Upgrading Traveler Information Systems on an Existing Fleet

Robert Gave, P.E.
Booz Allen Hamilton, Inc.
San Francisco, CA

Sandeep Bhanji
Booz Allen Hamilton, Inc.
Los Angeles, CA

INTRODUCTION

New rail vehicles are routinely purchased with state-of-the-art traveler information systems. These systems vastly improve the ridership experience and reduce train operator workload and distractions by automatically providing automated audible and visual announcements to travelers on board.

Upgrading an existing older fleet with new equipment may be difficult as these vehicles may have limited ability to support installation of the new equipment. This paper will address in detail the challenges of updating an older fleet with new equipment.

This paper will first discuss passengers' expectations of interacting with the state-of-the-art traveler information system installed on an agency's fleet of newer buses and/or rail vehicles. Inequities may be perceived when these expectations transfer to older vehicles without new systems. Next, the authors will present an overview of system functionality followed by a summary of typical design challenges faced installing new traveler information systems in an existing fleet. This will be followed by a discussion of design methodologies that address these challenges. Finally, system implementation issues including training, community outreach, and system cutover will be discussed.

PASSENGERS' EXPECTATIONS

Multimodal agencies typically operate mixed fleets of buses and rail vehicles of various types, ages, and vintages. In this scenario, a large number of passengers are exposed on a daily basis to modern traveler information system technologies while riding on an agency's bus fleet and newer rail vehicles. This inevitably sets their expectations for these amenities throughout the fleet causing some difficulties:

- The existing, as well as older fleet typically cannot be replaced to employ the carbuilder's state-of-the-art traveler information system
- Beyond what is usually considered higher priority work, i.e. propulsion, auxiliary power, brakes, and doors, there may be insufficient budget for the new technology
- Ridership advocacy groups, having come to expect a consistent level of service and amenities throughout the system, now generate concerns about transit equity and accessibility.

The following will provide a review of the technology, design considerations, and implementation issues that an agency faces. Most of this information was collected from recent vehicle overhauls, needs assessments, and procurement support to accommodate traveler information systems.

SYSTEM FUNCTIONS OVERVIEW

Modern traveler information systems announce audio messages to passengers and concurrently display visual messages on internal passenger facing signs. These systems typically also control the destination signs, run number signs, and interfaces to transfer and activate visual and audible announcements on all cars in a train consist. To enable remote diagnostics and data downloading, these signs interface with a wireless data transfer system installed at the vehicle storage facility.

On-board traveler information systems typically include the following equipment:

- Automatic Vehicle Location (AVL) equipment to provide vehicle location to sufficiently drive the automatic passenger information functions
- Wireless data transfer equipment (vehicle-borne and at fixed side at yards)
- An operator control unit
- An announcement logic and control unit with associated storage memory
- On-board public address system
- On-board electronic message sign(s)

- All necessary software and firmware
- Wiring, cabling, and other hardware

During operation, these systems can provide various types of audio announcements such as:

- Next stop or station message, when the vehicle leaves a stop or station
- Stop or station approaching message, when the vehicle is approaching
- Left or right side doors are opening and door closing warnings
- Route and destination on external speakers when doors are open at a stop or station, only at the side where the vehicle doors open
- Automatic ad-hoc public service messages
- Operator triggered messages.

Internal signs typically display the following information, most of which are synchronized with the audible announcements:

- Next stop or station name following departure
- Route and destination when the vehicle is stopped with doors open at a stop or station
- Automatic ad-hoc public service messages
- Message corresponding to the operator triggered annunciation
- Current time and date
- Advertisements.

In the event the system experiences a failure, a well designed system will enable the vehicle operator to override the automated system and manually announce messages over the public address system. In such cases, the passenger activated “Stop Request” system will still typically remain functional.

DESIGN CHALLENGES

Operating Environment

The railway operating environment presents unique challenges to electronic equipment installed on vehicles. Such challenges include:

- Operation near or around high voltage components and fields; electrical noise; radiated and inductive electromagnetic interference
- Dust and dirt from pantograph, brakes, or roadway
- Excessive heat or stagnant ventilation
- Smoke and flammability requirements for materials
- Limited space.

The effect of each of these items on the overall system and measures to mitigate them are identified below.

Operating near or around high voltage circuits, exposure to radiated or inductive electromagnetic interference, or other induced noise can effect the operation of traveler information systems. These systems interface with and/or operate near on-board components such as doors, couplers, train-lines, high voltage cabling/components, and other noise emitters. Without proper consideration in the design and integration of the traveler information system equipment, electrical noise and interference can affect the operation of electronic signs, the public address system, interface signals, or other components. Electrical isolation, shielding, proper grounding, and other techniques are necessary to mitigate these problems. In a worst case scenario, the traveler information system equipment may affect critical vehicle systems such as doors, brakes, or propulsion.

Dust and dirt can coat circuit boards causing unpredictable operation, clog ventilation ports, or corrode materials. Equipment designs should take into account a dusty and dirty environment.

Depending on the location, temperatures on rail vehicles can exceed 50 deg C. Equipment installed in or near these locations can overheat, experience reduced performance, or shortened life span. Lack of proper ventilation can cause the same results, although to a lesser extent. Equipment designs should account for this and not rely solely on ventilating air to remain within the range of operation, nor should equipment rely on forced (and potentially dirty) ventilating air passing over components.

Finally, strict adherence to smoke and flammability requirements is necessary if operating in tunnels or other confined spaces. Existing traveler information system equipment, if originally designed to operate on buses, will not likely meet these requirements. Displays, control equipment, wire, and cable must all be evaluated for suitability.

A typical rail vehicle is already overloaded with equipment, conduits, and cables. Adding more equipment results in the “installing wherever space is found” method, which may not be the best approach, and may result into one or more of the previously mentioned effects on equipment.

Vehicle Systems Integration

Vehicle electrical system integration

Integration into an existing vehicle's electrical system can present significant challenges. These challenges are primarily related to:

- Limitations to existing carbody wiring
- Power supplies and supply voltage
- Audio amplifiers, speakers, and wiring
- Coupler connections
- Ability to safely interface with other on-board systems.

No assumptions can or should be made regarding the availability of spare wiring on an existing vehicle, consistency from vehicle to vehicle, or the suitability of existing wire and cable. Numerous connections are required for electronic displays, the public address system, operator controls, and train-line connections. An existing vehicle may not have spare or sufficient wiring to support these additional requirements. If the wiring does exist, lack of interconnecting terminal blocks or other issues may prevent proper connections between components.

Power supply, voltage levels, and spare capacity present significant issues. Most traveler information system equipment is geared toward operation on buses in a 12 or 24VDC environment. Rail vehicles can have 36.5VDC low voltage supply buses requiring costly and space consuming power converters to step down to 12 or 24VDC. These converters will also require sufficient isolation to protect the traveler information system equipment from surges, spikes, or voltage sags.

Existing audio amplifiers, speakers and wiring may not be suitable for reuse. Audio amplifiers could be of outdated technology, of outdated design or unable to accommodate the necessary input channels. Interior speakers or speaker wiring can be defective, or there may be insufficient or unbalanced sound level coverage throughout the vehicle. Exterior speakers or wiring can be defective, corroded and may require replacement..

For existing public address systems, typically the train-line through the couplers is employed to transmit control and audio level signals to other cars in the consist. However, as additional systems/subsystems are added on vehicles, the coupler may not have enough spare capacity for the additional functionality inherent in the new systems, including the ability to drive electronic message signs in trailing cars.

Traveler information systems often have to interface with train-lines and other systems such as the doors. For example, the information system may need to display which side doors will be opening upon arrival at the next station, or if the doors are about to close. In such cases, additional consideration must be paid to fail-safe design, precluding latent failures from causing unpredictable responses, sneak circuits, etc. For instance, a spurious signal from the traveler information system that inadvertently causes a door to open while in motion, or causes a false "*Doors Closed*" signal enabling traction power to be applied could have catastrophic effects. All of these potential failures must be identified, mitigated, and demonstrated within a failure modes and effects analysis and subsequent testing. Alternatively, if possible, the traveler information system should be isolated from the critical vehicle subsystems to the maximum extent possible.

Vehicle carbody integration

Installing new equipment into existing spare space can prove problematic, especially if legacy equipment must remain in place until decommissioned. Interior equipment compartments usually have very little free space for installing new announcement controllers, amplifiers, power supplies, and other associated equipment. Installing equipment either below the car or on the roof is not preferred due to environmental issues such as clearances, heat, dirt, moisture, or maintenance accessibility.

Installing the operator control unit in the operator console can also present unique challenges. If no spare room exists in the operator console, as is usually the case, the unit must then be installed on top of the console. However, it must be installed in area that does not to obstruct the operator's view of the road through the front or side windows, and does not obstruct the operator's normal functions and access to the console.

Integration with Legacy Systems

If at all possible, the new on-board equipment should leverage existing equipment such as Global Positioning System (GPS). Depending on how the traveler information system equipment communicates with the fixed end servers while on the road, a wide area data radio system may be needed. The wide area data radio system may not have sufficient bandwidth or interface capability to meet these needs. An interface with the agency's scheduling system will be required to load the on-board equipment with routes, blocks, special service exceptions, etc. Finally, a method of authenticating the operator will also be needed. This may include inputting the employee ID number and possibly other data related to the operator to verify his or her identity.

Equipment Commonality

Maximizing the commonality with the rest of the agency's equipment throughout the fleet is also desirable. Ideally, equipment in use throughout the majority of an agency's rolling stock could be used as part of the upgrade of the older fleet. Among the obvious benefits are leveraging non-recurring engineering and system integration costs, making use of a common training curriculum, and more favorable spare parts pricing agreements due to larger quantities. However, this may not be possible if the agency's procurement regulations prohibit sole sourcing or if the equipment in most of the fleet is simply unsuitable for installation in the existing rail fleet.

DESIGN METHODOLOGIES

Based on passengers' expectations and the design challenges discussed above, this paper will summarize some of the design methodologies that can be employed to meet some of the requirements of a traveler information system upgrade on an existing rail fleet. The ensuing discussion will now focus on fundamental design criteria including power supply, data transmittal, general equipment design, and installation design. These are some examples of design methodologies and should not be considered as all inclusive.

Power Supplies

As mentioned previously, the majority of traveler information system equipment have been designed to operate on either 12VDC or 24VDC using a chassis ground. New power supply equipment will be required if 12VDC or 24VDC does not exist on the vehicle or the existing low voltage supply does not have sufficient capacity to support all of the traveler information system equipment. In either case, a compact solid state converter providing input voltage transient protection and input to output isolation is recommended. In proportion to other components that make up the traveler information system, power supply equipment will be a relatively costly but necessary investment in long term system reliability and stability. Generally, at least 50% additional spare capacity should be anticipated in the power supply for future growth.

Data Networks

Network technology and trainlines capable of supporting data communications are required in order to drive the electronic message signs in trailing cars. If the system designer is lucky, there already exists a low bandwidth "power line" network using the IEEE Std 1473-T/L technology (e.g. Lonworks® or TCN). If not, significant effort can be anticipated to identify spare train-lines to carry the data, select a network technology, develop application program interfaces with the traveler information system, and perform testing. We recommend that only non-critical/non-safety related data should be placed on the IEEE Std 1473-T/L type network.

Equipment Design

Electronic message signs on vehicles are usually single line devices with character heights that meet the ADA requirements. The only variations would be display color (usually red, green, or amber LEDs) and whether the "stop request" annunciation is part of the electronic message or exists as a stand-alone assembly in the sign housing. The advantage of the stand-alone stop request signal is that (for street running use) the stop request function would still operate after the traveler information system fails.

The vehicle logic unit can exist as a rack-mounted device made up with individual cards to implement the various system functions. Other configurations include sealed units with multiple connectors on the rear to interface with carbody wiring. If dirty cooling air is a problem, a sealed device is preferred.

Most traveler information system providers supply their own customized public address amplifier. Typically, this amplifier is electronically controlled by the vehicle logic unit and has multiple channels to support automated inputs, operator input, exterior announcements, and radio communications inputs. The vehicle logic unit can control other features such as adjusting the public address volume based on ambient noise level in the car. It is important to note that the amplifier settings should be tamper proof to prevent train operators from making their own personally preferred "adjustments" to the sound level.

The operator control unit design should be carefully considered to facilitate ease of system cutover. As mentioned previously, spare room seldom exists in the operator console for the existing public address control unit and the new operator control unit required by the traveler information system. If the new operator control unit cannot be installed in a location without obstructing the operator's view through the front or side window, another approach must be taken, or a different location should be identified. One such approach to addressing the shortage of space centers on providing a new operator control unit that can function as the existing public address controller unit until the new traveler information system is active. The new operator control unit can be used like the old public address controller until all features are active. Use of this approach would simplify the cutover process as the agency can wait for all vehicles to have equipment installed, and the entire system tested before allowing the system to go "live". This approach is dependent on the "go live" timeframe.

Design for Installation

A good design for installation takes into consideration workforce skills and capabilities, installation time constraints, and the quality control requirements throughout the installation process. An agency should strive to:

- Minimize the number of steps and movements required to install the equipment – while this may seem obvious, it is frequently overlooked. The installation design, and the process used to install equipment should minimize travel within and around the vehicle, actions needed to route wire, cut or drill holes, install equipment, and perform testing. Any additional steps introduced require additional time and introduce additional opportunity for defects.
- Understand the vehicle design – again what may seem obvious is often overlooked. The designer should have access to all drawing and schematics and use them as design inputs. For example, not knowing that a wire harness is located right behind a structure being drilled or cut can have disastrous consequences, especially if the damaged is undetected after installation.
- Wire and cable routing – optimize proposed routing with respect to interfering structures, articulation sections, terminal strips, etc.
- Carbody Modifications – install equipment in a way that minimizes the need to cut holes in structures, panels, or undercar assemblies. These activities require time, special tools, and additional inspection steps for Quality Control and vehicle structural verification.
- Testing – establish and adhere to a structured program to (1) test selected vehicle subsystems before installation, (2) test the newly installed equipment and systems, and (3) re-test vehicle subsystems after the installation is completed. Specifically do ensure during the testing that simulated failures in the traveler information system do not cause unwanted results in other systems.
- Quality Control – understand the program and procedures in advance. Have agreement as to who will provide Quality Control (QC) inspection services, and who will manage Quality Assurance (QA) program oversight. One approach is to have the equipment installer provide QC while the agency provides QA.

SYSTEM IMPLEMENTATION

Staff Training

Vehicle operator training

Prior to beginning the installation of equipment, the Contractor should submit a Training Plan to the agency. The purpose for the Training Plan will be to outline the activities for knowledge transfer, approve training materials and goals, and delineate the training responsibilities between the Contractor and the agency.

A training schedule should be submitted as part of the Training Plan. The schedule should take into account preliminary test activities, system startup activities, and full-scale training of operators prior to system cutover. Training operators too early will result in reduced retention when the system is finally deployed. Training too late will result in operators not knowing how to operate the equipment in their assigned train or, worse yet, having operators refuse to take the train based on union or safety regulations.

System administrator training

System administrators prepare the data, announcement files, and other elements required for the system to function properly. The level of effort for system administration depends on how frequently an agency changes rail schedules, routes, or stops. A system administration test environment consisting of all equipment installed on a board or in a box is recommended to fully test how the announcements will sound and appear on the electronic message signs. Any proposed system change(s) should be verified in this test environment.

System maintenance training

For system maintenance training, an agency should decide prior to deployment, which labor classes or staff positions will be responsible for maintenance of electronic equipment, system interfaces (e.g. power, next-stop pull chord), signs, speakers, and other equipment. As with the system administrators, a system maintenance test environment should be provided first for the maintenance training, and then for long-term system maintenance.

Community Outreach

An agency should embark on a formal and organized community outreach program prior to procuring any traveler information equipment in fleet. The travelers may have certain expectations from the agency which may differ from the agency's own priorities. It is also important to understand the ridership will be the agency's "eyes and ears" as the system is deployed. Public feedback should be encouraged and welcomed in order to create an environment of transparency. The community outreach program should include a combination of the following:

- Traditional print collateral such as brochures ("take-ones"), posters, and newspapers
- Electronic methods:
    - dedicated space on the agency's web site explaining the new technology in detail
    - social media such as Facebook© or Twitter©
    - Online news sites
- Targeted emails or RSS feeds for those who sign-up to receive updates on the traveler information system
- Neighborhood group meetings
- City-wide meetings

Traditional elements including brochures and internal signage should appear just prior to equipment installation, or if one or more test vehicles are running in revenue services. The electronic media and printed collateral should let the ridership know that changes are on the way, why they are occurring, what to expect, and when to expect it.

At any given time, the agency can begin to publicize the upgrade program on its web site. Motivation for the upgrade, more in depth explanations of how the technology works, and a deployment schedule should be openly discussed. If possible, include a means for readers to provide comments in an open forum. At a minimum, provide an email address for questions. This feedback early on in the program can provide valuable insights into the public's expectations for system performance.

Newer methods including use of social media can be used as the system is being deployed. This can be especially useful if a phased deployment is envisioned, for example line by line. Real-time updates to followers on Twitter (or equivalent) as the system is being deployed deliver the perception that the agency "gets it" and is making a concerted effort to keep the ridership informed of new developments. An agency's participation in social media is usually communicated using the printed collateral such as posters.

System Cutover

System cutover consists of installing equipment in vehicles, activating the passenger facing elements of the system, and performance monitoring.

Two different approaches can be taken for system cutover, each with its own pros and cons:

- Startup operation for the entire fleet at once – this approach consists of installing equipment in the entire fleet prior to activating the passenger facing elements in the vehicles, effectively transitioning from no active vehicles to the entire fleet being active overnight (literally!)
- Startup gradually – this approach allows the system to be activated in each vehicle as equipment installations are completed, effectively transitioning from no active vehicles to all vehicles gradually over a period of time

Each approach has its own distinct advantages and disadvantages with the agency having the final say in which method works best for itself and the ridership.

Startup operation for the entire fleet at once

In this approach, vehicle installations proceed until completion. As questions are bound to arise, public outreach should indicate the reason for existence of the new equipment and an anticipated "go-live" date. After, and only after, all of the vehicles have had equipment installed, the system goes live and provides information to passengers.

This approach provides several distinct advantages:

- Additional performance data can be gathered by agency staff while the system is operating in "stealth mode"
- All of the operators can be trained prior to the system being made operational
- The entire ridership receives benefits of the system at the same time.

Disadvantages may include:

- Increased time to fully deploy
- Effects of operator training can diminish over time increasing the need for refresher training ("use or lose" syndrome)
- Equipment is left installed in vehicles for an extended period prior to verifying proper operation prior to startup; additional final inspections may be required to ensure system availability.

Gradual cutover

In this approach, the system goes into operation vehicle-by-vehicle, after the installation on each vehicle is tested and accepted. Public outreach is still required to communicate the existence of the new equipment and schedule for deployment.

This main advantage to this approach is that it benefits the ridership immediately and increasingly as each new vehicle has equipment installed.

Disadvantages to this approach are more policy oriented and may include:

- Operators potentially not having been trained prior to taking out the train with the new equipment
- Certain segments of the ridership or routes voicing concerns or displeasure about the perceived lack of service while other routes benefit
- The disabled community voicing concerns regarding transit equity

SUMMARY AND CONCLUSIONS

Introducing new traveler information equipment in an existing fleet of vehicles can present significant challenges.

Design challenges begin with the operating environment. Dust, dirt, heat, high voltage, and other considerations conspire to drive special equipment requirements that add cost and lengthen the design cycle. Integrating this equipment into the existing vehicle, given the existing wiring and mechanical envelope constraints, can introduce requirements for more complex equipment and special one-off designs not usually encountered in "green field" installations. Finally, designing to interface with legacy scheduling systems and the need to achieve some level of equipment commonality throughout the entire fleet may introduce additional procurement challenges, or conflict with existing regulations.

Several mature technologies exist today to overcome some of the design challenges listed above. Included among these are compact high efficiency power supplies, data networking equipment, wireless networks, and digital signage. Installation design is as important as equipment selection. Designers, and the agency as reviewers, should consider work force skills, vehicle constraints, time, and monitoring of the quality from the beginning of the design cycle, effectively minimizing the need to correct any such deficiencies near the end, when the costs to make corrections will be considerably higher.

System implementation considerations include staff training, community outreach, and system cutover. Each is important and deserves significant consideration to achieve a successful implementation. Training operators on time (i.e. not too soon or not too late) is crucial to building confidence and helps to provide a smooth cutover. Community outreach should begin prior to hardware showing up on vehicles to educate the public, advertise that the agency cares about its ridership, and that feedback is welcome. System startup can be done on a vehicle-by-vehicle basis or after the entire fleet is installed. Each method has its own unique advantages and disadvantages and should be evaluated by the agency on a case by case basis.