signal in search of one or more RFID tags. The RFID reader also performs the function of monitoring for electromagnetic signals from the tags via the same antenna.

The function of the antenna is to transmit and receive electromagnetic signals between the tags and the reader. The effective electromagnetic field that the antenna transmits is known as the *interrogation zone*, where the antenna creates a three-dimensional space that is used to communicate with the RFID tags. In order to obtain successful communication, the tags must be within range of the antenna or in the interrogation zone.

In most cases, RFID tags and antenna/readers must operate in conjunction with a dedicated computer that operates the necessary software to integrate the tag IDs and the antenna reader locations to a logistical information system. Note that the system could be as simple as a portable hand-held reader or as sophisticated as a global corporate network.

An attractive match

Industrial engineering is a unique discipline that corresponds to diverse industries today. The skills that are most useful when applied to RFID include those that allow for the IE to implement an RFID system in a way that reduces costs. Principles learned in engineering economics, production planning and control, facilities planning and operations research are critical for designing a cost-effective system that can reduce inventory and labor or provide cost avoidance of additional facilities. Other special topics courses such as engineering management, engineering administration and project management provide additional managerial skills for implanting RFID projects. Advanced topics such as total quality management using Six Sigma techniques may provide modernized project execution skills. For example, at the RFID lab at the University of Nebraska-Lincoln, we use a Design for Six Sigma (DFSS) research foundation for RFID industry and research projects.

Providing RFID technology training in traditional universities and colleges necessitates a cross-section of faculty expertise. RFID technologies cross many traditional boundaries in traditional engineering curricula and only limited topics are covered in the business schools. Our approach includes addressing the engineering curricula, course development and necessary laboratory resources.

RFID requires knowledge in antenna design and inductance, substrate material and packaging, engineering economics and inventory control, and middleware and wireless communications, which can be associated with electrical, mechanical, industrial and computer science engineering, respectively. This multidisciplinary engineering education approach is required to deliver this type of knowledge. Most academic institutions

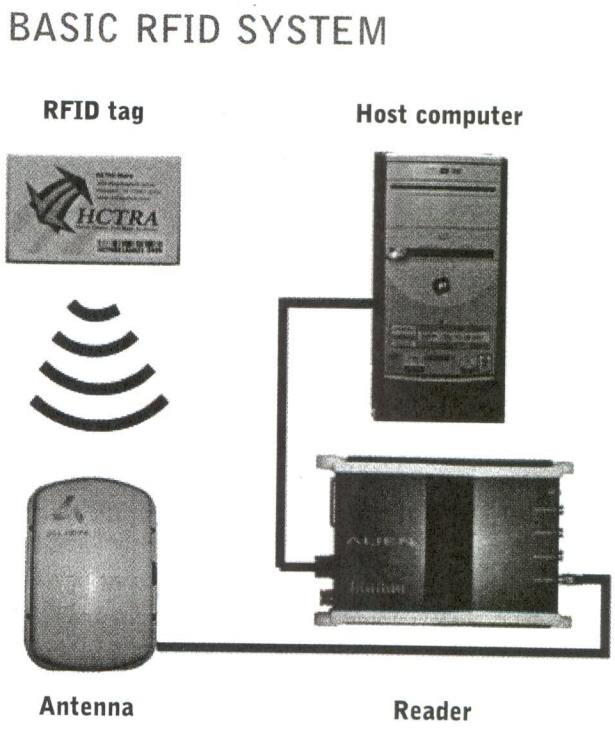


Figure 1. All automatic identification systems require various self-functioning components.

are not currently positioned to deliver knowledge in this manner though many institutions are moving in this multi-engineering direction.

Two approaches can be taken with respect to incorporating RFID subjects into the engineering curriculum: integration into existing courses and the creation of a dedicated RFID course.

The first approach is the integration of RFID technology issues in existing courses such as logistics, facility layout and production planning and control. For example, a logistics course can include tested applications of RFID technology in transportation and warehousing. Here, the focus is still on the original course subject, but information is included on how RFID technology can improve the performance of these systems. This allows for an easier modernization of the IE curriculum rather than the development of a completely dedicated IE course.

The second approach is to create a completely new RFID course. An advantage to this course is that it may be cross-listed with other engineering departments while being billed as an industrial engineering course. The course should include electrical engineering antenna design issues, information system software integration and industrial engineering-related applications. Aside from the theoretical coursework, this approach is best served with the simultaneous development of an RFID lab (as described in the next section).

At the University of Nebraska-Lincoln (UNL), the RFID Systems in the Supply Chain course covers the foundations of RFID systems, including the fundamentals of how RFID components of tag, transponder and antennae are used to create RFID systems. This course includes best practices for the implementation of RFID systems in common supply chain operations. Course objectives include the general problem-solving process, basic concepts of RFID systems, integration of RFID in supply chain management, logistics and manufacturing, practical hands-on teaching of using the RFID tags and antennas, and current mandates, research developments and job opportunities in RFID.

Laboratory resources and applications

The RFID educational efforts of UNL are supported by a dedicated RFID laboratory. This lab is also used for conducting RFID research and industry-supported projects. The lab is approximately 1,500 square feet. It is designed to mirror a miniature distribution center area with a conveyor system and RFID equipment. The floor plan illustrated in Figure 2 shows active, semi-active and passive RFID equipment that includes the following:

- Alien reader
- AWID reader
- Global Concept's warehouse management system
- Hytrol conveyor
- LXE hand-held reader and software
- Matrics/Symbol Reader AR-400
- SamSYS MP 9320 2.8
- SAVI Series 600 tags/active reader
- SAVI software
- Symbol hand-held reader and software
- VerdaSee Navigator

Projects that have been performed in the lab either funded through research or as class projects at UNL include:

- Integration of RFID and geographic information system for ticket/seat location
- Cost reduction of tags through micro-manufacturing process design
- Applying RFID technology to comprehensive sports timing in a marathon
- RFID testing of consumables in NASA storage containers
- Integration of animal ID into systems for cattle tracking
- RFID in the operating room and patient tracking

The resources in the RFID laboratory can naturally be used for conducting research. This includes master's theses and doctoral dissertations. Some examples of this at UNL include the usability of RFID technology in the construction industry and the feasibility of micro-RFID on medical devices and

LAB LAYOUT

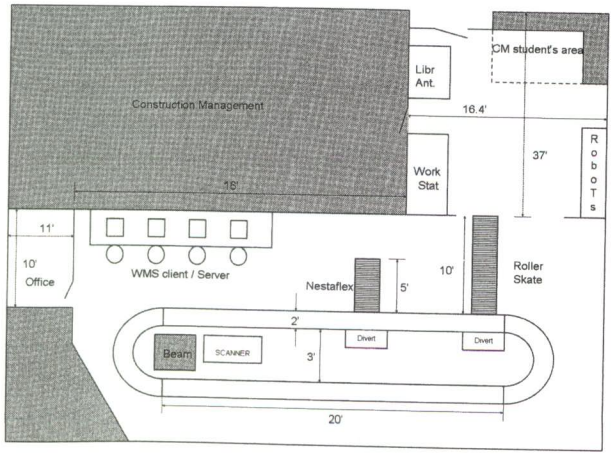
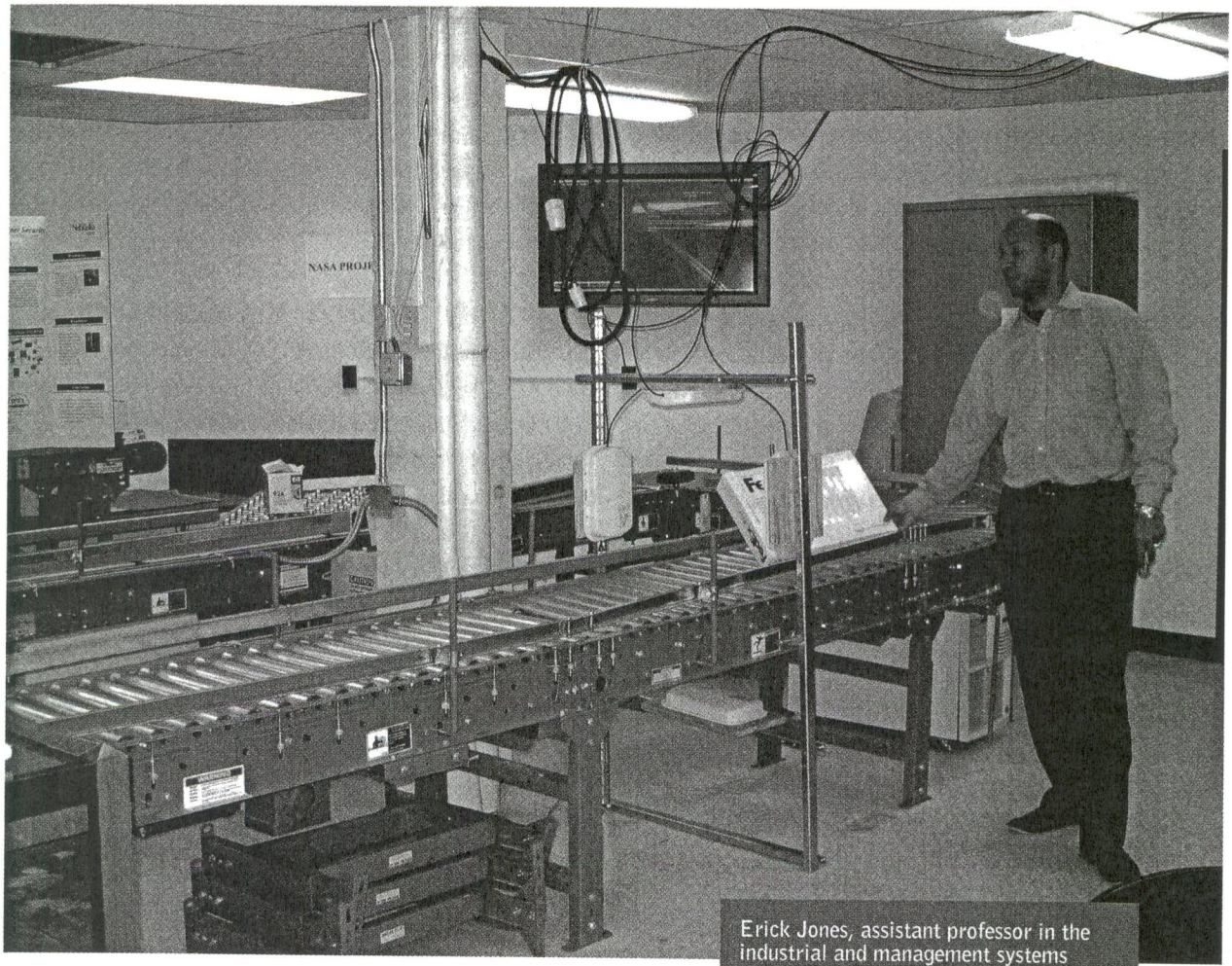


Figure 2. Floor plan for RFID testing



Erick Jones, assistant professor in the industrial and management systems engineering department at the University of Nebraska-Lincoln, demonstrates the RFID equipment that students apply to industry-related projects.

pill capsules.

RFID research efforts are supported by federal agencies such as the Department of Transportation and the National Science Foundation. The NSF support includes the Centers for Engineering and Logistics Distribution (CELDi) program. The CELDi program is an industry/university research cooperative that promotes industry research through universities. CELDi previously offered educational seminars and research in RFID for its members. The CELDi-partnered universities have included research from schools including University of Nebraska-Lincoln, University of Florida, Oklahoma State University, University of Oklahoma, Clemson University, Virginia Tech, University of Missouri, University of Louisville, Lehigh University and the University of Arkansas (where CELDi is headquartered). Given CELDi's focus on logistics, RFID topics are automatically integrated within these universities' IE curricula.

Trends to track

Much of the short-term gap of RFID knowledge is being addressed with RFID certifications. Other trends include training sessions at trade and research organizations' conferences. Conferences such as RFID Journal Live and RFID World offer leading RFID training and overviews, and some have offered certification training. Powerful organizations such as IEEE (Institute of Electrical and Electronics Engineers) are moving toward training for their members. These types of industrial training fulfill the short-term knowledge gap for industry.

Academic institutions have offered education and training in special topics courses including Texas A&M, the University of Texas-Arlington and the University of Alaska- Anchorage. We theorize that other academic institutions will also follow the lead of UNL, which offers RFID certification within the RFID industrial engineering course.

RFID is a technology that many organizations feel will change the way companies approach logistics, engineering and

manufacturing. Corporations have embraced the opportunity to use this technology to develop and manufacture cost-effective tags over the last decade. With EPCglobal's development of the passive tag standard, Electronic Product Code, the cost of RFID tags will inevitably be reduced to meet modern industry conventions.

The drive for current and future RFID technology arises from two separate but related sources: mandates from large retailers and the federal government and supply chain competition. Large retailers such as Wal-Mart Stores Inc. have issued mandates to their suppliers requiring the use of RFID technology. Similarly, mandates from governmental agencies, such as the U.S. Department of Defense, the Federal Aviation Administration and the U.S. Department of Agriculture, have driven the need for government and military logisticians and contractors to understand RFID technology. In addition to these mandates, other federal organizations, such as the U.S. Department of State, have begun using RFID technology in passports.

The second driving force is the need for any organization that uses supply chains to remain logistically competitive. Recent applications include companion pets, livestock, entertainment facilities, sports events and even security operations. Each of these application areas have become more operationally and logistically effective as a result of RFID technology integration.

The tagging of companion pets and livestock is now commonplace. Both veterinarians and animal control agencies automatically scan lost companion pets for RFID tags. Thousands of owners and their pets have been reunited through this technology. RFID technology also provides ranchers and farmers with the ability to locate, identify and treat livestock rapidly. The tags embedded or attached to the livestock are linked to the health and vaccination history of the individual animal.

Large entertainment facilities such as Dolly Parton's Splashtown now offer RFID wristbands for visitors. For a nominal charge, patrons are issued wristbands that are read by antennas located throughout the park. Any member of a party can present her wristband to a location kiosk. At the kiosk, a monitor indicates the location of all of the members with related wristbands. Among other things, this enables parents to monitor the location of children easily and quickly.

Large-volume, fast-paced sporting events use the tags to record competitors' times in distance running, triathlons and bike races. In these events, a small passive RFID tag is attached to the competitor's shoe or leg, and as the competitor crosses the start line, intermediate points and the finish line, he passes over a pair of RFID antenna mats that transmit his tag's IDs to a time-recording computer.

One up-and-coming RFID application area involves security operations. Currently, RFID tags are used to help secure and maintain the security of intermodal shipping containers. However, the use of RFID tags for small vessel marine security is developing interest. This involves the use of RFID tags on both recreational and commercial support vessels. By positioning RFID antennas in tactical locations, the U.S. Coast Guard, port operations and local law enforcement agencies will be able to increase port security and better respond to maritime emergencies.

One application area yet to become widespread is the credit card industry. Despite the implementation of specific measures to help eliminate data access issues, the general public remains skeptical. The obvious fear is that technologically savvy bystanders could potentially access identity and credit information from unwitting RFID cardholders. The credit card companies' attempts to educate the public on the benefits and safety of RFID cards appear to be ineffective. Some companies are even offering RFID-shielded wallets to pacify users that must use RFID cards.

Overall, the proliferation of RFID technology appears unstoppable. Federal and commercial mandates, as well as the need for organizations to remain logistically competitive, will require the industrial engineer of the future to understand the details of RFID technologies.

Erick C. Jones is an assistant professor at the University of Nebraska-Lincoln in the Department of Industrial and Management Systems Engineering. His areas of specialization and teaching include supply chain management, engineering management and total quality management. Jones currently chairs the University of Nebraska Certified Six Sigma Black Belt Committee.

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