



US Department  
of Transportation  
**Federal Railroad  
Administration**

# Research Results

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## Remote Control and Monitoring from the Locomotive Cab

### SUMMARY

The Office of Research and Development of the Federal Railroad Administration (FRA) has developed a system to monitor and control mechanical components on railroad freight cars from the safety of the locomotive cab. The project's main objective is to improve railroad safety and efficiency by using advanced technologies to monitor and control components, as well as, improve crew safety and operational efficiency during switching operations.

Several technologies have been combined to create the Advanced Concept Train (ACT) as shown in Figure 1. The ACT train consists of a locomotive and rail cars of various types. The subject of this research is the connection between the operator in the cab of the locomotive and the controllable components on the freight cars of the train. The controllable components are the handbrake, cut lever, tri-coupler, and angle cock. The hand brake is used to hold the rail car in place when it is not moving and is similar in function to a parking brake on an automobile. The handbrake must be set when a rail car is separated from the train and must be released before moving the car. The cut lever is used to uncouple rail cars. When the cut lever is lifted, the coupler is unlocked and rail cars can be pulled apart. The cut lever is not required to couple rail cars together. The angle cock is used to control the air system used for the train's pneumatic brake system. When a rail car is coupled to a train, the angle cock must be open to allow air to flow to the braking system. Additionally, the last rail car on the train must have its trailing end angle cock closed to prevent the air pressure from escaping out the rear of the train.



Figure 1 – FRA Advanced Concept Train

## BACKGROUND

Crew safety has been a concern of railroad operations for many years. Approximately 63 percent of railroad employees fatally injured in 2003 were performing switching operations [1]. The key goal of this research is to evaluate the use of advanced technologies to improve crew safety and increase operational efficiency during switching.

This research developed from an FRA-sponsored project initiated several years ago to develop an On-Board Monitoring and Control System (OBMCS) for railroad freight cars. This system monitors the state of various sensors onboard each car and wirelessly transmits this information off board for remote display and diagnostics. The OBMCS research created a framework for gathering data from a railcar through self-powered electronic components utilizing advanced technology. Once technology was onboard each car to monitor various sensors, the next logical step was to demonstrate remote control of various mechanical railcar components such as handbrakes, angle cocks (i.e. brake valves), and cut levers used during switching operations.

This research investigates the feasibility of remotely controlling rail components from the locomotive cab using advanced technologies.

## OBJECTIVES

The main objectives of this project are:

- Demonstrate wireless communication between a locomotive and rail cars
- Demonstrate control of various components and systems equipped on rail cars from the safety of the locomotive cab
- Demonstrate that rail components and systems could wirelessly transmit data to the locomotive for display to the locomotive operator
- Demonstrate that rail car performance data gathered by the locomotive can be transmitted to an off board server for display and remote monitoring
- Demonstrate a Human Machine Interface (HMI) for controlling the rail cars which is intuitive and easy to use by locomotive operators

## METHODS

In order to maximize the long-term viability of the system, commercial-off-the-shelf technology was utilized whenever possible. This development approach leverages mature technology. Consequently, the development effort focused on the improvements required to adapt existing technology to the physical demands of the locomotive environment and existing railroad business processes.

In order to control the advanced features of the rail car components and systems, a secure and reliable communication link is required between the locomotive and the rail cars. The same Wi-Fi technology used in businesses and homes is used as the core technology. The Wi-Fi technology is augmented with mesh technology that improves wireless performance in mobile vehicles. Wi-Fi with mesh technology is widely used by public service organizations such as police and fire.

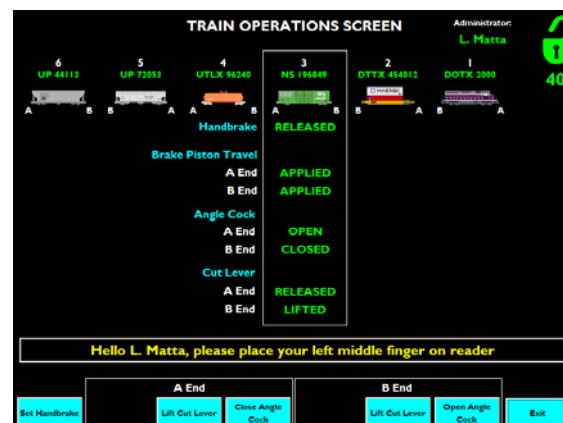


Figure 2 – Train Operations User Interface Touch Screen

To monitor and control the rail cars, the locomotive cab is equipped with a wireless computing platform and a rugged LCD touch screen, as shown in Figure 2. The computing platform is Wi-Tronix's Wireless Processing Unit or Wi-PU. The Wi-PU is a proven device that is used in hundreds of locomotives throughout North America. The Wi-PU's software manages all communications with the rail cars and implements the Graphical User Interface (GUI) which the train operator uses to monitor and control components and systems on the rail cars.

Hundreds of data parameters are transferred back and forth between the rail cars and locomotive. In order to manage this complex digital communications infrastructure, software middleware is required. The open standards based Data Distribution System (DDS) was selected as the middleware [2]. DDS is available from many software vendors and is used in a number of commercial and military applications. DDS provides the foundation for the reliability required to remotely control rail car operations.

## RESULTS

The Wi-Fi mesh networking system has been demonstrated on the Advanced Concept Train's (ACT) rail cars and locomotive. The mesh technology allows each vehicle to act as a gateway to another vehicle in a peer-to-peer topology. This is contrary to the typical Wi-Fi set up in a home or office that requires a central access point. The mesh network topology allows the locomotive at one end of the train to communicate to a rail car on the other end of the train that is out of direct communications range. This is accomplished by the signal "hopping" the length of the train, 4 to 5 cars at a time.

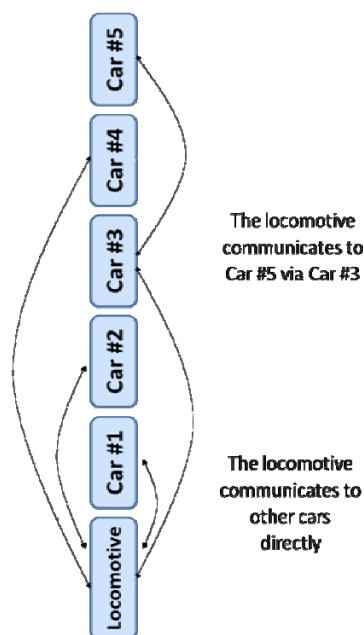


Figure 1 - Mesh Network Topology

The mesh technology not only extends the range of the Wi-Fi system but also greatly improves the reliability. There are multiple communication "hop" paths available to reach any particular rail car from the locomotive. Static testing of the ACT train with the mesh networking system has been completed. The test results show that the standard Wi-Fi signal can reach a distance between three to four rail cars. With the mesh technology enabled, the locomotive was able to directly communicate with the 4<sup>th</sup> car back but communicated to the 5<sup>th</sup> car by relaying or hopping through the 3<sup>rd</sup> car as shown in Figure 1. This test demonstrated the capability for the Wi-Fi Mesh communications system to function reliably on long trains.

The HMI was designed using graphical elements that are familiar to most train operators. GUIs using high-resolution LCD display screens have been deployed on locomotives for over 15 years. The Association of American Railroads has established recommended practices on the color, layout and function of locomotive GUIs [3]. These recommended practices were employed to create the HMI to control and monitor the rail cars. A touch screen utilizing acoustic waveguide technology allows the HMI to be operated with gloved hands.

The user interface is constructed based on a horizontal depiction of the rail cars in the train as shown in Figure 2. Photo realistic icons representing the rail cars are used to optimize the visual feedback to the operator. The operator navigates to the rail car of interest by pressing the rail car icons. When a rail car icon is pressed, that rail car is centered on the display screen. The cut levers, angle cocks and handbrake can then be controlled on the selected rail car. The display below the rail car icon shows the current state of the controlled components. Additionally, monitored parameters such as brake piston travel are also displayed.

When a rail car is selected, the operator can activate buttons along the bottom of the screen to control the rail car components (i.e. apply and release the hand brake).

When the operator activates the component, immediate visual feedback is provided and the control command is transmitted to the rail car. Feedback from the rail car is continuously monitored and displayed to the operator until the operation is completed.

## CONCLUSIONS

Existing technologies can be combined and customized to implement the advanced systems required to remotely control the coupling and uncoupling of freight cars from the safety of a locomotive's cab. The required technology is reliable and cost effective. The cost and complexity of the system is comparable to other electronic systems currently deployed in the rail industry. Locomotive operating crews are familiar with the GUIs contained on modern locomotives. Given this familiarity, user interfaces have been designed for remote rail car operations that are both familiar and highly functional.

## FUTURE ACTION

The core features of the rail car remote control system are scheduled to begin field testing in revenue service. It is expected that the technology demonstrated by the ACT will spur additional interest within the rail industry and drive larger scale demonstrations.

As remote control of rail car functions mature, further integration with the core locomotive electronics system is expected. Increased integration will further enhance the value of the system and speed the technology adoption process.

## ACKNOWLEDGEMENTS

The ACT is an integration project that involves FRA's Office of Research and Development along with multiple contractors including Wi-Tronix, TIS, SAIC, Wilcoxon Research, Sharma & Associates, Fulcum Corporation, New York Air Brake and others.

## REFERENCES

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- [2] "Data Distribution Service for Real-time Systems Specification, Version 1", Object Management Group, Inc, December 2004
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## KEYWORDS

locomotive, freight car, wireless  
communication, remote control, monitoring,  
graphical user interface, GUI, HMI, locomotive