Journal of
INDUSTRIAL
TECHNOLOGY

Volume 24, Number 2 - April 2008 through June 2008

A Preliminary Study on the State of AutoID

By Dr. Kenneth W. Stier

Peer-Refereed Article
Applied Paper

KEYWORD SEARCH

Industrial Distribution
Information Technology
Manufacturing
Supply Chain Management

Ken Stier is a professor and Certified Manufacturing Engineer in the Department of Technology at Illinois State University. He is the sequence coordinator for the Integrated Manufacturing Systems Sequence and teaches materials technology, manufacturing processes, and supply chain logistics.

A Preliminary Study on the State of AutoID

By Dr. Kenneth W. Stier

Abstract

This study was intended to provide more information with regard to automatic identification and add to the body of knowledge that exists in this area. It was done as part of the planning stage of a newly renovated laboratory facility to help make decisions in purchasing and installing autoID technology along with high-end automation hardware and software.

There were five objectives to the study. They focused on the usage of autoID within the companies surveyed, types of autoID, effectiveness of the technologies, projections for implementation of autoID technology in the future, and brand names purchased.

The methodology for this study consisted of randomly selected participants by Standard Industrial Codes from the Institute for Supply Management (ISM) database. The participants in the study were asked to complete a survey consisting of questions with regard to demographics and automatic identification technology. A 5 point likert scale was used for some questions and the ratings were analyzed. Fill in the blank responses were listed and analyzed qualitatively.

Introduction and Background

The global competitive climate of the 21st century is facilitating the development of new manufacturing techniques designed to increase flexibility and responsiveness while maintaining lower unit cost and higher quality. Traditional practice has focused on achieving economy of scale by planning long manufacturing runs. Today, flexible and lean manufacturing logic is driven by a desire to increase responsiveness to customer requirements and compete in the global economy (Bowersox, Closs & Cooper, 2006). Building to customer order is becoming necessary for manufacturing companies to maintain market share. Automation is one alternative that managers in manufacturing companies in this country have embraced as a means to achieve these goals. The decision to use automation as a competitive means to combat the low wages and favorable tax laws that are found in developing nations has helped to prevent more off-shoring of U.S. manufacturing plants.

The capturing of data is an essential component in automating a manufacturing plant. Data is required for planning and control of a production process. There is a critical need for managers to know what the company has in inventory (including work-in-process), where it is, and what is being done to it (Fales, 2005). Traditional practices in manufacturing are centered on making decisions with historical data. World class manufacturing requires real time data for decision-making. Additionally, 21st century commerce is conducted with the demand for required documentation for operating in the international marketplace and under the constant threat of terrorism (Bowersox, Closs & Cooper, 2006). Consequently, the government is placing pressure on the pharmaceutical industry to track and trace products to the shelf level (Frontline, 2005). Further pressure is being placed on manufacturing suppliers by large customers in the supply chain such as the Department of Defense and Wal-Mart (CNN, 2007). The Department of Defense has approximately 43,000 suppliers alone and Wal-Mart has approximately 10,000 suppliers (Kane, 2006). There is a rapidly growing need for employees with a variety of autoID and data capture skills, especially with regard to radio frequency identification (RFID) (Morrison, 2005) which the Department of Defense and Wal-Mart have mandated their suppliers to use. A recent survey showed that the average

base salary for those working in RFID-related industries in the United States was $82,120 (Survey, 2005).

In order to meet compliance mandates some suppliers are building on what they learned when they installed bar coding systems. This technology first entered the marketplace in the early 1970s and now has become ubiquitous in tracking inventory. Some would argue that the current compliance mandates to implement RFID technology are similar in nature to the mandates that suppliers were given by their larger customers to install bar codes in the 1970s. Today bar coding and RFID technology co-exist, but RFID technology has seen an annual growth rate of approximately 45%. One of the biggest RFID markets is smart cards (an RFID chip implanted in a plastic card) (Ferguson, 2006). If projections are correct, RFID market growth is expected to continue to expand at 20% annually through 2012 (DeWaal, Liard, & Crabtree, 2008). Several emerging applications of RFID are projected to expand between 30% and 60% over the next five years (DeWaal, Liard, & Crabtree, 2008).

Still there are technical challenges and barriers that need to be overcome for widespread adoption of RFID to take place. Some would suggest that the RFID "revolution" will take 10-20 years to complete. Obstacles that impede its rapid adoption include the high cost for RFID tags and tag readers, the lack of standards for universal adoption and compliance, questionable accuracy of the readers, input overload with the immense volume of data collected, the lack of software to integrate RFID technology with other business applications, shortage of expertise with RFID use, privacy issues and concerns, and hackers reprogramming the radio tags to change the data. Consequently, other forms of autoID such as bar coding still remain the inexpensive tracking system of choice (Nevshehir, 2004; Deal, 2004).

Even though the use of RFID technologies is expanding at a staggering rate, not much research exists with regard to which systems are being used by manufacturers. The *Modern Materials Handling Journal* has done an annual survey of top automatic data capture suppliers, but it is based on the company posted revenues for the year (Trebilcock, 2003). Little information is provided as to what industries are using these technologies and where in the company organizational structure it is being used. Other research that exists is somewhat application specific (Information Week, 2005). Much of it is concerned with analyzing the effects of inaccurate data collection and inventory records (Gershwin & Hartman, 2005; Mussa & Upchurch, 2002).

A proposal for formal funding for a line of research designed to add to the body of knowledge that currently exists was submitted by the author. The study coincided with a major laboratory renovation that was being completed at the time through funding from a capital campaign contribution acquired by the University Advancement Department. A 1.2 million dollar donation was contributed by a major corporation in the area to renovate two adjoining laboratories and convert them into one high technology laboratory with automation workcells. The faculty and administration wanted RFID technology to be part of these workcells. This study was intended to support the renovation and help make a more informed decision with regard to selecting RFID hardware and software in the new laboratory.

While the major focus of the study was intended to be on bar coding and RFID technologies, other autoID technologies such as biometrics (the automated recognition of individuals based on their behavioral and biological characteristics) (Sickler & Kukula, 2005) and voice/speech technology are also becoming of growing importance. Therefore, the questionnaire for this study was developed with a broader listing of autoID technologies in an effort to not overlook any trends that might be occurring in manufacturing companies at the present time.

Objectives of the Study

The objectives of the study were to:

a. determine if the companies in this study were using autoID and, if not, then why not.
b. determine what types of autoID technologies were being used by the companies surveyed in this study and where were they being used (i.e. procurement, logistics, manufacturing, distribution)
c. determine how effective these technologies were for their application.
d. determine how extensively RFID technology was used in the manufacturing companies surveyed
e. provide a better understanding of the degree to which manufacturers have implemented RFID technology.
f. determine the projections for implementation of RFID technology in the future for companies in the study who were not current users.
g. identify some of the types of RFID tags, printers/encoders, readers, and middleware that are being used in companies.

This project was timely because of the recent changes in the manufacturing industry. Advancing technology and management practices have reached a point to where further information is often welcomed by the end users.

Methodology

Subjects

The Institute for Supply Management (ISM) supplied the contact information for the following standard industry codes (SIC) in manufacturing: 300 - rubber and miscellaneous plastic products; 320 - stone, clay and glass products; 340 - fabricated metal products; 350 - machinery, except electrical; and 370 - transportation equipment. The number of contacts provided by the ISM for these SIC codes determined the population size for this study which totaled 4491. Krejcie and Morgan's (1970) method for determining sample size indicates a sample size of 354 should be used for this population size to provide data that reflects the total population with a sampling error of +/- 5% at a 95% confidence level. Even though this was a preliminary study

that was not intended to use statistical methods to quantitatively analyze the data, a random sample of 340 companies was selected by standard industry code for this study to be within the proximity of Krejcie and Morgan's required sample size.

Assessment instrument and data collection

A questionnaire survey was developed and piloted with faculty at the university. Revisions were made based on the feedback from the piloting of the survey. A website was developed for the study utilizing the expertise of individuals in the Center for Teaching, Learning and Technology at the university.

A letter was sent to the company postal address of each contact person explaining the study and its importance. A web address was listed in the letter sent to each contact person and they were asked to enter it on the World Wide Web to go to the questionnaire for the study. The contact person was also asked to forward the letter to a more appropriate individual within the company if they felt they were not qualified to accurately complete the questionnaire. The web site for the survey contained an informed consent form as well as a means for the participant to receive a copy of the results of the study if desired. Each participant was expected to provide consent in accordance with university policy to be part of the study. Demographic questions concerning company characteristics were included in the first part of the questionnaire. (A paper copy version of the questionnaire can be found in appendix A.) These included such things as the type of business (headquarters, branch, or stand alone facility), number of people employed, type of markets (local, national, international), and the type of products manufactured. The second part of the survey contained a web page with four categories in column form. The first category consisted of a column with prevalent autoID technologies with "yes" and "no" icons for the participant to indicate if they were used in their company. The second category was located to the right of the autoID column and was a likert rating scale from 1 to 5 for the participant to rate the effectiveness of the technologies they were using in their company. A "1" indicated that the technology was not effective and a "5" indicated that it was very effective. The third category was located to the right of the effectiveness column and had the names of common functional areas within a manufacturing company at the top of the page. A column with "other" listed was also included. Below each of these names were icons in column form so the participant could identify which areas of the company used the autoID technology. The fourth category was located to the right of the functional areas column and asked the participant to indicate how extensively the technology was used in their company. A likert rating scale from 1 to 5 was used with a "1" indicating very little use and a "5" indicating that it was widely used. The effectiveness category, functional areas category and degree of use category would go blank if the participant indicated that the autoID technology was not used in their company. There was a fill in the blank area under RFID for the participants using this technology to identify the company that sold it to them and trade names. There was another fill in the blank area below the column listing all of the autoID technologies that was activated if the participant indicated they did not use any type of autoID in their company. If they answered "no" to all of them, they were asked to explain why their company was not using any autoID. The last two questions on the survey asked the participants who worked for companies who did not use any RFID technologies to indicate if their company had any plans to implement this technology. They selected from yes and no icons to answer the question. Those that responded with "yes" were asked for a projected timeline for the implementation. The participant was asked to choose an icon from the following categories: 0-2 years, 2-5 years and 6-10 years.

Two follow-up mailings were conducted at timed intervals after the initial mailing. The follow-up mailings gave the respondents a choice of going to a web address and completing the questionnaire, or returning the paper version by mail. A cover letter, informed consent form, questionnaire and postage paid return envelope were included in the follow-up mailings.

Discussion of Return Rate

There were 83 letters returned for such reasons as return to sender, retired and no longer with the company, and for various other reasons. Consequently, these questionnaires could not be used. Approximately 24% of the questionnaires were in this category. A total of 24 usable responses (sample size of 340) were received for a 7% return rate. The low return rate for this study might be due to such things as inaccurate mailing data, incorrect contact people within the companies, lack of the feeling of anonymity by the participants of the study, and reluctance of participants to respond to an unfamiliar web address because of problems that could occur with viruses and all sorts of other unwanted repercussions. Even though the cover letter was sent on official university letterhead, some respondents may have been reluctant to believe that it was genuine. Every attempt was made in the two follow-up mailings to eliminate these concerns and increase the response rate.

Quantitative Analysis of Data

The response rate is shown in table format to describe the results of the demographic information and the second part of the survey. Fill in the blank responses are listed and analyzed qualitatively.

Employer Data

For the questionnaires that were returned from the employers and could be used as part of this study, the author created a Microsoft Excel spreadsheet for ease of entry. The data were analyzed in terms of (a) demographic variables, (b) autoID used, (c) effectiveness of the autoID, and (d) implementation plans.

Demographic variables

The first eight questions addressed demographic variables of the respondents (see Tables 1-5). The author found all the respondents who replied to the questionnaire were 30 years and older. The 50 and older age group was the largest group of respondents (see Table 1). This suggests that the respondents had been in the business for quite a while and that the workforce is aging.

The second question asked for the gender of the respondents. Seventeen males and seven females answered the survey. Question three asked about the educational level of the respondents. Table 2 shows the number of responses in each category. The largest response was a bachelor's degree and the second largest category was other non-degree qualifications. There was no indication of the type of bachelors degree held by each respondent who selected that category, nor was there any indication of what non-degree qualifications were held by the respondents. This may be an area for further study.

The next question asked for the job titles of the respondents. These varied widely and included titles such as: Director of Inventory Control, Accounting Manager, VP Purchasing, Regional Account Manager, Procurement Specialist, Strategic Purchasing Engineer, Purchasing Manager, Purchasing Agent, Operations Manager, Office Manager, Regional Sales Manager, Planning Manager, Director - Strategic Procurement, Finance Manager, Object Manager, General Manager and Controller. Purchasing Manager and Purchasing Agent were identified twice. The responses suggest that most of the respondents were involved with inventory and purchasing or procurement. The fifth demographic question asked what type of facility the respondent was working at. Eleven indicated that they worked at the headquarters of the company, five indicated that it was a branch of the company, and eight indicated that it was a stand-alone facility. There was no dominance of one type of facility in the study.

Table 3 shows the size of the companies involved in the study by categories. The responses indicate that there was a fairly even distribution of the size of company represented by those who responded. It was good to have an even distribution of small, medium and large companies for the study. Originally the author wanted to stratify the sample for the study, but was not able to do so because the database did not contain that type of break down.

Question seven asked what type of markets the companies of the respondents were involved in. Multiple responses could be checked for this question. Nine indicated that they were involved in local markets, fifteen indicated national markets, and fifteen indicated

Table 1. The age of the respondents

Age Category	Number of Responses
Up to 25	0
29-29	0
39-39	3
49-49	9
50 years and over	12

Table 2. The type of educational background

Educational levels	Number of Responses
Trade Certificate	0
Technical Certificate	3
Other Non-degree qualifications	7
Bachelors Degree	10
Masters Degree	4
PhD Degree	0

Table 3. The size of companies by categories

Company Category by Size	Number of Responses
0-49	6
50-99	2
100-249	5
250-499	3
500-999	2
>1000	6

Table 4. The type of industry by category

Industry Category	Number of Responses
Plastics products	9
Rubber products	2
Stone, clay, glass and concrete products	4
Fabricated metal products, except machinery and computer equipment	7
Industrial and commercial machinery and computer equipment	1
Transportation equipment	1

international. This suggests that a majority of the companies responding were involved in the global marketplace. It would also indicate a need on their part to track and trace their inventory very accurately.

The final demographic question asked the respondents to select the type of industry their company was involved in. Table 4 (see page 5) shows the results of this question. A majority of the respondents were in the plastics and fabricated metal products industry. This corresponds well with the number of companies under each SIC code selected for the study.

AutoID Data

Questions 9-19 on the survey focused on RFID and other autoID technologies. The respondents were asked if their company used any of the technologies listed in Table 5. The table shows the total number that responded yes to the autoID item and those that indicated no. The data suggests that bar codes still are the most widely used automatic identification technology found in the companies responding in the study. There was very little usage of the other technologies by these companies.

If a respondent indicated "yes" to their company using a technology listed in Table 5, then they were asked to rate how effective the technology is and how extensively is it used. A likert scale from one to five was used for the rating. A one (1) indicated the technology was not very effective and a five (5) indicated it was very effective. Table 6 shows the ratings for each technology. Bar codes received the highest rating and it indicated that the respondents felt bar codes were quite effective. All the other autoID technologies listed in the table, with the exception of smart tags, received favorable ratings. However, only one respondent in the study indicated they used these technologies (see Table 5) so this data is limited to one person's response. Smart tags did not receive a rating because none of the respondents were using that technology.

Table 5. The responses for the autoID listing

Listing of AutoID Technologies	Number of Responses		
	Yes	No	No Response
Active RFID tags	1	22	1
Passive RFID tags	1	20	3
Bar Codes	17	7	0
Biometrics	1	21	2
Smart Cards	1	21	2
Smart Labels	1	21	2
Smart Tags	0	22	2
Voice/Speech Technology	1	22	1

Table 6. The ratings for the effectiveness of the technology

Rating of the Effectiveness of the Technologies	Ratings
Active RFID tags	4
Passive RFID tags	4
Bar Codes	4.2
Biometrics	3
Smart Cards	4
Smart Labels	4
Smart Tags	no rating
Voice/Speech Technology	3

Table 7. The ratings for the usage of the technology

Rating of the Extent to Which the Technology Is Used	Ratings
Active RFID tags	4
Passive RFID tags	3
Bar Codes	2.3
Biometrics	0
Smart Cards	0
Smart Labels	3
Smart Tags	0
Voice/Speech Technology	0

The respondents, who indicated "yes" to their company using a technology listed in Table 5, were also asked how extensively it is used. A likert scale from one to five was used for the rating. A one (1) indicated the technology was used extensively and a five (5) indicated it was used on a limited basis. Table 7 shows the ratings for each technology. Bar codes received the highest rating and it indicated that the respondents felt bar codes were used quite extensively in their company. RFID tags and smart labels were rated as not being used very extensively. All the other autoID technologies listed in the table were not rated. Again, the data on all the technologies in Table 7, except for bar codes, is limited to one respondent's opinion (see Table 5).

Any respondent indicating "yes" to their company using a technology listed in Table 5, then was asked to identify what area of the company it was being used. Table 8 (see next page) shows the responses for each technology. Bar codes received the most responses and

are used in the shipping and receiving area the most in the companies of the respondents. The second highest area of usage was in manufacturing and that was followed by distribution. The one respondent who indicated their company used RFID tags identified the manufacturing area as one part of the company that used both active and passive tags. The respondent also indicated that active RFID tags were being used in maintenance, distribution, and shipping and receiving. All the other autoID technologies listed in the table were not being used in any of the areas of the company listed. This suggests that bar codes are still widely used.

The respondents were asked if their company had any plans to implement RFID technology if they were not using it yet. Two responded yes, eight responded no, and nine indicated they didn't know. Table 9 shows that the two that responded yes to this question projected that their company would implement RFID technology within the next five years.

Qualitative Analysis of Data

The respondents were encouraged to write comments under the "other" category when identifying what areas of the company use autoID technology. No respondent chose this category so no comments were written in the area provided.

Question 17 asked the respondents to list the company and/or brand name of RFID technology that had been purchased by their company. Only one person responded to this question. That respondent wrote in IBM for this question. The response was so limited that it is best used as "food for thought."

Implementation of the Results

As the research study began, it was intended that the analysis of the data and results of the study would be used to support the launch of a newly renovated integrated manufacturing laboratory at the author's university through the addition of RFID technologies (see Figure 1). Ten workcells were installed with machine vision, ABB robot arms

Table 8. The area of the company where the technology is used

AutoID Technology	Area of the Company							
	Research & Development	Design	Manufacturing	Maintenance	Distribution	Logistics	Shipping & Receiving	Other
Active RFID tags	0	0	1	1	1	0	1	0
Passive RFID tags	0	0	1	0	0	0	0	0
Bar Codes	0	0	8	3	6	2	12	0
Biometrics	0	0	0	0	0	0	0	0
Smart Cards	0	0	0	0	0	0	0	0
Smart Labels	0	0	0	0	0	0	0	0
Smart Tags	0	0	0	0	0	0	0	0
Voice/Speech Technology	0	0	0	0	0	0	0	0

Table 9. Projections for Implementation of RFID Technology

Projections in Years	Number of Responses
0 - 2 years	2
2 - 5 years	2
6 - 10 years	0

Figure 1. An integrated manufacturing laboratory.

tool changers, conveyors with encoders, programmable logic controllers (PLCs), networked pneumatic valves, panels with human machine Interface (HMI) and personal computers (see Figure 1). Each workcell cost approximately $60,000 with the educational discount that was received. A palletized conveyor system is installed around the perimeter of the room as can be seen in figure one. RFID magnetic tags are mounted on the pallets and the RFID readers are installed on the frame of the conveyor system (see Figure 2). An HMI panel (see Figure 3), which is connected to a master PLC, prompts the end user with questions to determine how to program the RFID chip. The RFID reader at each workcell reads the RFID chip on each pallet to determine what needs to be loaded on the pallet. A local PLC then directs the robot to appropriately load the pallet. The RFID controller, antenna, cabling, and other miscellaneous materials cost approximately $15,000.

The results of the study provided background information for the broader scope of the project. It indicated that this project was at the cutting edge of the technology and that the specific system would need to be chosen based on input from an advisory board, intended projects to be carried out in the lab, and cooperation from vendors.

The remodeled facility serves as a teaching laboratory for students majoring in the Integrated Manufacturing Systems Program and as a simulation of an exemplary integrated manufacturing system in industry incorporating RFID technology as part of the system. The lab has the potential to provide an incubator-type context for research projects for manufacturing companies who need to know more about the implementation of autoID in their company.

Figure 2. An RFID reader (in blue), pallet on a conveyor, and the RFID tag (round black object in the white pallet).

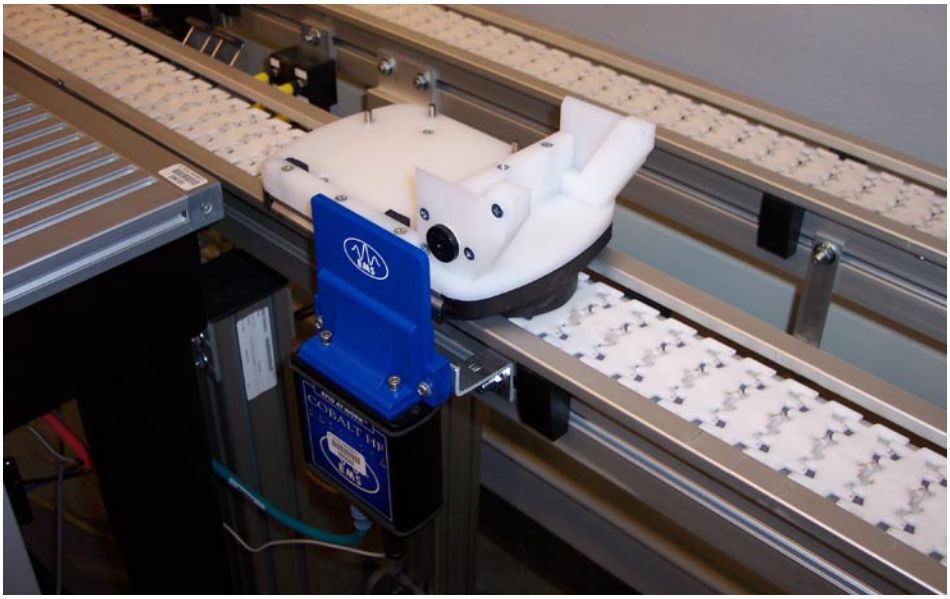

Figure 3. An HMI panel with prompting questions.

Conclusions and Discussion

Eight questions addressed demographic variables of the respondents and the results are discussed in this paragraph. The majority of the respondents were over 40 years old which suggests the respondents had been in the business for a considerable period of time. The majority of the respondents were males. However, seven females responded to the questionnaire as well. Almost half of the respondents had a bachelor's degree and four had a master's degree. This suggests that a considerable number of the respondents had sound formal education. The second largest category of respondents had other non-degree qualifications suggesting on-the-job training. The titles of the respondents varied with Purchasing Agent and Purchasing manager being listed more than once. The list of titles indicates that the majority of the respondents were involved with inventory and purchasing. The type of facility the respondents worked at was fairly evenly distributed

between headquarters of a company, branch office, and stand-alone facility. Coinciding with the type of facility, the size of the company the respondents worked at was evenly distributed between small, medium, and large. This provided feedback from an even cross section of companies. The data also suggests that the companies were involved in the global marketplace and that they would need to track and trace their products on this scale. It was also noted that the majority of the respondents were in companies in the plastics and fabricated metal products industry.

Questions 9 to 19 on the questionnaire focused on autoID technologies. The data suggests that bar codes still are a widely used automatic identification technology. There was very little usage of the other technologies by the companies represented by the respondents. When respondents were asked to rate the effectiveness of the technology and the amount of usage, bar code technology received the best rating. RFID tags, bar codes, smart cards, and smart labels were rated well by the respondents in terms of effectiveness of the technologies listed on the questionnaire. The responses to the questionnaire indicated that bar codes are used in the shipping and receiving area the most, followed by manufacturing and distribution. The one respondent who indicated their company used RFID tags identified the areas of manufacturing, maintenance, distribution, and shipping and receiving as locations in the company where they were used. Most respondents did not identify brand names or companies of the RFID technology that they were using. This is often proprietary information and respondents are often reluctant to give out that information for that reason. Only two respondents indicated that their company had plans to implement RFID in the next five years. The rest of the respondents either indicated that their company was not going to implement RFID technology or that they did not know. No further comments were provided by the respondents and only one respondent indicated an RFID vendor. The responses to this study did not seem to be consistent with the literature with regard to the growing use of RFID technology (Nevshehir, 2004; Ferguson, 2006; & Hines, 2006). Instead, the responses to this study were more consistent with the study by the Computing and Technology Industry Association which showed that while that vendors have high expectations for greater use of RFID, customers have been slow to apply this technology (Morphy, 2007).

This was a status study of where autoID technologies, and RFID specifically, are in the industry. It was done to determine the status of these technologies and help formulate questions for a full study. The responses to the questions in this study have brought to the author's attention some issues that will be the focus of further examination and will lend themselves to statistical analysis when the full study is conducted and more data is available.

References

Bowersox, D. J., Closs, D. J. & Cooper, M. B. (2006). *Supply chain logistics management*. MCGraw-Hill Irwin: New York, NY.

CNNMoney, (2007, July 30). Wal-mart seeks to speed up RFID: Three studios join standards-setting group, http://money.cnn.com/news/newfeeds/articles/newstex/RBI-0086-17874630.htm

Deal, W. F. (2004, April). RFID: A revolution in automatic data recognition, Technology *Teacher*, (63:7), p. 23.

DeWaal, R. J., Liard, M. J. & Crabtree, R. (2008, January). 2008 RFID outlook: Optimistic, *WERCSheet*, pp. 6-7.

Fales, J. F. Automatic identification and data capture technical institute. Center for Automatic Identification, Athens, OH, July, 2005.

Ferguson, R. B. (2006, December 29). RFID in '06 and '07: Years of ups and downs, *eWeek*, http://www.eweek.com/article2/0,1895,2078044,00.asp

Frontline. (2005, September). "General Session: Identification technology – A balanced view," Frontline Conference and Exposition, Chicago, IL.

Hines, M. (2006, November 6). "Smart Cards Spread," *eWeek*, http://www.eweek.com/article2/0,1895,2055257,00.asp

Information Week. (2005). RFID: All systems go – NASA's Dryden Flight Center successfully tests radio-frequency identification technology as part of a real-time network to monitor hazardous chemicals, (1021), p. 21.

Kane, P. (2006, January). How to implement RFID in your courses, Web Seminar sponsored by the National Center for Manufacturing Excellence, Sinclair Community College, Dayton, OH.

Kern, C. & Nauer, M. (2004). Implementing RFID in libraries for process automation – Experiences from over twenty current installations, *LIBER Quarterly*, (14:1), pp. 200-218.

Krejcie, R. & Morgan, D. (1970), Autumn). Determining sample size for research activities, *Educational and Psychological Measurement,* (30), pp. 607-610.

Morrison, J. (2005, March/April). Help wanted, *RFID Journal*, (2:2), pp. 13-20.

Mussa, R. & Upchurch, J. E. (2002, August). Simulator evaluation of incident detection by transponder-equipped vehicles, *Transportation*. (29:3), pp. 287-305.

Nevshehir, N. (2004). Making waves: Integrating radio frequency identification (RFID) technology into your supply chain, Society of Manufacturing Engineers. Dearborn, MI.

Rogers, E. M. (2003). *Diffusion of innovation, 5th ed.* Free Press: New York, NY.

Sickler, N. & Kukula, E. (2005, July). "Biometrics", presented at the Automatic identification and data capture technical institute. Center for Automatic Identification, Athens, OH.

Smart, L. J. (2005). ACRL National Conference: Considering RFID – Benefits, limitations, and best practices, *College and Research Libraries News*. (66:1), pp. 13-18.

Survey. (2005, May/June). *RFID Journal*. What RFID skills are worth, (2:3), p. 8.

Trebilcock, R. (2003, November). The top 20 ADC suppliers, *Modern Materials Handling*, (58:12), pp. 59-60.

Appendix A – The Questionnaire

Automatic Identification Technologies Survey

Confirmation of participation: Please enter assigned number_____

I. DEMOGRAPHIC INFORMATION

1. Age in years (circle one)
   a. up to 25
   b. 25-29
   c. 30-39
   d. 40-49
   e. 50 years and over

2. Gender (circle one)
   a. Male b. Female

3. Educational level (Please circle each qualification you have gained in any discipline)
   a. Trade Certificate
   b. Technical Certificate
   c. Other non-degree qualification
   d. Bachelors Degree
   e. Master's Degree
   f. PhD

4. Job Title (Please list)

5. Type of Facility (circle one)
   a. Headquarters b. Branch c. Stand alone facility

6. How many employees work for your company? (circle one)
   a. 0-49
   b. 50-99
   c. 100-249
   d. 250-499
   e. 500-999
   f. >1000

7. Type of markets (Circle all that apply.)
   a. Local b. National c. International

8. Type of industry (circle one)
   a. Plastics products
   b. Rubber products
   c. Stone, clay, glass and concrete products
   d. Fabricated metal products, except machinery and computer equipment
   e. Industrial and commercial machinery and computer equipment
   f. Transportation equipment

9. Do you use active RFID tags? (**Circle the appropriate answers below**.)
   a. yes b. no (If you selected no, then skip down to #10)

   How effective is this technology? (1 = not very effective, 5 = very effective)
   1 2 3 4 5

   What area within your company uses this technology?
   1. Research & Dev.
   2. Design
   3. Manufacturing
   4. Maintenance
   5. Distribution
   6. Logistics
   7. Shipping & receiving
   8. Other (if selected, explain in textbox)

   How extensively is this technology used? (1 = very extensive use, 5 = very limited use)
   1 2 3 4 5

10. Do you use passive RFID tags? (**Circle the appropriate answers below**.)
   a. yes b. no (If you selected no, then skip down to #11)

   How effective is this technology? (1 = not very effective, 5 = very effective)
   1 2 3 4 5

   What area within your company uses this technology?
   1. Research & Dev.
   2. Design
   3. Manufacturing
   4. Maintenance
   5. Distribution
   6. Logistics
   7. Shipping & receiving
   8. Other (if selected, explain in textbox)

   How extensively is this technology used? (1 = very extensive use, 5 = very limited use)
   1 2 3 4 5

11. Do you use bar codes? (**Circle the appropriate answers below**.)
   a. yes b. no (If you selected no, then skip down to #12)

   How effective is this technology? (1 = not very effective, 5 = very effective)
   1 2 3 4 5

   What area within your company uses this technology?
   1. Research & Dev.
   2. Design
   3. Manufacturing
   4. Maintenance
   5. Distribution
   6. Logistics
   7. Shipping & receiving
   8. Other (if selected, explain in textbox)

   How extensively is this technology used? (1 = very extensive use, 5 = very limited use)
   1 2 3 4 5

12. Do you use biometrics? (**Circle the appropriate answers below**.)
a. yes b. no (If you selected no, then skip down to #13)

How effective is this technology? (1 = not very effective, 5 = very effective)
1 2 3 4 5

What area within your company uses this technology?
1. Research & Dev.
2. Design
3. Manufacturing
4. Maintenance
5. Distribution
6. Logistics
7. Shipping & receiving
8. Other (if selected, explain in textbox)

How extensively is this technology used? (1 = very extensive use, 5 = very limited use)
1 2 3 4 5

13. Do you use smart cards? (**Circle the appropriate answers below**.)
a. yes b. no (If you selected no, then skip down to #14)

How effective is this technology? (1 = not very effective, 5 = very effective)
1 2 3 4 5

What area within your company uses this technology?
1. Research & Dev.
2. Design
3. Manufacturing
4. Maintenance
5. Distribution
6. Logistics
7. Shipping & receiving
8. Other (if selected, explain in textbox)

How extensively is this technology used? (1 = very extensive use, 5 = very limited use)
1 2 3 4 5

14. Do you use smart labels? (**Circle the appropriate answers below**.)
a. yes b. no (If you selected no, then skip down to #15)

How effective is this technology? (1 = not very effective, 5 = very effective)
1 2 3 4 5

What area within your company uses this technology?
1. Research & Dev.
2. Design
3. Manufacturing
4. Maintenance
5. Distribution
6. Logistics
7. Shipping & receiving
8. Other (if selected, explain in textbox)

How extensively is this technology used? (1 = very extensive use, 5 = very limited use)
1 2 3 4 5

15. Do you use smart tags? (**Circle the appropriate answers below**.)
a. yes b. no (If you selected no, then skip down to #16)

How effective is this technology? (1 = not very effective, 5 = very effective)
1 2 3 4 5

What area within your company uses this technology?
1. Research & Dev.
2. Design
3. Manufacturing
4. Maintenance
5. Distribution
6. Logistics
7. Shipping & receiving
8. Other (if selected, explain in textbox)

How extensively is this technology used? (1 = very extensive use, 5 = very limited use)
1 2 3 4 5

16. Do you use voice recognition/speech technology? (**Circle the appropriate answers below**.)
a. yes b. no (If you selected no, then skip down to #17)

How effective is this technology? (1 = not very effective, 5 = very effective)
1 2 3 4 5

What area within your company uses this technology?
1. Research & Dev.
2. Design
3. Manufacturing
4. Maintenance
5. Distribution
6. Logistics
7. Shipping & receiving
8. Other (if selected, explain in textbox)

How extensively is this technology used? (1 = very extensive use, 5 = very limited use)
1 2 3 4 5

17. If your company does use RFID technology, please list the company and/or brand names that your company has purchased.

18. If your company does not use RFID technology, are there any plans to implement it?
a. yes b. no c. don't know

19. If you answered yes, then what are the projections for implementation?
a. 0-2 years b. 2-5 years c. 6-10 years

Request Summary of Research: Please circle yes if you would like to receive the results of the study.

YES – Please send a summary of the study results.
No – I don't need a summary of the study results.

If you are requesting the results of the study, please enter your email address below.

Thank you for completing the survey!