U.S. Department
Of Transportation

**Federal Railroad
Administration**

Research Results

**RR04-01
January 2004**

Development and Deployment Of a Vehicle Tracking System

SUMMARY

A vehicle tracking system (VTS) was installed and deployed at the Federal Railroad Administration's (FRA's) Transportation Technology Center (TTC) in November 2002. The fundamental goal of this program was to enhance the already high level of safety for TTC personnel in a spread out field test environment and allow for a higher level of asset monitoring and management by providing near real-time vehicle location determination. This system leverages several enabling technologies for Positive Train Control (PTC) systems that are now available off-the-shelf, such as:

- The U. S. Department of Defense Global Positioning System (GPS)
- The USDOT differential augmentation to GPS, known as Nationwide GPS (NDGPS)
- Digital radio frequency communications for transmission of mobile vehicle situation data
- Wireless local area network communications for high-speed transmission of mapping data

The tracking system, which has been operational since November 2002, is installed on 17 vehicles, including four locomotives. There are also five spare units that may be used to equip mutual aid responders during emergencies. The system is flexible enough for future expansion.

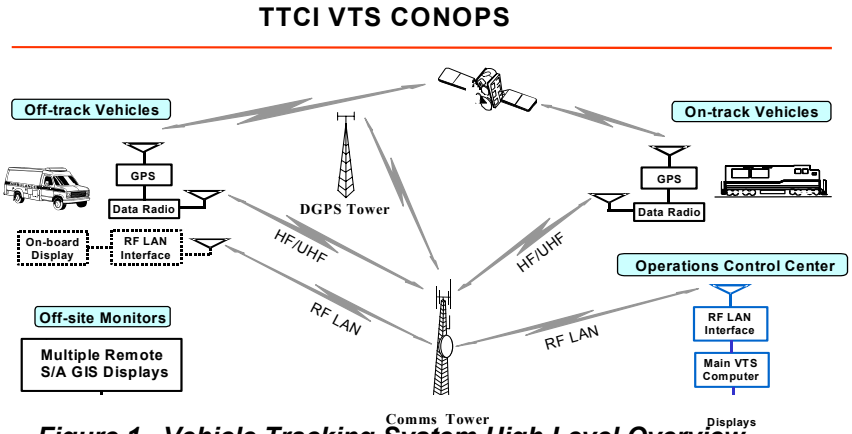

Figure 1. Vehicle Tracking System High Level Overview.

BACKGROUND

The objective of this program was to install an operational VTS that can be used by TTC personnel during everyday operations. This system will enhance the safety and efficiency of research, development, and testing operations programs at TTC. Examples of TTC functions that have been enhanced by the VTS system include emergency services and high-speed train testing. The FRA's Office of Research and Development funded this work.

The TTC is a railroad and rail transit test facility owned by FRA, which contracts with the Transportation Technology Center, Inc. (TTCI), a wholly owned subsidiary of the Association of American Railroads, for the day-to-day operations of the facility. The test center itself consists of 48 miles of railroad track dedicated to testing of rolling stock, track, communications and signaling equipment, and associated systems. The three primary components are the Railroad Test Track, the Facility for Accelerated Service Testing, and the Transit Test Track.

SYSTEM OVERVIEW

A systems level schematic of the VTS is depicted in Figure 1. As discussed previously, the VTS leverages technologies such as GPS/NDGPS for positioning, digital RF communications for unit identification and position reporting, and the wireless local networking for updating the VTS map.

Mobile units, consisting of VTS-monitored units and VTS-smart vehicle units, are currently installed on twenty-two vehicles. VTS-monitored vehicles transmit identification, location, and velocity information to the VTS Server located at the Operations Control Center (OCC). VTS-smart vehicle units, in addition to having the VTS-monitor functionality, also contain an onboard computer (OBC) with a WLAN card. The card interfaces with the pre-existing WLAN at the TTC and gives the VTS-smart vehicles the ability to connect to the VTS Server. This provides the OBC with the ability to display a map of the test center with near real-time tracking of mobile units.

Figure 2 shows a VTS fixed installation in a locomotive cab. An example of a VTS portable installation is shown in Figure 3. Each mobile unit includes an eight-channel GPS receiver with an integrated NDGPS beacon receiver for the most reliable location reporting. The NDGPS beacon signal is received from a broadcast station at the nearby Pueblo Chemical Depot. The close proximity of the TTC to the Depot results in a reduction in errors from atmospheric variation in the differentially corrected DGPS signal. This means that the final resolved position for each mobile unit is more robust than the 1 – 3 meters accuracy advertised by the U S Coast Guard, the operator of the NDGPS network.

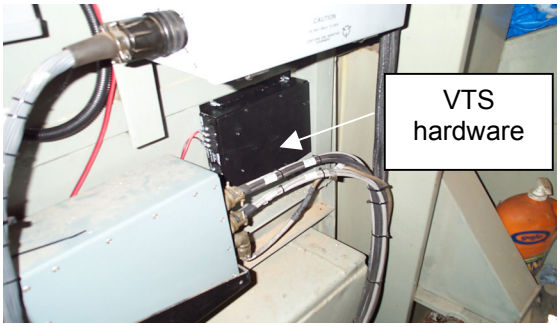

Figure 2. Locomotive Installation of Vehicle Tracking System Hardware (Courtesy of Radio Satellite Integrators, Inc.)

Figure 3. Portable Installation of Vehicle Tracking System Hardware (Courtesy of Radio Satellite Integrators, Inc.)

The VTS communications system allows for the tracking of 5-6 vehicles per second. The backbone for the communications network is a UHF data channel pair operating at 452.475 and 457.475 MHz, respectively, with a 12.5 KHz channel bandwidth.

The base station, located at OCC, broadcasts at 452.475 MHz, while the mobile units transmit at 457.475 MHz. The communications network employs a time division multiple access (TDMA) polling scheme, thereby restricting each mobile unit to a defined broadcast time slot. This precludes the collision or overlap of data transmissions from multiple units.

VTS BENEFITS

The vehicle tracking system was developed with the vision of enhancing the safety and effectiveness of TTC activities through increased situational awareness and control of test center operations. As such, FRA and TTCI employed a systems engineering approach in building the vehicle tracking system. One of the key steps in this process was for the VTS development team to interview TTC personnel who are responsible for certain critical operations. The results of the interviews were used as inputs in developing the VTS Concept of Operations document. This process, which occurred well before the selection of a technology or vendor, included interviews with the OCC manager, the fire chief, and the facilities support manager.

Operations Control Center

The OCC is the central facility at TTC where all dispatching of rail vehicles is performed. As such, OCC personnel represent one of the core VTS user groups. OCC employees are responsible for control monitoring and control of all voice radio communications at TTC as well as the coordination and monitoring of the safe movement of road vehicles and heavy equipment. The benefits of the VTS to OCC personnel include:

- The ability to define and monitor no entry zones. This provides OCC personnel with an additional tool in preventing vehicles from entering potentially hazardous or proprietary test locations.
- The use of graphical displays that show the location of all tracked vehicles.
- The ability to create vehicle specific attributes such as icons, alphanumeric text, and colors that can be assigned and edited on the fly.
- The use of mass storage devices for storing and recalling mobile vehicle tracking information.
- The functionality for integrating and displaying information from other OCC safety systems.
- The ability to link VTS displays to remote locations via the Internet.

TTC On-Site Emergency Responders

TTC employs its own fire department and rescue squad as well as it own security department. The VTS characteristics that these personnel are benefiting from include the following:

- The ability to coordinate and control all TTC on-site emergency responders.
- The upgrade of the TTC Fire Chief vehicle with VTS-smart display mobile equipment. This type of equipment will enable the fire chief to monitor, coordinate and direct all active emergency onsite emergency responders.
- The configuration of emergency response vehicles with VTS-monitor mobile equipment.

Mutual Aid Emergency Responders

TTC has reciprocity agreements with various off-site entities for emergency situations requiring a response that is beyond the capability of on-site emergency responders. As such, the VTS was designed with specific features to coordinate communications between TTC and the off-site responders during emergencies. They are:

- Portable VTS mobile units that are stored at the main gate to TTC for quick installation into vehicles of arriving mutual aid responders.
- The use of digital data links for communications over the entire test facility.
- The ability for OCC personnel to delineate the demarcation lines for emergency locations or no entry zones.

Benefits to Other Users

Some of the ancillary beneficiaries of the VTS are the TTC Facility Support Manager, on-site engineers, customers, and authorized government personnel. The TTC Facility Support Manager is now able to exploit the tracking and monitoring functionality to more effectively allocate TTC resources, and staff for reduced response times for trouble calls. On-site engineering staff, customers, and authorized government personnel are now able to monitor

the location of test vehicles and progress of test activities. Test activities can now be monitored by means of the OCC, the wireless LAN, or the Internet.

DEPLOYMENT

The minimum configuration for every mobile tracking unit consists of an eight-channel GPS receiver with an integrated NDGPS beacon receiver, and a UHF radio. Seven of the mobile vehicles are configured with smart vehicle equipment, including an onboard computer with near real-time graphical display capability of vehicle movements. A screenshot of the VTS operating display is found in Figure 4.

This is a breakdown of the vehicle configurations:

- 1 - VTS-smart vehicle unit, fire chief truck
- 2 - VTS-smart vehicle units, locomotive use
- 2 - VTS-monitor only units, locomotive use
- 2 - VTS-smart vehicle units, auto vehicle use
- 15 - VTS-monitor only units, including five spares.

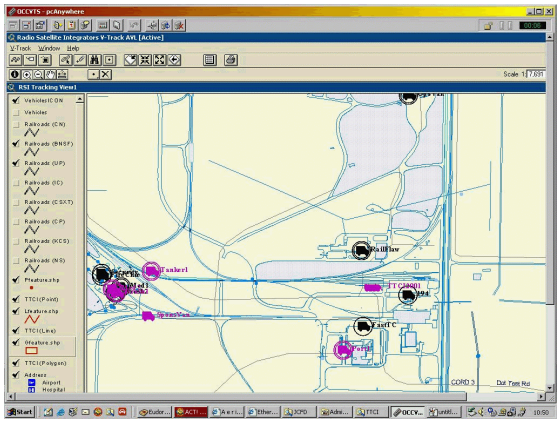

Figure 4. Screen shot of the VTS display map of TTC.

CONCLUSIONS

FRA's Office of Research and Development has leveraged the strength behind two recent trends in the vehicle tracking system industry to develop and deploy a highly functional system at the TTC in Pueblo, Colorado.

First, the constituent technologies that VTSs are comprised of such as GPS receivers, wireless data communications equipment, and microcomputers have decreased significantly in cost over the past decade. Second, as the costs have decreased, the efficiency and robustness of these technologies, many of which are found in PTC systems under development in the U S, have increased.

As a result, these technologies, which were once considered expensive, have achieved off-the-shelf status. VTS systems are now commonplace in police, fire, and emergency vehicle applications, public works departments, and public transportation systems.

REFERENCES

[1] Transportation Technology Center, Inc. (2002). "Concept of Operations for a Vehicle Tracking System at the Transportation Technology Center," Draft Working Copy.

[2] Radio Satellite Integrators, Inc, (2003).

ACKNOWLEDGEMENTS

This project was conducted under the guidance of Gunars Spons, FRA Resident Engineering Manager of the TTC. The USDOT/RSPA Volpe National Transportation Systems Center provided technical guidance on this program. TTCI managed the project and Radio Satellite Integrators, Inc. fabricated and installed the vehicle tracking system.

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