TECHNOLOGY DIGEST

Timely Technology Transfer — 01-017

Integrating Technology into the Locomotive Cab

by Brian Smith

Summary

The Transportation Technology Center, Inc. (TTCI) is integrating various communication networks into cabs of test locomotives for demonstration purposes at the Facility for Accelerated Testing (FAST), Pueblo, Colorado. This is being done to investigate opportunities to improve safety and efficiency by providing the locomotive engineer with performance information concerning the infrastructure and the train.

In work completed to date, a radio frequency (RF) wireless local area network (WLAN) system was installed as a communication backbone covering the FAST area. Interfaces for multiple wayside detection systems and onboard health monitoring systems into the communications link have also been developed. An industry standard protocol, Simple Network Management Protocol (SNMP) was established to combine pertinent information from each system. Finally, these steps have culminated in the display of wayside and onboard real-time health status information in the cab. In addition to the health of various systems being displayed, Differential Global Positioning System (DGPS) information is available on the display to allow location of the train, as well as other similarly equipped vehicles, to be monitored by TTCI's control center.

Other benefits resulting from this technology integration include the ability of test engineers to remotely conduct analysis and monitor operations at the Facility for Accelerated Service Testing (FAST) in real-time. Also, maintenance personnel are able to monitor, diagnose, and correct problems remotely. Work on testing and improving the computer systems will continue through 2001.

Suggested Distribution:

- ❑ Mechanical
- ❑ Operations
- ❑ Safety

Work performed by TTCI Transportation Technology Center, Inc.
a subsidiary of the Association of American Railroads

INTRODUCTION

Communication information gathering and display technologies offer many potential benefits to the operation of rail and other network type equipment. In recognition of this potential, Transportation Technology Center, Inc. (TTCI) has pursued a demonstration program of these technologies at the Facility for Accelerated Service Testing (FAST) located at the Federal Railroad Administration's Transportation Technology Center. This work is sponsored by the Association of American Railroads as part of a Strategic Research Initiative in Signals, Communications, and Train Control. The goal is to integrate and enhance information available in the locomotive cab to improve safety and efficiency by providing the locomotive engineer with performance information concerning the infrastructure and the train.

FAST is a controlled rail operation, and thus an obvious choice for a demonstration program. The FAST train is made up of four locomotives and up to 76 125-ton gondola and tank cars. FAST offers limited track length and consistent equipment.

INTEGRATED TECHNOLOGY DISPLAY

The integration of technologies onto the locomotive culminates in a display of information in the locomotive cab. The cab display is based on the Association of American Railroads' Locomotive Systems Integration (LSI) standard screen. The LSI screen displays pertinent information about the locomotive, as well as information about other associated systems.

Pertinent information from the integration of technologies is demonstrated with examples shown in Exhibit 1. Integration of onboard systems results in the display of information such as brake condition and speed from the locomotive along the top of the screen. Information from wayside systems is displayed in two forms in the display. First, icons representing the condition of each subsystem are shown on the center status bar of the display. Green icons represent conditions allowing the train to operate at normal speeds. Yellow icons represent compromised operating conditions. Red

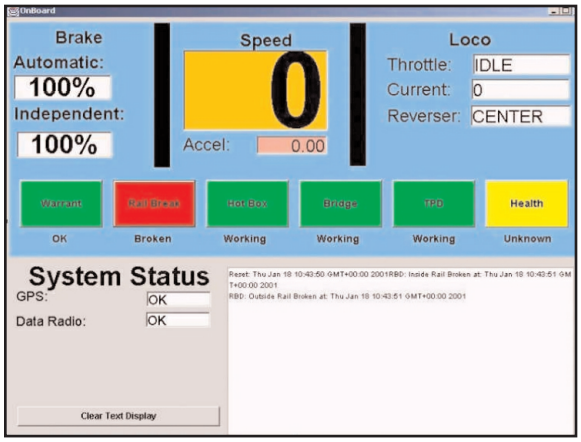

Exhibit 1. LSI Standard Display Screen

icons represent unacceptable operating conditions. These icons present information about both the status of the system (broken rail, etc.) and about the health status of the detection systems.

In addition to the icon color representations, pertinent text messages are displayed in the bottom right-hand field for compromised or unacceptable operating conditions. At FAST, this information is helpful to quickly identify where and when problems exist. It should be noted that only exception-based information is passed through to the display.

COMMUNICATIONS NETWORK

In order to provide information to the locomotive cab, the first system component required is a communications network. For cost and implementation reasons, an IEEE 802.11 RF LAN radio system, with a maximum throughput capability of 11 megabits/second, was chosen to meet the communications needs at FAST. The system works in the 2.4 GHz spread spectrum Industry Science and Medicine (ISM) band.

Installation of this system offered several benefits at FAST that may or may not be applicable in other railway environments:

- Two-mile radius coverage per antenna
- Windows®/Linux® operating system compatibility

- Low Cost
- Ease of integration with already existing systems at FAST
- Ease of integration with TTCI's existing LAN system

This communications backbone enabled access to all of the wayside detector locations at FAST and to the lead locomotive of the train. Once the capabilities of this system were identified, TTCI expanded the system to include sitewide coverage.

WAYSIDE SENSOR SYSTEMS

Four wayside sensor systems are included in the list of devices monitored at FAST. These systems include:

- Rail-Break Detection System
- Hot Bearing/Dragging Equipment Detection System
- Bridge Deflection System
- Truck Performance Detection (TPD) System

The Rail-Break Detection System at FAST is an integral part of the FAST operations. The FAST train operates for up to 150 laps per night over the 2.7-mile High Tonnage Loop (HTL) resulting in 4 to 4.5 million gross tons (MGT) of traffic per week. This short track length results in a 4-minute interval between locomotive passes. The importance of the Rail-Break Detection System is compounded by the 1,000 or so rail welds within the HTL. Testing rail weld types and techniques is one of the functions of FAST. The detection system monitors the inner and outer rails separately with low-level direct current circuits. Conventional output through signal masts at two locations around the loop is done with a green light signifying clear track and a red light signifying a broken rail condition. To monitor rail-break data remotely, a data acquisition system (DAS) was installed with the capability to connect to a radio frequency (RF) Wireless LAN (WLAN) network. Thresholds for voltage conditions of certain components are monitored and exception-based messages are passed along to the appropriate personnel.

The HTL is equipped with a Harmon Cyberscan 2000™ hot bearing/dragging equipment detection system. Conventional output is done through a flashing light and radio output similar to systems in revenue-service. To pass information directly to the cab, a PC was attached to the hot bearing system and to the RF WLAN system.

As part of a bridge deck research program, a two-span, four-girder bridge was installed in the HTL. As a research extension of the program, one of the girders has fatigue cracks that are monitored. This girder has been monitored with a limit switch since installation. To enhance the bridge monitoring capability, deflection measurement devices were installed on each girder of the bridge. These deflections are monitored using the same PC that communicates with the hot bearing detection system. Deflections beyond allowable thresholds are reported through a flashing light and sent through the RF WLAN to the locomotive cab.

The Truck Performance Detector (TPD) is the fourth wayside detection device incorporated into the monitoring system. Truck performance monitoring is accomplished using a DAS system that measures wheel/rail forces from wayside locations. A variety of strain gages attached to the rail to measure vertical and lateral wheel forces during each train pass. The lateral and vertical measurements are combined to output the L/V ratio for each wheel. Angle-of-attack measurements are also output from the TPD system.

The TPD system offers a wide variety of operational benefits to FAST. Since individual wheel, axle, and truck performance of each railcar are monitored every lap, performance changes over time can be identified. Poor performance due to component failure is identified rapidly and depending on the level of performance, individual cars can be identified and removed from the train during the next lap.

The HTL is equipped with wayside lubrication devices to reduce curving resistance. If multiple railcars report degraded performance at the same time, often the cause is a lubrication system failure. Through

a long history of operation at FAST, the system has been able to identify out-of-round wheels through these same performance measurements.

Conventional output from the TPD system has been in a wide variety of forms including e-mails, pages, and faxes. Since this system was already incorporated into the RF WLAN system, integrating the exception-based output into the locomotive cab display was straight forward.

ONBOARD SYSTEMS

Onboard data is being captured through an interface with WABTEC Trailing Locomotive Control (TLC) equipment installed on two of the FAST locomotive as part of the cable-based electronically controlled pneumatic braking system. The TLC system offers distributed power control of multiple locomotive consists at FAST and offers onboard health feedback information for this program.

Additionally, an onboard monitoring system was installed early in this program on the four FAST locomotives to measure end-of-axle, motor-support bearing, and gear-box temperatures. Traction motor current from each locomotive was also monitored. This system will be incorporated into the newly installed cab display this year.

GLOBAL POSITIONING LOCATION

Information on train position through a Global Positioning System is currently being implemented as part of the program. A Differential Global Positioning System (DGPS) is in place at TTC from earlier work sponsored by the Federal Railroad Administration. As a result, only a few components are required to allow the DGPS train position to be known. This will allow the position of the FAST train to be displayed on board the locomotive relative to other equipment and facilities at TTC. It also allows the train location to be monitored by other vehicles and TTC's Operations Control Center as part of TTCI's "Mobile Tracking System" (Exhibit 2).

Other benefits are being realized in the FAST operation through this technology integration. Maintenance personnel are able to access systems remotely and diagnose and correct problems as they are identified. Engineers monitoring tests are also now able to conduct analyses over the RF WLAN system. Work on system hardening (robustness of software/hardware systems) will continue through this year.

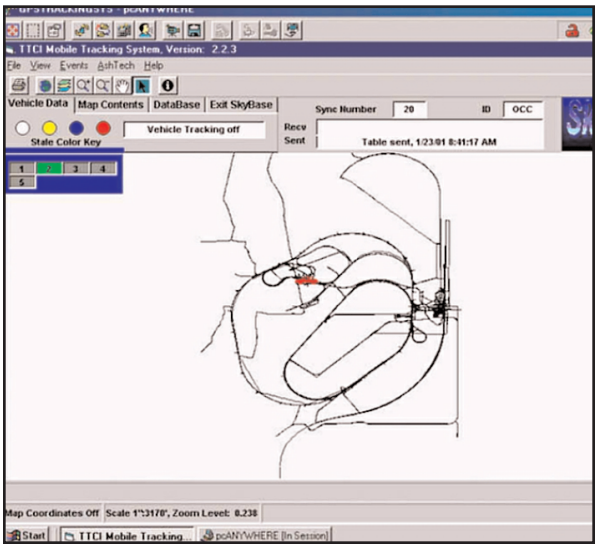

Exhibit 2. Mobile Tracking Display Screen

Note: Please contact Brian Smith at (719) 584-0558 with questions or comments about this document.

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A MORE DETAILED REPORT, WHICH MAY CONTAIN REVISED INFORMATION, MAY BE AVAILABLE AT A LATER DATE THROUGH AAR/TTCI, PUBLICATIONS, P.O. Box 79780, BALTIMORE, MD, 21279-0780.