LEVERAGING FUEL MANAGEMENT TECHNOLOGIES TO DRIVE OPERATIONAL EFFICIENCIES
ABSTRACT

The railroad industry in the 21st century is becoming increasingly data-driven. Railroads use data to make important operational and business decisions—equipment and track maintenance programs, fault detection and health monitoring, capital planning, train and traffic control, and everything in between. Access to real-time, accurate fuel-use data has taken on additional urgency. Incorporated into the overall data stream, a data-based fuel management program is an indispensable part of a railroad's overall business strategy, one focused on safety, efficiency, sustainability, service quality, cost control and profitability. Indeed, fuel management goes well beyond basic fuel conservation.

Among the primary jobs of railroad personnel responsible for managing locomotive fleets is ensuring that locomotives get fuel where and when they need it. However, the data needed to make business-appropriate strategic decisions often lacks detail and/or comprehensiveness. For example, actual fuel consumption is often higher than what is projected. Reconciliation of purchased gallons with actual gallons consumed is very challenging.

There are many considerations. Locomotives, individually or in multiple-unit lashups, are often cut out of a train to visit the fueling pad. With Distributed Power (DP) units spaced throughout a consist (more common today, with longer, heavier trains operating under Precision Scheduled Railroading), this becomes more problematic. Even with run-through refueling pads located on the main line handling multiple locomotives simultaneously, a train must still stop for an extended time period. Traffic control, even for the most experienced dispatchers, is often a chess game. Refueling stops, planned or unplanned, are just one of many pieces on the board.

Locomotive fuel tank gauges have improved over the years, from simple sight glasses to gauges that use compressed air to determine how much fuel is left in the tank. But these methods have up to a 5% margin of error (for example, plus or minus 250 gallons on a 5,000 gallon tank). Fuel level readings are skewed by roll and pitch and rail cant, and whether a train is operating on a grade or flat territory, through curves or on tangent track.

Fuel costs vary, depending upon geographic region. Fueling in regions where prices are higher impacts cost control initiatives. Delaying locomotive refueling until a train is operating in a region where prices are lower creates risks: running out of fuel, stranding power on line-of-road, unplanned stops, and financial penalties for delayed trains and shipment deliveries outside of contracted windows. The remedy is a DTL (Direct To Locomotive) fuel stop requiring a contracted truck making a fuel delivery in a remote location, at higher cost than a railroad facility. DTL, however, can be problematic, particularly, reconciling billing with the amount of fuel actually delivered.

Technology exists in the market today that provides the benefits of reduced fuel consumption, simplified fuel consumption accounting, and reduced emissions. This technology, utilizing AI (Artificial Intelligence) as well as railroad operating systems, is designed to provide high-quality data—real-time and historical—for every locomotive in the fleet, resulting in “refueling optimization.” This paper describes fuel monitoring and refueling optimization technologies, how they function, and the multi-part value proposition they bring to a railroad.
Fuel: High Cost, High Price Volatility

According to the Association of American Railroads, “As the most sustainable way to move goods over land, a freight train, on average, moves one ton of freight more than 470 miles on one gallon of fuel. Moving goods by rail instead of truck reduces greenhouse gas emissions up to 75%, on average.” Yet, even with this advantage, Class I railroads still spend billions on locomotive fuel, a cost only fractionally offset by fuel surcharges added to freight rates that are regulated by the U.S. Surface Transportation Board. One Class I, for example, spent nearly $3 billion on fuel in 2019, second only to compensation and benefits, at just over $5 billion.

Fuel prices are also volatile, rising and falling in response to economic forces that impact supply and demand. The most recent example of this is the COVID-19 pandemic and its resulting free-fall in demand for motor vehicle fuels, which caused the per-barrel price of crude oil to plummet temporarily. Railroads sometimes hedge fuel prices to limit exposure to an increase, but this strategy can backfire when a sudden, unexpected downward shift in price per gallon occurs—like during the COVID-19 pandemic.

Compensation and benefits may be the highest operating cost for railroads, but compared to fuel costs, they are far more predictable. This is because they are based on long-term contracts negotiated through collective bargaining for agreement employees, or by established guidelines for non-agreement employees.

A refueling optimization program driven by state-of-the-art technology, supported by real-time, accurate fuel-use data gathered through AI, can help alleviate a railroad’s exposure to fuel price volatility. As fuel costs increasingly become less predictable, implementing a successful fuel savings program is necessary for a railroad. Monitoring its success will have an immediate positive impact on the bottom line.

Emergence of EMS (Energy Management Systems)

Energy Management Systems (EMS) technology is in widespread use at Class I railroads. These systems assist locomotive engineers in reducing fuel consumption while managing trip time and minimizing in-train forces. Such systems monitor throttle, dynamic brake, independent brake and air brake settings, enabling more-precise train handling.

To address the numerous challenges railroads encounter like those described above, Wi-Tronix® has developed the Wi-FuelSensor, Wi-Nav and Fuel Efficiency Monitor (FEM) System technologies. All are fleet-agnostic, AI-based solutions that generate fuel data used to provide alerts and reports. Integrated within a refueling optimization program, these solutions provide access to real-time, accurate fuel data, generating alerts when specific fuel conditions are met. They allow railroad personnel to make real-time adjustments for optimal fuel consumption, ultimately decreasing fuel costs and increasing operating efficiencies. They take EMS to the next level. As the second-largest railroad operating expense, fuel is always a focus for cost reduction opportunities that can have a significant impact on the bottom line.

Excessive Fuel Consumption and Spend Causes and Solutions

There are numerous causes of excessive fuel consumption and spend. Traditionally, these causes have been identified and addressed separately, with little or no “connective intelligence”—data—integrating them into an all-encompassing fuel monitoring and refueling optimization program. All of them are challenges managers in a railroad’s mechanical, operating, finance, environmental and safety departments—working collaboratively or independently—can encounter with a locomotive fleet.
Wi-Tronix® has combined contactless ultrasonic measurement technology with customized fuel tank profiles in its Wi-FuelSensor system, which monitors fuel consumption in real time. Wi-Nav technology improves the accuracy of refuels by remotely monitoring fuel tank level within 1%; correcting fuel level for pitch, roll and rail cant, and neutralize inaccurate readings on grades. It provides real-time business intelligence, such as fuel burn rate analysis, that translates into for “smart fueling.” The Fuel Efficiency Monitor (FEM) System monitors locomotive performance. Web services integrate reports and relay them to railroad SAP/Oracle business management systems. All this is integrated to address the following challenges:

Excessive Idling

It is often difficult to determine when and where locomotives are idling, and for how long. Excessive idling increases fleet fuel costs and compromises efforts to reduce environmental impact from emissions. Even with AESS (auto engine start-stop) systems, the parameters that drive locomotive operating rules—how often a locomotive is allowed to shut down, and under what conditions—are difficult to manage without some form of real-time or near-time data derived through remote health monitoring.

CHALLENGE: A report of excess idle minutes across the network for a given month indicates that the numbers are way too high for that time of the year. The challenge is to reduce the excess idle minutes by 50% by utilizing real-time fuel data and geofencing around major yards.

SOLUTION: Wi-Tronix® Wi-FuelSensor and Wi-Nav provide real-time, accurate, reliable data and diagnostics on such parameters as locomotive idling time and fuel tank levels, as well as comparisons among asset and crew data from HPTT, APU, AESS, EMS and other systems.

“Guesswork-Based” Refueling

Locomotive “out-of-fuel” measurements often are inaccurate, creating an unacceptable failure frequency rate. Railroads try to compensate by increasing the number of touch-points for locomotive refueling, but that only drives frequency in the opposite direction—too high. Employees responsible for refueling often add an arbitrary amount of fuel—1,000 gallons, for example, in a 5,000-gallon tank—just to ensure that a unit has been refueled, when it really isn't needed. There is no fuel data analysis to reduce the total number of daily system refueling events without negatively impacting the “out-of-fuel” failure frequency.

CHALLENGE: The finance department has tasked the mechanical department with decreasing fuel inventory levels by 15% to decrease fixed holding costs. The challenge is using locomotive fuel data from each location, in conjunction with fuel storage information, to achieve that goal without running out of fuel inventory at any given location.
**SOLUTION:** Use of **Wi-Tronix® Wi-FuelSensor** and **Wi-Nav** systems reduce service interruptions caused by low fuel/running out of fuel, and improve operational safety through real-time alerts for insufficient fuel, based on a train’s distance to destination. Fewer refueling events—for example, adding 2,000 gallons once instead of 1,000 gallons twice—will substantially improve network velocity and yard fluidity.

### Rapid Fuel Loss

This problem is more common than realized, because up to now there haven’t been any remote monitoring systems available that provide real-time alerts for rapid fuel loss. In the U.S. and Canada, major fuel leaks are most often the cause of rapid fuel loss. Such leaks are difficult to detect, because they can occur in many different locations on a locomotive: the tank (bad welds, or punctures), fuel delivery lines, filter assemblies, pumps, injector lines, etc. To a lesser extent, theft is a problem, mostly on unattended units in remote locations (sitting on a main line siding, for example), rather than within the confines of a yard or shop.

### CHALLENGE:

The frequency of fuel spills while refueling is increasing. The mechanical department has been tasked with figuring out how much fuel is being lost due to spillage. The challenge is reconciling data from on-board fuel measurement systems with measurements from wayside fueling systems to determine how much fuel is being spilled, at what frequency and at what locations.

**SOLUTION:** **Wi-Tronix® Wi-FuelSensor** and **Wi-Nav** continuously monitor fuel level in real time to detect rapid fuel loss resulting from leaks or theft, enabling fuel theft prevention and identification of where rapid fuel loss is occurring.

### Fleet Optimization

Under PSR, but also driven by decreased traffic in a down economy, many railroads are optimizing their locomotive fleets. Locomotives will either be stored serviceable, for when traffic levels rebound, or deemed excess inventory and sold/returned from lease.

**CHALLENGE:** The objective is to determine which locomotives in the fleet are the least fuel efficient, and as such should be removed first from the active duty roster. The challenge is using each unit’s on-board fuel and tonnage data to determine their fuel efficiency and, thus, their ultimate disposition.

**SOLUTION:** **Wi-Tronix® Wi-FuelSensor** and **Wi-Nav** and **Fuel Efficiency Monitor (FEM) System** combine to provide an accurate picture of locomotive fuel efficiency and performance.
Excessive DTL Refueling Costs/Inaccurate DTL Billing

“You can’t manage what you can’t control.” Railroads that rely too heavily on DTL as a refueling strategy risk exposing their most expensive assets—locomotives—to uncertainties. Without remote fuel level monitoring, it is difficult to confirm that the fuel paid for is consistent with the amount actually delivered and dispensed. This is not to say that outside firms retained as DTL contractors are purposely overbilling. Rather, it has to do with quality control and verification. An isolated anomaly—for instance, a reading that’s a few gallons over what was actually dispensed—isn’t very significant. But on a large network, multiple anomalies quickly add up. A series of small errors turns into a significant financial impact.

CHALLENGE: The finance department has tasked the mechanical and operating departments to collaborate on a measurement system that reconciles off-line (external) DTL vendor receipts with how much fuel was actually dispensed to a locomotive, and build a report card for each vendor. The challenge is measuring fuel tank level change by combining on-board fuel data with the GPS location of where the train is stopped for refueling, to build that vendor report card.

SOLUTION: Wi-Tronix® Wi-FuelSensor and Wi-Nav enable improved fuel inventory control with accurate fuel recoverables data for foreign power; improved DTL billing accuracy, with less labor needed to reconcile fuel invoices; simplified fuel cost accounting; best-price-based refueling location planning; and reduced service interruptions caused by low fuel/running out of fuel.

Fuel Purchase Locations Not Optimized for Lowest Price Points

Purchased fuel price points across a railroad’s network vary widely from lowest to highest, and the gap can widen. Refueling in states with a high motor-fuels tax (federal tax is consistent from state to state) should be minimized to reduce exposure to those taxes, but purchasing or consuming more fuel at low-cost locations than at high-cost ones is problematic without a source of reliable, accurate data.

CHALLENGE: The number of foreign locomotives on trains equipped with run-through power (via trackage or haulage rights) from an interchange partner is increasing. However, the railroad’s locomotives operating off-system are lower in number, and are off-system for less time. The challenge is determining how to reconcile the cost of fuel recovery before the difference gets too large. As well, fuel burned within a specific geographic location is eligible for a tax credit. The challenge is to determine how much fuel is consumed in any given month, within a set geographic boundary.

SOLUTION: Wi-Tronix® Wi-FuelSensor and Wi-Nav enable simplified fuel cost accounting and best-price-based refueling location planning.
Sub-Optimized Train Handling

With PSR in wide-scale deployment across the North American railroad network, long, heavy trains with high trailing tonnage and multiple locomotives are the rule, rather than the exception. Train handling—managing in-train forces (buff and draft) is more difficult, even for experienced engineers. EMS technology, DP (Distributed Power) and more-balanced air brake propagation through simultaneous application from the head end (locomotive) and rear end (End-of-Train device) help. However, accurate fuel burn data remains elusive.

**CHALLENGE:** The railroad’s road superintendents want the operating department to devise a fuel efficiency grade for each locomotive engineer. Their objective is to include that metric in annual engineer assessments; for qualifying engineers to operate in new territory; and for FRA license recertification. The challenge is utilizing locomotive fuel data and train data, including engineer IDs, to build a database and measurement system, and lower operator-induced excess fuel consumption. Tied in with this, the operating department has instituted a new rule that trains operating at speeds above 50 MPH but not exceeding 60 MPH are not allowed to be above throttle position 6. The challenge is using real-time on-board locomotive data as the basis of an alert system that dispatchers can use to notify engineers who are out of compliance. As well, constant improvements are being made to an EMS system, working with the supplier. The challenge is tracking fuel savings improvements while the system is being utilized, using fuel data and other on-board metrics that show how often and for how long EMS is being used on a given trip. Also, the operating and mechanical departments have been tasked with lowering the railroad’s overall Horsepower Per Trailing Ton (HPTT) number. The challenge is figuring out how to use existing fuel data to look for opportunities by train type and symbol. Plus, the railroad is increasing use of Distributed Power (DP) as trains continue to grow in length under PSR. The challenge is to determine the amount of fuel being saved by using DP versus not using DP for trains of similar length and trailing tonnage.

**SOLUTION:** The Wi-Tronix® Fuel Efficiency Monitor (FEM) System monitors locomotive performance, scientifically calculating a unit’s brake-specific fuel consumption, and communicating real-time information on the effectiveness of a railroad’s fuel conservation efforts in real dollars, while assets and operators are working in revenue service. It provides comparisons among asset and crew data from HPTT, APU, AESS, EMS and other systems.

**Technology Assessment and Special Projects**

Railroads are continually evaluating new and/or improved technologies that promise to deliver increased efficiency, productivity and safety, while lowering costs. Assessing and quantifying such technologies is challenging. Following are a two examples of how Wi-Tronix® fuel management solutions can help.

**CHALLENGE:** A new locomotive on-board lubrication technology is under evaluation. The challenge is validating the 3% fuel savings the supplier is promising, using fuel data from locomotives equipped with this technology, during a three-month field test.

**SOLUTION:** With Wi-Tronix® Wi-FuelSensor and Wi-Nav, performance validation for operating practices, diesel engine modifications and fuel/lubricant additives is easily attainable. Geofence-based alerts for assets and specific personnel provide accurate location and movement data.

**CHALLENGE:** The mechanical department has discovered that air leaks on locomotives and throughout train line air systems are activating air compressors at more than normal rates. This in turn is increasing fuel consumption. The challenge is using on-board fuel monitoring and other data generated by the event recorder (such as brake pipe or air line pressure) to identify bad-actor locomotives and determine how much fuel could be conserved if those bad actors were repaired.

**SOLUTION:** Wi-Tronix® Wi-FuelSensor and Wi-Nav continuously monitor fuel level in real time to, combined with event recorder data, detect fuel loss resulting from excessive air compressor activation caused by braking system air leaks.
RESOURCES

• Driving Rail Operational Efficiencies with a Connected Ecosystem Technical Paper: The realities of transportation are constantly changing, and to remain competitive, embracing technologies that support safe and more productive operations has become mandatory. https://www2.wi-tronix.com/iot-for-rail-technical-paper/

• A Connected IoT for Rail Eco-System PDF: Combining Edge and Cloud Computing enables railway operators to consolidate and analyze multiple data streams, paving the way for automated train operation. https://www2.wi-tronix.com/wp-content/uploads/2020/05/Wi-Tronix-Ecosystem-IoT-for-Rail-Solutions_052020.pdf


• Digital Video Recorder Packages PDF: The Violet Edge IoT platform is a connected Digital Video Recorder solution giving you secure access to view on-board data anytime, from anywhere, on any device. https://www2.wi-tronix.com/wp-content/uploads/2020/05/Wi-Tronix-Violet-Edge-DVR-Packages_052020.pdf

Wi-Tronix®: Anytime, Anywhere, Any Device

**Fuel Volume Graphing Tool**

![Fuel Volume Graph]

4 gallons X 24 hours X 3 days = 288 gallons

Wi-Tronix® has been supporting mobile users in the rail industry for more than 15 years. Everywhere you go these days, we are becoming more and more connected. While at your home or office, or when you are out walking, driving, or even flying, you are more connected to your friends, your work, and your entertainment. Tablets, smartphones and laptops have been the tools of our new connected life. Wi-Tronix® connects railway personnel to critical information about locomotives, from historical information for incident investigation to real-time viewing of a specific vehicle, our user portal is powerful and secure website. We are combining edge processing with advanced systems like Visual Intelligence (VI), Artificial Intelligence (AI), and Machine Learning (ML) to detect and interpret actionable information that improves railway safety, operational efficiency and service reliability in real-time. As the preferred connected solutions provider to over one-third of all locomotives in North America, more than 2,000 Wi-Tronix® Violet Edge IoT platforms have been ordered and more than 12,000 rail vehicles from all types of manufacturers have Wi-Tronix® systems installed.

Connect. Anytime, Anywhere, Any Device with a cohesive cloud-based IoT Platform Solution
https://www2.wi-tronix.com/connect/