An Introduction to Human Systems Integration (HSI) in the U.S. Railroad Industry

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Final
April 2007

CONTENTS

Executive Summary 2

1. Introduction 5
2. What is HSI? 6
3. How Does HSI work? 11
4. What Are Some HSI Opportunities in the U.S. Railroad Industry? 11
   - 4.1 PTC Systems 11
   - 4.2 RCL Systems 12
   - 4.3 CAD Systems 12
   - 4.4 Optimally Manned Train Operations 13
5. What Are the Advantages of HSI? 13
6. What Can the U.S. Railroad Industry Do to Implement HSI? 14
   - 6.1 What Can Railroad Management, Labor, and Trade Associations Do to Implement HSI? 14
   - 6.2 What Can Railroad Suppliers Do to Implement HSI? 15
7. References 16

Executive Summary

Human systems integration (HSI) is a systematic, organization-wide approach to implementing new technologies and modernizing existing systems. It is a combination of managerial philosophy, methods, techniques, and tools designed to emphasize, during the acquisition process, the central role and importance of end-users in organizational processes or technologies. This approach optimizes the safety and efficiency of these systems through the consideration of all the system's elements. Traditional approaches to technological implementation focus on mechanical, hardware, and software design challenges. Often, little attention is paid to the end-user and his/her capabilities and limitations. An assumption is made that the introduction of the technology automatically will be acceptable to the users and will improve job performance. This does not always hold true.

The safety and reliability of new and modernized technologies and systems ultimately depend on their interaction with end-users—operators and maintainers. Even the most sophisticated technologies, when designed and implemented without proper consideration of user needs and requirements, may not achieve optimal system performance because of mismatches between the technology and human operator limitations or capabilities. To help achieve optimal overall system success, the human operator should be viewed as a central part of the system. Careful evaluation of an operator's interaction with a system during its initial design eliminates potential mismatches downstream during the system's implementation and operation.

The Federal Railroad Administration (FRA) is interested in introducing HSI to the railroad industry to help railroads further improve the safety and efficiency of their operations. An HSI approach to railroad technology acquisition and implementation can increase user acceptance of the technology, increase usability of the technology, and increase the likelihood of successful technology deployment. Investing in a systems approach to technology acquisition and modernization can provide a return on investment that is both tangible (e.g., cost savings) and intangible (e.g., improved labor relations).

Over time, U.S. railroads have incorporated individual elements of an HSI approach (e.g., user testing, consideration of training requirements, etc.) into the acquisition of various technological systems. The purpose of this paper is to provide an introduction of HSI concepts to the U.S. railroad industry and stimulate discussion of an HSI framework that can support railroads' technology acquisition processes, since it is in these processes that railroads have the ability to economically and efficiently specify system requirements and most successfully implement technology.

The U.S. military is currently the largest HSI practitioner in the United States. The U.S. Army articulates the following seven topical areas where the impact of a new technology must be considered before the technology is approved, acquired, and deployed (or modernized):

1. *Manpower*. The manpower domain includes consideration of the staff required to operate, maintain, sustain, and train for the technology or system under consideration.
2. *Personnel*. This domain focuses on the knowledge, skills, abilities, and other characteristics (KSAOs) necessary to train for, operate, maintain, and sustain the new or modernized technology or system.
3. *Training*. The training domain addresses the instructional requirements crucial to instill the KSAOs that are necessary to operate, maintain, and sustain the new or modernized technology or system.
4. *Human factors engineering*. Human factors engineering focuses on designing human system interfaces to optimize user performance and reduce the likelihood of user errors.
5. *System safety*. System safety addresses the potential for new or modernized systems to contribute to, or cause, errors or failures that can lead to accidents.
6. *Health hazards*. The health hazards domain focuses on mitigating the potential for regular and routine use of the system to result in bodily harm; that is, injury, illness, and death, as well as reduced system performance that may result from bodily harm.
7. *Survivability*. This domain addresses the need to increase the likelihood that soldiers survive attacks of various natures, including fratricide. In the context of railroad operations, this domain might focus on designing systems to improve occupant protection and survivability.

Advantages of HSI include the potential to:

- Increase U.S. railroad safety.
- Improve operator performance and operational efficiency.
- Increase user acceptance.
- Reduce training time and costs.
- Reduce the likelihood of, and costs associated with, system upgrades and midcourse design changes.
- Reduce system lifecycle costs.

To gain the full benefit of HSI and its integrated systems approach to technology and modernization programs, railroads, including management, labor, and trade associations, can:

- Allocate sufficient monetary and staff resources to develop an HSI program to support system acquisitions and modernizations.
- Develop an overarching HSI policy and process that governs how HSI will be applied to new system or technology acquisitions and modernization programs.
- Develop a human systems integration plan (HSIP) for each new or modernization program.

- Appoint a human factors champion to each program.
- Incorporate human factors engineering data collection and analysis techniques to understand users, tasks, and the operational environment.
- Use quantifiable and documented human factors engineering data to guide and support HSI design specifications and requirements.
- Use HSI design specifications and requirements to support the statement of work and the specific tasks that a technology or system supplier must complete when developing the technology or system to be acquired.

In support of railroads' effort to apply an HSI approach to technology upgrades and modernization programs, railroad suppliers can:

- Employ and use human factors professionals on railroad programs to ensure that user capabilities, limitations, and requirements are considered and included in system designs.
- Involve human factors specialists at the earliest stages of, and throughout, system design and development.
- Use human factors data collection and analysis techniques to collect quantitative and qualitative user performance, preference, and acceptance data when developing new or modernized systems. Start with fundamental baseline data, such as results from task and job analyses.
- Ensure design decisions for new and modernized systems, including human factors and human performance data, to the extent possible. Sources of data may be internal usability tests or published information, such as anthropometric data. One approach to ensuring the use of human factors and human performance data is for suppliers to develop an internal quality standard that requires the use of these data as part of their design and development process.
- Ensure that designers have a mastery of the subject domain for which the new technology or system will be used. This might involve utilizing in-house subject matter experts (SME), hiring an SME consultant, or including railroad SMEs as part of a design advisory group.
- Ensure that the system being developed satisfies all of the contracting railroad's human-centered design requirements and specifications.

The following white paper presents a more thorough introduction to HSI, briefly discusses other industries that have used HSI in the United States and abroad, provides examples where HSI can be applied in the U.S. railroad industry, discusses the advantages to HSI implementation, and concludes with some HSI suggestions that the railroad industry can begin to adopt.

1. Introduction

HSI is a systematic, organization-wide approach to implementing new technologies and modernizing existing systems. It is a combination of managerial philosophy, methods, techniques, and tools designed to emphasize, during the acquisition process, the central role and importance of end-users in organizational processes or technologies. This approach optimizes the safety and efficiency of these systems through the consideration of all the system's elements. Traditional approaches to technological implementation focus on mechanical, hardware, and software design challenges. Often, little attention is paid to the end-user and his/her capabilities and limitations. Rather, an assumption is made that the introduction of the technology automatically will be acceptable to the users and will improve job performance. This does not always hold true.

The safety and reliability of new and modernized technologies and systems ultimately depend on their interaction with end-users—operators and maintainers. Even the most sophisticated technologies, when designed and implemented without proper consideration of user needs and requirements, may not achieve optimal system performance because of mismatches between the technology and human operator limitations or capabilities. To help achieve optimal overall system success, the human operator should be viewed as a central part of the system. Careful evaluation of an operator's interaction with a system during its initial design eliminates potential mismatches downstream during the system's implementation and operation.

FRA is interested in introducing HSI to the railroad industry to help the railroads further improve the safety and efficiency of their operations. An HSI approach to railroad technology acquisition and implementation can increase user acceptance of the technology, increase usability of the technology, and increase the likelihood of successful technology deployment. Investing in a systems approach to technology acquisition and modernization can provide a return on investment that is both tangible (e.g., cost savings) and intangible (e.g., improved labor relations).

Over time, U.S. railroads have incorporated individual elements of an HSI approach (e.g., user testing, consideration of training requirements, etc.) into the acquisition of various technological systems. The purpose of this paper is to provide an introduction of HSI concepts to the U.S. railroad industry and stimulate discussion of an HSI framework that can support railroads' technology acquisition processes, since it is in these processes that railroads have the ability to economically and efficiently specify system requirements and most successfully implement technology. The intended audience is railroad executives, senior level managers, acquisition specialists, and any others who have a role in specifying, approving, and/or acquiring railroad systems and technologies.

This paper has several sections. Sections 2 and 3 introduce the concept of HSI and discuss an array of current applications of HSI, including extensive use in the U.S. military and U.K. rail industry. Section 4 discusses a number of opportunities where HSI principles, methods, and techniques can be applied in the U.S. railroad industry, either as new technologies are introduced or as modernization programs are initiated. Section 5 discusses the advantages of incorporating an HSI approach to the acquisition or modernization of railroad technologies and systems. Section 6 discusses next steps that the railroad industry—carriers, labor, and suppliers—can take to begin incorporating HSI into their system acquisition and modernization programs. Lastly, Section 7 includes a list of references used in the preparation of this paper.

2. What is HSI?

HSI is a systematic, organization-wide approach to implementing new technologies and modernizing existing systems. It is a combination of managerial philosophy, methods, techniques, and tools designed to emphasize, during the acquisition process, the central role and importance of end-users in organizational processes or technologies. This approach optimizes the safety and efficiency of these systems through the consideration of all the system's elements. In essence, HSI integrates organizations, technology, and people (Booher, 2003). HSI techniques and processes can be used to address the acquisition of one small device or an entirely new way of organizing work tasks in an organization.

The U.S. military is currently the largest HSI practitioner in the United States. The U.S. Army's Manpower and Personnel Integration (MANPRINT) technical and management program, created in 1986, is perhaps the most well-known HSI program. The primary objective of MANPRINT is "…to place the human element…on equal footing with other design criteria such as hardware and software" (MANPRINT Handbook, 2005; p. 1). According to Booher (2003, p. 3), "The most unique aspect of the program was effective integration of human factors into the mainstream of system definition, development, and deployment." MANPRINT articulates seven topical areas where the impact of a new technology must be considered before the technology is approved, acquired, and deployed (or modernized). The following describes the seven topical areas, including brief descriptions for each:

1. *Manpower*. The manpower domain includes consideration of the staff required to operate, maintain, sustain, and train for the technology or system under consideration. These requirements are to be considered under all operating conditions and within current and/or proposed staffing levels. For example, if an organization has established a particular staffing limit, then this staffing level may impact the number of staff available to operate and maintain the new equipment. This, in turn, will impact the equipment's design (specification) to ensure that adequate staff will be available to operate and maintain the equipment once it has been deployed.

2. *Personnel*. This domain focuses on the KSAOs necessary to train for, operate, maintain, and sustain the new or modernized technology or system. The manpower and personnel domains are closely related; manpower addresses staffing levels while personnel addresses the KSAOs required of these staff. This domain also includes many aspects of an organization's approach to talent management—how to best recruit, place, and retain its workforce.

3. *Training*. The training domain addresses the instructional requirements crucial to instill the KSAOs that are necessary to operate, maintain, and sustain the new or modernized technology or system. As technologies are introduced or modernized, tasks change, job requirements are altered, new positions may be introduced, and functions are added and removed. Consequently, it is critical to ensure that those who will operate, maintain, and otherwise support the new or modernized technology have the requisite job skills and knowledge to effectively and safely interact with the new or modernized technology or system. The total training

impact on individuals and the organization should be considered. This includes technical and methodological considerations (i.e., how to train), as well as the cost of this training.

4. *Human factors engineering*. Human factors engineering focuses on designing human system interfaces to optimize user performance and reduce the likelihood of user errors. This is accomplished through designs that are compatible with user capabilities and limitations. User populations include operators, maintainers, and trainers, among others.

5. *System safety*. System safety addresses the potential for new or modernized systems to contribute to, or cause, errors or failures that can lead to accidents. The goal is to minimize the likelihood of accidents and injuries through careful evaluation and mitigation of potential system failures and their harmful outcomes. Risk assessment techniques can be used to identify potential system safety problems, and then design specifications can be developed to guard against such problems.

6. *Health hazards*. The health hazards domain focuses on mitigating the potential for regular and routine use of the system to result in bodily harm; that is, injury, illness, and death, as well as reduced system performance that may result from bodily harm. Health hazard assessments can be used or required early in the system design process to first identify and then eliminate or mitigate potential problems related to harmful exposure to vibration, noise, ambient temperature, and various HAZMAT substances.

7. *Survivability*. This domain addresses the need to increase the likelihood that soldiers survive attacks of various natures, including fratricide. In the context of railroad operations, this domain might focus on designing systems to improve occupant protection (e.g., improved cab seat designs) and survivability (e.g., new emergency egress options, automatic collision notification systems).

Although each MANPRINT domain is defined separately, in practice these domains are often interrelated. For example, manpower, personnel, and training are all highly interrelated, as are the system safety and health hazards domains.

The U.S. Department of Defense (DoD) has recently adopted HSI into system acquisitions for all branches of the military. The DoD *Defense Acquisition System* cuts across all military branches and includes two policy documents (5000.1 Directive and 5000.2 Instruction) and a guidance document (Defense Acquisition Guidebook; a compilation of best practices). The guidebook contains a full chapter devoted to HSI in the acquisition process. Each branch of the military is responsible for implementing its own HSI program, such as that of the U.S. Army's MANPRINT program. The U.S. Navy and Air Force each have their own HSI program as well. The U.S. Navy HSI program is called SEAPRINT and is based on MANPRINT. SEAPRINT is currently being used to modernize Naval ships and aviation (APA, 2005). DoD has also put together the Human Systems Integration Information Analysis Center (HSIIAC), an in-house HSI reference source that can be used to support the HSI efforts of the entire DoD.

The U.S. Air Force has observed that HSI pays off in terms of (1) obtaining more user-friendly equipment and (2) facilitating successful field deployment: "Users will have confidence in the equipment, no redesign [is] necessary, no unexpected training, maintenance or supply problems [are encountered]; and [the system has] reduced life cycle costs" (Lipscomb & Young, n.d.; slide 11).

The U.K. Ministry of Defense (MOD) and Canadian armed forces (Defence Research and Development Canada) also incorporate HSI (HSI is referred to as human factors integration (HFI) in the United Kingdom.) into their system acquisition processes. The U.K. MOD has six HFI domains:

1. Human factors engineering
2. Training
3. Manpower
4. Personnel
5. (System) Safety
6. Health hazards

The Canadian armed forces have identified five HSI domains:

1. Human factors
2. Training
3. Personnel
4. Health hazards
5. System safety

Although the number of HSI domains and their terminology may vary, the overall HSI content remains the same across institutions.

HSI is also used by other U.S. government agencies that are responsible for significant mission and safety-critical technology acquisitions or that have regulatory responsibilities over industries that make significant mission and safety-critical technology acquisitions. For example, the Federal Aviation Administration (FAA) produced the *Human Factors Design Standard* in 2003 to serve as a reference for use in FAA system acquisitions. The Department of Energy (DOE) has also focused on HSI issues. DOE's Brookhaven National Labs, for example, has an HSI research program that is exploring HSI issues within the energy sector. In particular, Brookhaven scientists and engineers are looking at control room design and development, and advanced alarm designs.

It is not just government agencies that have incorporated HSI into their acquisition process. The U.K. and European rail industries have made significant strides in incorporating HSI methods and tools into their technology acquisition processes. In the U.K., for instance, as a result of changes to a significant London Underground railroad extension project (the Jubilee Line Extension (JLE)), a number of training, operability, and system reliability concerns were identified by the regulatory agency providing government oversight. One such example was the development of an alarm list for an information system that overloaded operators (Lucas, 2004). These changes threatened both the safety of the line and the ability to complete the project. To rectify these problems, an interdisciplinary group from London Underground was organized and matched with a group of human factors experts to address and rectify these problems. Although successful, this mid-course change in project management and oversight was costly.

To prevent similar occurrences from happening on future projects, London Underground made a number of changes to its rail systems engineering processes. Most notably, London Underground produced an HSI standard, *HFI Standard E1035*, to ensure proper and timely integration of human factors principles and methods into the design and development of all future London Underground railway control systems. A manual of best practices was also produced to accompany the standard. The London Underground standard identifies the following areas where human factors are considered integral to systems development:

- Operability of equipment
- Physical design of equipment
- Functional safety and system security
- Staffing and training development
- Procedures and staff organization

The London Underground HFI standard contains the following major sections:

1. Responsibilities
2. Project organization
3. End-user representation
4. Operational concept
5. Human factors integration plan

The first three sections are administrative and address how London Underground should interact with suppliers. The fourth section places the onus on London Underground to specify how a system is to be used (i.e., concept of operations). The fifth section is a requirement for suppliers to plan for how they will integrate human factors into their system development.

Network Rail's (formerly Railtrack) *Thameslink 2000* program provides another example of how HSI can be applied to railroad system design and development. Network Rail, which maintains and operates the U.K. rail infrastructure, undertook a major rail infrastructure expansion project to expand capacity and improve service. As part of this project, the former Railtrack created a human factors operability group that was responsible for HSI. The group had three primary roles: define user requirements, ensure due process, and approve the work. The group developed an HSI strategy and created a human factors database to monitor and track human factors issues that were identified during the project. They also required each external work contractor to (1) develop a human factors work plan that identified how human factors issues would be addressed and (2) employ or engage human factors professionals to support their work.

The U.K. Office of Rail Regulation (ORR), which is responsible for economic and safety regulations in the U.K. rail industry, also recognizes the importance of HSI within railroad development projects. An online ORR paper entitled, *Human factors–Human factors integration* (ORR, n.d.), provides support and guidance to the U.K. rail industry on the value and critical features of HSI within railroad projects. ORR identifies the following three categories through which human factors can impact the safety and health of rail operators, maintainers, and users:

- Job: Tasks, workload, environment, displays and controls, and procedures
- Individual: Competence, skills, personality, attitudes, and risk perception
- Organization: Culture, leadership, resources, work patterns, and communications.

According to the online ORR paper:

> Human factors cuts across the boundaries between many traditional railway industry disciplines and yet adequate management of human factors is often overlooked. Human factors are not a series of independent issues to be conveniently addressed in isolation, or on a piece-meal basis. Nor can human factors be effectively incorporated just before the end of a project or design process. Instead, human factors considerations should be integrated throughout the lifecycle of systems development, functions of the owner organisation and the different roles of individuals in project teams. (p.1)

The ORR paper also identifies three key indicators of successful HSI policies (pp. 2-3):

1. Resources and commitment to HSI processes
2. A design process that includes user involvement
3. Assurance and testing

Finally, the ORR paper describes the benefits of successful HSI (pp. 3-4):

- Improved system performance
- Reduction in system whole life cycle costs
- Reductions in procurement cost and risk
- Improved recruitment and retention
- Removal of health hazards and consequent reduction in liabilities
- Reduced likelihood and severity of accidents

3. How Does HSI Work?

HSI is multi-faceted. No one approach works best. In general, organizations that acquire or modernize large technological systems may formalize their HSI approach through the following types of activities:

- Obtain a clear commitment from the top-most levels of the organization on the importance of HSI in acquiring and modernizing technologies and systems along with adequate resources to implement an HSI process.
- Assign ownership of HSI activities to a human factors professional or other individual within the acquiring organization, who is responsible for HSI activities within his/her organization and by contractors developing the new or modernized systems. Responsibilities include development of the HSI process within his/her organization, development of HSI-related design specifications, and the ability to sign off on HSI-related design specifications.
- Develop design specifications that address HSI domain issues for the technology or system to be procured.
- Develop requirements for user involvement in design and/or testing.
- Use formal human factors techniques (e.g., task analysis) to provide baseline and quantitative (i.e., measurable) data and information to support new designs.
- Require contractors to employ or use formal human factors staff to oversee technology development HSI activities.

4. What Are Some HSI Opportunities in the U.S. Railroad Industry?

The U.S. railroad industry continuously seeks to improve the safety and efficiency of its operations through the use of advanced technologies. This has been evident, for example, since railroads transitioned from manual to automatic coupler systems and from manual tie-down to automatic train air brake systems (and most recently, to electronically controlled brakes). Most recently, several significant technologies exist that the industry has begun to study (positive train control (PTC)) or has begun to deploy (remote control locomotive (RCL) operations). Furthermore, railroads are continually upgrading or modernizing existing technological systems, such as computer-aided dispatching (CAD) systems. Lastly, the possibility of new train crew configurations under optimally manned train operations brings with it the expected need for technological (as well as procedural) changes to support these new operations. This section discusses how HSI might play a role in the acquisition or modernization of each of the four major technological systems in the U.S. railroad industry.

4.1 PTC Systems

Each of the major U.S. Class I railroads has been exploring the use of PTC systems over the last 20 years. In January 2007, in fact, FRA approved the first PTC system developed under new 2005 PTC regulations for operation on BNSF Railway. PTC systems may be deployed across the U.S. Class I railroad network if the systems can prove to be cost effective and reliable and increase safety. It is advantageous to utilize a process of technology acquisition and implementation that includes consideration of PTC users and their anticipated role in operating, maintaining, or otherwise using PTC systems. Without this user-centered approach, a potential mismatch may occur between the PTC users and system operation because human limitations and requirements may be overlooked or otherwise not identified and addressed in the system's design. The result is an increased risk of future operational errors or system failure. For example, when designing the user interface, it is paramount to ensure that appropriate system information feedback is provided to the user to support decisionmaking and maintenance of situation awareness without overwhelming the user. HSI can also assist system designers in ensuring successful PTC interoperability, a significant goal and necessity for PTC to succeed across the industry.

Anticipated PTC users include train crews, railroad dispatchers, train crew supervisors (i.e., road foremen, trainmasters), communication and signal personnel, information technology (e.g., computer support) personnel, and system maintainers. Consistent with an HSI approach to technology acquisition, the job functions of each of these users should be included in specifying and designing PTC systems, including overall function allocation, task requirements, operator interface design, and identification of training requirements on the new systems. All of these factors will influence the design engineering of the PTC system, including the user interface, system functions and operation, and training.

4.2 RCL Systems

U.S. Class I railroads began to deploy RCL systems in early 2002. By the beginning of 2006, a significant percentage of yard assignments had been converted to RCL. An opportunity now exists to systematically evaluate RCL effectiveness to identify opportunities to enhance future RCL systems. Such future RCL systems may include new features like switch control and digital video cameras. Some FRA-sponsored research on RCL operations has been conducted that can support HSI evaluation. Furthermore, given that RCL operations have been around for more than 4 years, railroads can draw on the experiences of remote control operators (RCOs) to further understand and identify human factors, system safety, and training issues that may need to be addressed as future iterations of RCL technology are developed and fielded.

4.3 CAD Systems

U.S. railroads are experiencing record traffic volumes and seek to continue this growth. One of the ways in which the railroad industry can accommodate increased demand for rail service is through the effective use of technology. PTC systems and RCL operations are two examples. A third example is CAD systems. U.S. railroads, especially the large Class I railroads, are continually improving their CAD systems to enhance the efficiency of their operations. CAD systems, with their route planning and optimization tools, have the potential to help dispatchers and others increase network velocity and boost capacity, thereby improving service and asset utilization

Various forms of CAD systems have been in place for many years at most of the large railroads and many of the smaller railroads. Consequently, CAD system changes are an example of a system modernization program. That is, each railroad has currently implemented some form of the CAD system. Enhancements or upgrades to a CAD system are designed to improve operational performance while, at the same time, these enhancements must work with some legacy components. Application of HSI principles can help modernize the system by providing a formal means of ensuring that the dispatcher, his/her tasks, and, more generally, dispatcher performance are considered foremost in any changes or updates to the CAD system.

4.4 Optimally Manned Train Operations

As railroads continue to seek to make their operations more efficient, an area that will attract more and more attention over the next few years is the possible change in train crew size, makeup, and skill. In order to safely implement any such staffing changes, it is critical to account for all tasks and procedures now carried out by train crewmembers and determine how technology may assist in those tasks and procedures. Application of HSI principles can ensure that all train crew tasks are adequately addressed in the design of advanced technological systems to support optimally manned train operations.

5. What Are the Advantages of HSI?

Very briefly, HSI has the potential to:

- *Increase U.S. railroad safety* by minimizing the potential for system failures through careful consideration of the user as part of overall system reliability and operation.
- *Improve operator performance and operational efficiency* by specifying and designing the system to accommodate user capabilities and limitations.
- *Increase user acceptance* through active involvement of users in testing and evaluation, resulting in a human-centered design.
- *Reduce training time and costs* through design of a human-centered system that requires less specialized training to operate and maintain the technology or system.
- *Reduce the likelihood of, and costs associated with, system upgrades and midcourse design changes* by carefully considering the user at the start of the design cycle, thereby avoiding human-centered design shortcomings that may otherwise result if the user is not considered early in the design stage. Costs associated with implementing an HSI process during system acquisition will be less than costs associated with midcourse design changes or post-deployment upgrades.
- *Reduce system lifecycle costs* by holistically viewing a technological system to include the operators, maintainers, and trainers. Such a holistic view that considers and evaluates the system design, staffing requirements, training requirements, personnel requirements, and system safety will optimize overall system performance, which, in turn, will control or minimize lifecycle costs.

6. What Can the U.S. Railroad Industry Do to Implement HSI?

So far, this paper has introduced the concept of HSI, provided examples of HSI processes and techniques, discussed several technologies where HSI could be introduced, and identified advantages to HSI in the U.S. railroad industry. The U.S. railroad industry has, over time, implemented different aspects of an HSI approach to various technology and modernization programs (for example, use of human factors professionals and human performance data collection methods to design in-cab displays). This section identifies a few specific areas where U.S. railroad management and labor, and suppliers, can begin to implement HSI processes and/or techniques. This list is not meant to be exhaustive; rather, it is meant to serve as a starting point and reference. It is understood that some railroads already carry out one or more of the following suggestions.

6.1 What Can Railroad Management, Labor, and Trade Associations Do to Implement HSI?

There are a number of HSI processes and techniques that the railroad industry—railroad management, labor unions, and trade associations, such as the Association of American Railroads (AAR) and American Short Line and Regional Railroad Association—can adopt and implement. Some, of course, have already been adopted. The following short list includes a host of possible HSI processes and techniques. Not all need to be followed in any one program. In general, the more that are followed, the more robust will be the HSI.

- Allocate sufficient monetary and staff resources to develop an HSI program to support system acquisitions and modernizations.
- Develop an overarching HSI policy and process that governs how HSI will be applied to new system or technology acquisitions and modernization programs. While railroads would be responsible for developing their own HSI policies, a trade organization could support this process by developing a guidance document on how railroads can establish an HSI process. AAR, for instance, already produces a variety of guidance documents (e.g., Locomotive System Integration Operating Display Standard S591; AAR, 2006) to support railroad technology development and use in the U.S. railroad industry.
- Develop an HSIP for each new or modernization program. Among other purposes, the HSIP should indicate how human factors requirements will be addressed during the program, convey the scope of human factors work to be performed, identify critical human factors milestones and constraints, assign roles and responsibilities, and provide a means of recording and resolving problems and trade-offs.
- Appoint a human factors champion to each program to ensure that human factors are considered and included in the design and development stages.
- Incorporate human factors engineering data collection and analysis techniques to understand users, the tasks, and the operational environment. These techniques are best utilized proactively to ensure that users and their tasks and interactions with equipment, people, and procedures will be optimized. An example is conducting risk assessment methods, such as a failure modes, effects, and

criticality analysis (FMECA), to identify and prioritize potentially hazardous scenarios and conditions associated with a new system.

- Use quantifiable and documented human factors engineering data to guide and support HSI design specifications and requirements.
- Use HSI design specifications and requirements to support the statement of work and the specific tasks that a technology or system supplier must complete when developing the technology or system to be acquired.

6.2 What Can Railroad Suppliers Do to Implement HSI?

There are also a number of HSI processes and techniques that railroad suppliers can adopt and follow to support the railroads in their efforts to acquire new technologies and processes, and modernize operations. Undoubtedly, different suppliers have already incorporated some of the following approaches. The following list is meant to serve as a starting point and reference. A few HSI approaches include the following:

- Employ and use human factors professionals on railroad programs to ensure that user capabilities, limitations, and requirements are considered and included in system designs.
- Involve human factors specialists at the earliest stages of, and throughout, system design and development.
- Use human factors data collection and analysis techniques to collect quantitative and qualitative user performance, preference, and acceptance data when developing new or modernized systems. Start with fundamental baseline data, such as results from task and job analyses.
- Ensure design decisions for new and modernized systems, including human factors and human performance data, to the extent possible. Sources of data may be internal usability tests or published information, such as anthropometric data. One approach to ensuring the use of human factors and human performance data is for suppliers to develop an internal quality standard that requires the use of these data as part of their design and development process.
- Ensure that designers have a mastery of the subject domain for which the new technology or system will be used. This might involve utilizing in-house SMEs, hiring an SME consultant, or including railroad SMEs as part of a design advisory group.
- Ensure that the system being developed satisfies all of the contracting railroad's human-centered design requirements and specifications.

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