TECHNOLOGY ADOPTION AND BARRIERS TO CHANGE AT US RAILROADS: AUTOMATIC EQUIPMENT IDENTIFICATION AS AN EXAMPLE

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Abstract

North American railroads are well on the way towards complete tagging of their locomotives and railcars with Automatic Equipment Identification (AEI) equipment. As of the end of 1994, nearly all locomotives and more than 80 percent of railcars have been AEI equipped. Railroads are now slowly beginning to develop the software applications to make use of the highly reliable AEI data base.

INTRODUCTION

Deregulation of the 1980s in the United States released carriers and shippers from a great deal of federal regulation and bureaucracy. It also allowed the "hands of competition" to have a direct impact on regulating the marketplace. Competition has made significant changes in service standards (Walton 1994). Shippers are now demanding better customer service, more detailed shipment information and more accurate and timely delivery schedules.

In response to these demands, North American railroads in 1991 made a decision to employ Automatic Equipment Identification (AEI) technology to efficiently and quickly collect shipment tracking information. AEI, a radio frequency identification system, identifies a moving object electronically (Anonymous 1992). A small electronic tag is attached to each unit, encoded with the vehicle identification. When the unit (railcar, locomotive, end-of-train device, trailer or container) approaches a reader which is strategically located throughout the rail network, the unit identification information is retrieved electronically from the tag. The reader then transmits this information to the carriers' remote computer. This technology reduces errors and provides more accurate, complete and timely car movement and shipment status information for both carriers and shippers (Bell 1990). According to work by Welty there are virtually no technology problems with either hardware or software (Welty 1991).

North American railroads are well on the way toward complete tagging of their locomotives and railcars with AEI equipment. As of January 1995, nearly all locomotives and more than 70 percent of railcars and over 95% of the locomotives in the USA had been tagged. The remaining units were to be tagged as they are scheduled for shop maintenance or interchanged.

No system of automatic equipment identification will work up to its full potential unless the system is completely applied in terms of both hardware and software components. The US railroads are attempting to determine what software applications, using the AEI data, would be most cost effective.

The purpose of this paper is to investigate the process at four US railroads towards applying the AEI data for a variety of applications affecting both internal operations to improve productivity and the promises of better service to external customers (shippers). Toward this end, this paper adopts a conceptual framework of technology adoption found in management literature. The framework states that rail line managers will go through several stages including awareness, identification of specific applications and their benefits, and then commitment and adoption before this technology is fully integrated into line operations. The research also addresses the following questions:

1. What benefits do rail line managers, both in operations and in sales and marketing, believe AEI will provide?
2. At what stage of technology adoption do the US railroads find themselves in 1995 with respect to AEI?
3. With AEI hardware robustly installed, what is the expected roll out timetable for user applications?

This paper is divided into four parts. First, a brief description of the AEI technology is presented. Second, the framework that provides theoretical foundation for the variables studied is explained. Third, the methodology used to investigate the technology is described. Lastly, the preliminary research findings from this study are presented.

BRIEF DESCRIPTION OF RAILROAD AEI

The AEI technology adopted by the North American railroads was developed by Amtech Corp. It is a radio frequency-based systems tested by the railroads (Rao and Blaze 1993). The standard

adopted by the Association of American Railroads (AAR) is compatible with identification standards adopted by the American Trucking Association (ATA), the American National Standards Institute (ANSI), and the International Standards Organization (ISO). Thus, the transportation industry, ie railroads, trucks, maritime container lines, and intermodal carriers, could all potentially be using compatible AEI standards.

The AEI technology system consists of a tag (transponder) affixed to a conveyance vehicle, a wayside transceiver which generates the radio waves sent to the vehicle tags and receives the reflected, modulated signals from the tags, an antenna setup which focuses the radio signal and receives the response from the tags and a reader (controller) which processes the tag information. Wheel detectors are also an integral part of this system. They activate the system with the first wheel of the train and enable the recording of a car even if it is untagged.

There are three types of tags:

1. beam-powered—primarily used with rail cars;
2. battery powered—used with intermodal equipment;
3. dynamic—primarily used with locomotives at this time.

All the components of the AEI system work together to collect data from the vehicle quickly, efficiently and accurately without ever slowing down the passing vehicle. The data are subsequently transmitted to a remote computer where they are stored, sorted for database matching and/or enhancement.

FRAMEWORK OF TECHNOLOGY ADOPTION

Due to the scarce amount of academic research pertaining to AEI technology adoption, the foundation for this study rests in general technology adoption literature. The four classical adoption models depicted in Table 1, along with conventional wisdom, were used to test the variables in this study.

Table 1 Examples of five adoption models

Stage	AIDA model	Paradigm model	Innovation adoptive	Hierarchy of effects model	Communications model
Cognitive	Attention	Exploratory	Awareness	Awareness Knowledge	Exposure Reception Cognitive Response
Affective	Interest	Descriptive	Interest Evaluation	Liking Preference Conviction	Attitude Intention
Behavior	Desire Action	Deductive/ Predictive	Trial Adoption	Purchase	Behavior

The objective of the adoption process is to prompt the organization to behave or act in a manner conducive to adoption. According to classical models of adoption, this objective is reached after the adopting firm moves through three stages. In the *cognitive stage* managers and executives of the firm mentally consider or are exposed to the technology. After sufficient managers become aware of the technology's existence, the firm moves into the *affective stage.* This stage is based on managers' feelings toward the technology. If 'managers' feelings are favorable the firm will then move into the *behavioral stage* and adopt the technology.

The classic "AIDA" (Strong 1925) model supposes that the firm first becomes aware of the technology. This awareness leads to interest. The interest in the technology fuels a desire for the benefits the technology provides, which finally leads to action or adoption of the technology.

The "Hierarchy-of-Effects" (Lavidge and Steiner 1961) model follows a similar yet more detailed flow of events. This model presumes the adopting firm first becomes aware of the technology's

existence. Awareness of the technology leads to fact gathering and knowledge of the technology. Assimilating this knowledge, the firm's managers develop some feelings about the technology. The positive feeling of 'liking' leads to a preference, which results in a conviction which ultimately leads to purchasing or technology adoption.

The classic Innovation Adoption Model (Rogers 1962), like the previous two models, assumes the firm travels through a cognitive stage. During this stage the firm becomes aware of the new innovation or technology. Then the firm moves to the affective stage. In this stage, the adopting firm's interest is peaked and the firm begins to evaluate the benefits of the innovative technology for the firm's specific needs. Next, the firm moves into the behavior stage where it will test the technology. Lastly, after testing the technology, the firm will act by adopting the new technology.

The fourth classic model presented is the *"Communications Model"* (Kolter 1984). This model was presented by Kotler in his 1984 work. In the awareness stage the adopting firm will first become exposed to the technology. The exposure will lead to the technology's reception. The reception will in turn lead to a cognitive or mental response. As the firm moves into the affective stage, an attitude about the product will be formed. The attitude will manifest into a firm's intention to act. According to the model this intention ultimately leads to adoption behavior.

As previously presented, the four classical adoption models along with conventional wisdom, were used to provide the foundation for the variables tested in this study. The variables and definitions in this study are shown in Table 2.

Table 2 Variables studied and their definitions

Variables Studied	Definition of Variables
Awareness	Understanding of AEI technology
Benefit	Positive attributes of AEI technology
Technology Use	Estimated time when various AEI applications will be available
Organizational Openness	Rail firms willingness to use AEI technology
Demand Drivers	Source of AEI technology request
Evaluation	Result of rail firms investigation of AEI, including pilots and prototypes

RESEARCH METHODOLOGY

The present research is a descriptive study that attempts to explain the barriers to change that are preventing full AEI technology adoption. A natural starting point to gain insights into AEI implementation and adoption is to gather the advice and opinions of those being affected and those affecting the status of AEI. Toward this end, in depth telephone interviews were conducted with transportation executives with Class I Railroads (see Table 3).

Table 3 Organizations studied

Organization	Number of Respondents Interviewed
Railroad A	30
Railroad B	7
Railroad C	5
Railroad D	5

A sample of forty seven respondents from Class I railroads was used. It was decided that the sample of carriers needed to be national in scope and representative of those that were committed at the corporate level to implementing the technology (Anonymous 1991).

Scale development

In order to test the variables ability to explain barriers to AEI, a survey instrument was developed to gather information on six variables. Specifically, the survey was designed to address the research questions and to provide data for testing. The survey employed the use of multi-item likert scales to ascertain the degree of agreement or disagreement for each item. Table 4 lists the variables and a sample of the items used to gather information for this study.

Table 4 Research variables and sample scale items

Research Variables	Sample Scale Items
Awareness	How would you rate your understanding of AEI technology for railroads, compared with your peers?
Benefit	Railroads will benefit by using AEI to better track equipment.
Technology Use	Please provide an estimate of *when* each of the applications will be available.
Organizational Openness	My organization is studying how we can make use of AEI.
Demand Drivers	Our customers are interested in using AEI technology to better manage rail shipments.
Evaluation	My organization's 5-year business plan incorporates the use of new emerging technologies.

The preliminary draft of the survey was given to a panel of experts for feedback on wording, clarity and appropriateness for the sample. After the comments and suggestions of the panel were reviewed the survey instrument was refined by adding, deleting and modifying items based upon the panel comments. The survey was then pre-tested on a small sample of carrier managers. The survey was then modified to reflect the tested feedback.

Software application focus

Three AEI applications were picked as the foci for examining how this technology was being integrated by each railroad into various customer service, operations, and new products/service development efforts.

The three potential applications examined were:

1. using AEI data to better track rail equipment; at US railroads, including automation of customer service tracking
2. using AEI data for improving on-time reliability feeding software to help scheduling power, car movements, etc.
3. relating AEI data to customer inventory records to assist these customers with their logistics and even their regulatory responsibilities on reporting shipment whereabouts.

RESEARCH FINDINGS

Level of respondents understanding about AEI technology

In order to gain information about the level of understanding respondents had about AEI, they were asked to rate their understanding of what AEI technology represents for the railroads compared to their peers. During the interviews, it was explained that the question pertained to how AEI could be used, not the technical aspects of how AEI works. The main purpose of this question was to assure that respondents with little exposure to AEI technology would not be included in the survey. The findings are presented in the attached Figures (charts). Most respondents felt they had a very good understanding of AEI relative to their peers (see Figure 1). This finding is not

surprising given that most respondents were aware that their railroad had over 70 percent of its equipment tagged during the interviews (see Table 5).

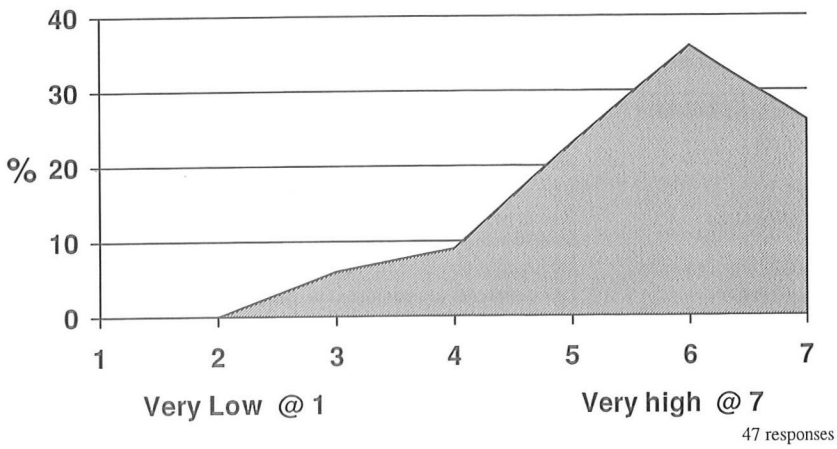

Figure 1 **Personal awareness: "I have a strong understanding of what AEI technology represents for RRs"**

Table 5 **Status report**

May 1	By Year End
• 1,135 reader sites (Canada and USA) • 1.2 mil railcars • 19,000 locomotives • 9,000 EOT's	• 1,523 reader sites • 1.4 mil railcars

Managers expectations about AEI's ability to provide benefits

When asked whether or not they agreed that AEI would enable better tracking, improve on-time reliability or provide value-added services most opinions were mixed. In regards to enabling better tracking, most respondents strongly agreed that AEI will provide this benefit. However, when those same people were asked about improving on-time reliability the opinions were not as strong.

While most responses did indicate agreement with the statement, they were not as optimistic that AEI could improve asset reliability. Most respondents viewed asset management software as well as logistics software as being very complex applications.

Expectations about the delivered availability of AEI applications

When being questioned about the availability of AEI applications for tracking rail cars/trains, to improve reliability and to assist in the provision of value-added services the responses were again mixed. As shown in Figure 2, most respondents thought that within 12 to 24 months AEI applications for tracking rail equipment could be available.

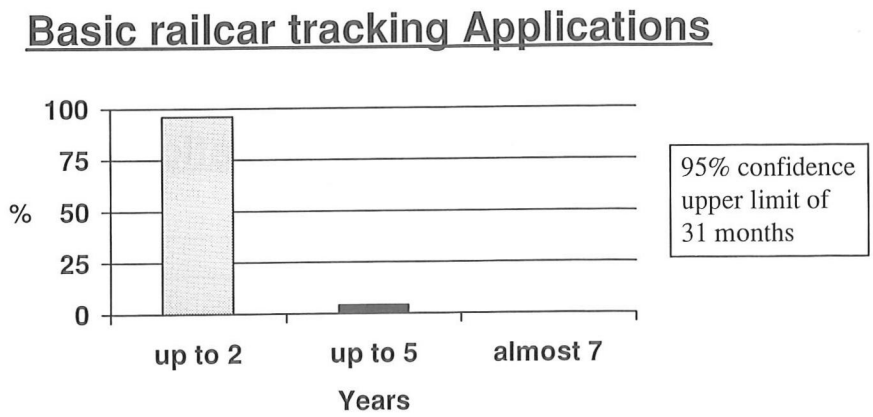

Figure 2 Expected rollout time (by RR managers)

However, they were not as optimistic about the timing of applications to improve reliability. In fact, most respondents felt anywhere between 24 to 30 months or even longer was a more realistic time frame for RR Asset Utilization applications (see Figure 3).

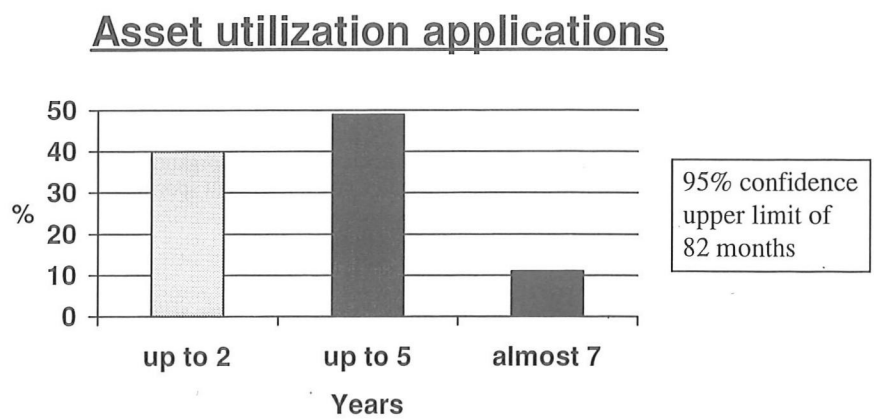

Figure 3 Expected rollout time

Most respondents thought AEI applications to assist in the provision of value-added services would be the most complex and take the most amount of time. The mean response was for 27 months, with perhaps an additional 16 months for complex uses. Up to 63 months was a likely projected time line (see Figure 4).

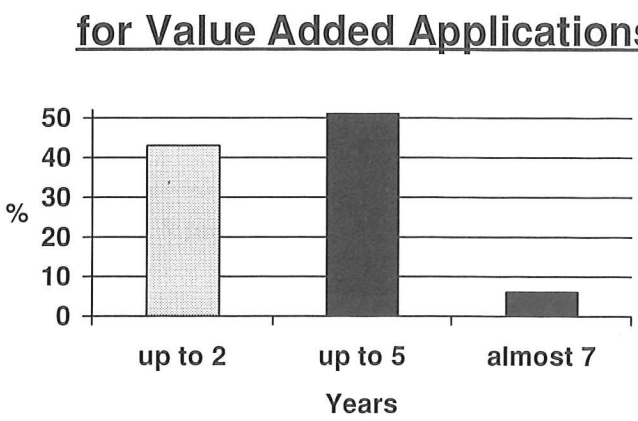

Figure 4 Expected rollout time

Organizations: how they study possible AEI uses

Several questions in the survey instrument attempted to capture a measure of how open the rail organizations were to adoption of new technology. For instance, respondents were asked to indicate their level of agreement or disagreement with the statement: "My organization is studying how we can make use of AEI". Most respondents responded positively. A majority indicated a strong agreement with the statement.

Similarly, when asked if they agreed with the statement that their organization's five year plan included the use of new technologies, most responded yes, but without specifics.

Shippers interest in AEI technology

To gather information about shippers interest in AEI, respondents were asked whether they agreed with the statement: "Our customers are interested in using AEI for inventory management". Most had some form of agreement with the statement. This may indicate that railroad customer growing awareness could eventually motivate new applications of the technology.

SUMMARY

The research indicates that most rail managers at the 4 railroads studied believe that AEI will provide benefits to their firm, particularly in the areas of enabling better equipment tracking.

However, the pace to adoption will be slow. The railroad managers expect sophisticated asset utilization tools and customer inventory tools to take much longer: perhaps 3 to 6 years to be fully developed. A further analysis of the data using estimated coefficients for the variables of the technology adoption model suggests steps rail management can take to accelerate and more fully integrate AEI technology into all aspects of rail operations and support services. Management could, however, take steps to accelerate the adoption pace. Several executives within the surveyed railroad are now examining such process adoption change.

This research presented some of the preliminary findings about the adoption of AEI technology. The authors hope that this report will spark interest for additional studies about the technology's uses at rail firms.

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