# THE SOLUTION TO YOUR PTC
## FALSE POSITIVE ENFORCEMENT PROBLEM

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With a rail network totaling more than 150,000 miles and comprising 538 railroads, it shouldn't be surprising that the implementation of Positive Train Control (PTC) is one of the largest engineering projects in the history of the world.

America's Class I railroads and the smaller companies that fall under the jurisdiction of PTC are not just seeing improved safety, but have now entered the digital age and are reaping the advantages of advanced connected technology and Big Data.

PTC is the culmination and integration of a variety of technical advancements and improved services that railroads have been designing and implementing since the 1980s. But it is really just in the past decade that computing power has met the challenges of collecting, analyzing and reporting the massive datasets that it takes to run a Class I railroad that meshes seamlessly with the entire rail U.S. network.

**From a transportation and legal perspective, the challenge is nearly met. By the end of 2020, the Association of American Railroads expects Class I railroads to have completed the following milestones:**

- **All hardware installed.**
- **Over 50% of PTC territory or route miles implemented.**
- **All radio spectrum acquired.**
- **All required employee training completed.**

**The completion of these major goals puts the industry on schedule for full completion of the system by the end of 2020.**

# HOW POSITIVE TRAIN CONTROL WORKS

The U.S. railroad industry moves more than 1.6 billion tons of freight and 500 million passengers per year. Integrating PTC systems not only complies with governmental guidance and regulation, it improves a railroad's insight into safety, operations and performance.

Much of the control and dispatch of these trains is currently issued verbally via two-way radio and with printed orders. It is the responsibility of the dispatcher to issue track orders that ensure no trains operate on the same section of track as another. Train crews must have complete knowledge of a route, any orders from the dispatcher, temporary restrictions, as well as the ability to respond to changing conditions along the route.

In addition to these dispatcher-based routing, other areas are controlled by signaling and in some-cases on-board train control and in-cab signaling enhancements.

PTC is an evolution and integration of all existing train control systems currently in use. When fully implemented, it will protect operations and people across most of the Class I freight network and in passenger operations.

***1.6 BILLION TONS OF FREIGHT***

***500 MILLION PASSENGERS PER YEAR***

***PTC WILL PROTECT OPERATIONS AND PEOPLE***

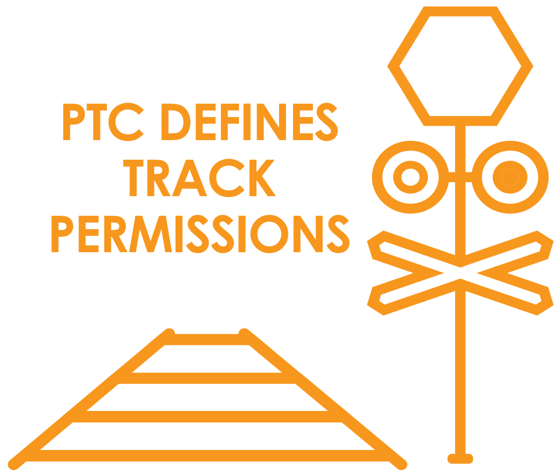
## THE RULES OF POSITIVE TRAIN CONTROL

Although a PTC implementation is a complex interconnected computer system, the guidelines that cover PTC are not a technical specification. PTC is a functional specification and each railroad adheres to this specification with a different system or set of systems.

**The basic purpose is to provide information and automation for these four functions:**

- **Prevent train-to-train collisions**
- **Enforce speed limits**
- **Protect track workers**
- **Keep trains from running through a misaligned switch**

The term "positive" is an important factor because a locomotive must receive positive permission -- "Yes, you are permitted to enter" – before entering a track block. Otherwise, the block will be protected by a red signal and in-cab warnings to the engineer that he or she does not have permission to proceed.




At its most straight-forward definition, a PTC implementation is a system that dynamically defines track permissions and train speed based on static rules such as speed limits as well as current conditions such as traffic, repairs or inspections, weather or other variables.

Every block of track has its own sensors that report on the current state of that track segment. These sensors report back a constant state. Sensors report by radio to the central monitoring system.

Every train has an on-board system that automatically reports its location, speed, weight, length and other details of current operations. Basic on-board train functionality includes awareness sensors and alerters that assure the crew's attention while also transmitting the condition of the locomotive.

These two components work together by reporting to the central monitoring system to provide dynamic information back to each train. On-board systems also receive information that includes permission to enter the block (known as a track warrant), track conditions ahead, permitted speed and other schedule or warning information.

## POSITIVE TRAIN CONTROL IMPLEMENTATIONS

Each railroad has a custom technology to implement PTC. One of the additional regulatory requirements is that each central monitoring system must be able to transmit and receive information from other railroads that might need to travel on its track. So there is a level of compatibility and cross-communication required among railroads that share track.

## PAMTRAK'S ATC, ACSES AND ITCS SYSTEMS

**ATC:**
Automatic Train Control (ATC) in Amtrak, the Long Island Rail Road (LIRR) and other passenger railroads works with an in-cab signaling system. Simple ATC systems have been in use for speed control on passenger railroads for decades. Electronics in the cab detect permanent wayside devices (often in their most simple forms these are magnets embedded in the track) that can communicate line speeds to the cab. When the system detects that the engineer is exceeding permitted speed, it can automatically apply the brakes. The engineer must acknowledge the signal through an alerter system. The use of permanent wayside devices is practical in high-traffic commuter areas such as the Northeast Corridor, but is generally not used in lower traffic freight-only areas. Exceptions to this include freight trains that use the Northeast Corridor or LIRR and a few other railroads that employ legacy in-cab signaling systems.

**Advanced Civil Speed Enforcement System (ACSES):**
Amtrak brought Alstom's ACSES (pronounced "access") onto the Northeast Corridor as part of its compliance with PTC regulations. ACSES uses a database of local permanent speed restrictions combined with temporary speed information received by radio. Using the embedded wayside devices to determine the train's location, ACSES computes not only the maximum permitted speed, but also the best time to begin braking to put the train below the next upcoming speed limit. In-cab displays show both the current speed limit and the number of seconds before the engineer must apply braking. If the engineer does not begin braking early enough to match the required "braking curve" for the upcoming speed change, the system automatically applies emergency braking. ACSES has been in partial use since 2002, but was fully in place between Washington and Boston (including commuter lines that use those tracks) in 2015 and is expected to be further deployed in similar high-traffic areas for both Amtrak and other passenger railroads. Future installations of wayside equipment along Amtrak routes will be able to work with both ACSES and the different systems in use for freight trains.

**Incremental Train Control System (ITCS):**
Between Detroit and Chicago, GE Transportation's ITCS system allows passenger trains to travel 110 mph. This system uses wayside devices and a satellite system to track the train's current location and provide advance warning of signaling and other track conditions.

## ETMS ON BURLINGTON NORTHERN SANTA FE (BNSF), ALASKA RAILROAD AND KANSAS CITY SOUTHERN

**Electronic Train Management System (ETMS):**
Wabtec has deployed its ETMS system for several large and small railroads across the country. ETMS predates the current generation of GPS-connected PTC systems, but uses similar train tracking and wayside communication to control speed and track warrants.

## I-ETMS ON NORFOLK SOUTHERN, CSX AND OTHER CLASS I RAILROADS

**Interoperable Electronic Train Management Systems (I-ETMS):**
Wabtec is taking its existing ETMS system a step forward by creating a complete system that also works across the territory of other railroads. With interoperability between locomotives and signaling systems at all the Class I railroads, trains can operate seamlessly across the country. Norfolk Southern and CSX are making quick progress and they work to complete installation of equipment and employee training by the 2020 deadline. Additionally, several commuter railroads also selected I-ETMS as their preferred PTC system and many miles of commuter track are already equipped.

# BENEFITS OF PTC

By combining wayside track sensors and signaling with on-board locomotive computers, railroads can now receive a live feed of the location, condition, operating status and speed of any train on the PTC network. When the safety component of PTC activates, dispatchers and the central office know immediately, and the information cascades down the entire network to inform other traffic. Dispatchers can change schedules and routing in real time to avoid trouble spots and ensure the continued flow of traffic.

**The immediate impact of this is on safety performance.**
**PTC systems would have helped prevent tragedies such as:**

### 2008

A 2008 collision in Chatsworth, California, between a Union Pacific (UP) train and a Metrolink commuter train that resulted in 26 deaths.

### 2004

A 2004 collision in Macadona, Texas, in which a BNSF train hit a UP train and resulted in three deaths.

### 2005

A 2005 incident in Graniteville, South Carolina, in which a crew misaligned a switch and a derailed train released chlorine gas.

**A PTC-EQUIPPED LOCOMOTIVE CAN ONLY OPERATE WHEN THE SYSTEM IS COMPLETELY SURE IT IS SAFE TO DO SO.**

The positive permission aspect of both signaling and speed control assures that a PTC-equipped locomotive can only operate when the system is completely sure it is safe to do so. If a wayside sensor or a signal loses communication with the central systems, the PTC controls default to slow or stop the train.

Track work can proceed more efficiently based on the assurance that all trains in the area now operate with full awareness of the safety situation in a given spot. Additionally, temporary speed restrictions due to track work can now be defined and enforced at a more granular location, allowing normal operations to take place outside a smaller work zone. Instead of slowing an entire section of track, PTC can enforce speed restrictions over a smaller area. This improves traffic flow and prevents a short area of out-of-service track from cascading delays throughout the region.

Improved safety remains the prime goal and expected end results of all PTC implementations. But the massive deployment of sensors, microprocessor-equipped signaling and on-board computers presents ample opportunity to register not just PTC data, but also other relevant information about railroad equipment and infrastructure. The sensors installed in the track, on board engine cabs, end-of-train devices (EOTD) and even in cars transmit radio or cellular signals to the central location. By adding additional functionality and employing advanced data analytics, railroads are a creating an incredible level of detailed near-instantaneous information about every element of their rail network.

**IMPROVED SAFETY REMAINS THE PRIME GOAL AND EXPECTED END RESULTS OF ALL PTC IMPLEMENTATIONS.**

This type of insight is unprecedented in the nearly two centuries of railroad transportation. It allows for improved scheduling, monitoring and control of fuel efficiency, and improved maintenance scheduling provided by a complete suite of sensors in each locomotive.

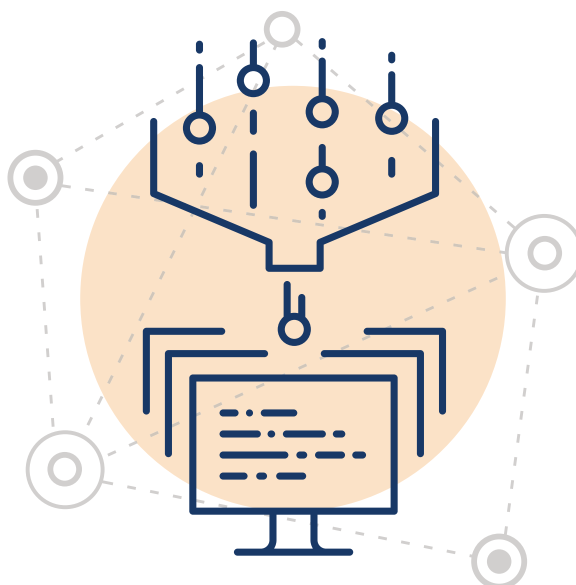
## THE CHALLENGES OF PTC

With the explosion of information available, managing it quickly and efficiently is a huge project. Train dispatchers are used to dealing with an influx of important information and carefully managing the routing and scheduling of their trains. But the shear explosion of data has the potential to overwhelm any operation.

PTC is designed to address both serious incidents and routine disruption of service. In the past these types of incidents and threats to safety were most often the result of not having enough information about the current state of the tracks or trains. Ironically, however, a fully implemented and properly functioning PTC system might actually offer too much information to properly conduct normal rail operations.

## INTRODUCING DIGITAL RAIL WORKS

In addition to PTC making the rails safer, the same equipment can also deliver data on performance, reliability, routing and logistics, and maintenance. But that influx comes in many different forms of data, across different systems and towards different intended audiences. Digital Rail Works provides the solution to this problem by putting the right information in the hands of the people who need it to take intelligent action.



Separating the important data (current track safety conditions, for example) from the less important (locomotive #1850 is using a little too much fuel) are similar to the types of challenges presented by the increased size of datasets across many different industries. Railroads will soon be inundated with new data points and unique macro-sized problems that have only been seen on a micro scale. Juggling this new data provides its own challenges in the face of ongoing operations and scheduling. With the full integration of different regions and divisions, the headaches of a regional dispatcher, a yardmaster or maintenance shop chief are now shared and multiplied across the entire railroad.

Big Data Analytics and the integration of machine learning has helped many other industries take advantage of the chance to gain more insight into their operations. Digital Rail Works does this for railroad's Big Data problem. The data gathering systems are just about in place. Now railroads need to find the best and smartest ways to use that data.

## INGEST AND DISPLAY OF BIG DATA

Railroads are no stranger to the problem of managing information. Railroads and the telegraph drove the need for standardization of time and schedule management across the Old West in the 19th century. On a local level, dispatchers using 20th century technology such as radio and block signaling can schedule and safely route traffic through their division of the rail network. This work requires a particular expertise and mastery of a very narrowly focused dataset.

PTC, along with the continued growth of the demand for efficient logistics and shipping, has changed the look of that data and added even more datasets, making the smart analysis and delivery into a more vital function than ever.

Management and analytics of Big Data are problems faced by many industries. Information Technology exists of carefully parse datasets and deliver optimized display, but until recently, railroads lacked a complete picture of their operations. Many important tasks that were performed in the field or through manual processes can now be centralized. The addition of PTC-compliant technology has brought the railroads head on into the world of Big Data management.

Fortunately, the data delivery systems can be aggregated and combined into a single intelligent display. With the backing of robust big data analytics and a machine learning engine that can read and organize a wide variety of data, it is possible to present a "pane of glass" dashboard view to deliver important information directly to the person who needs it no matter the source.

## USING THIS SYSTEM:

**The Dispatcher:**

- Can see GPS-provided location, speed and tracking data on any train.
- Knows the current track conditions by viewing a straight-forward map or drilling down on specific track orders or alerts.
- Can customize displays for specific areas or conditions.
- Can predict and model conditions based on scheduled traffic.
- Can review historical data and gain insight on choke-points or situations that commonly slow traffic.

**The Yardmaster:**

- Can see the current location, contents and scheduled destination of any car in the yard.
- Can see crew assignments, maintenance status, fuel and other details about any locomotive.
- Can direct hostlers and other crew based on current or historical activity.
- Can see at a glance where pieces of equipment are, where they came from, and where they are going.

**The shop manager:**

- Can view the current maintenance work and its progress.
- Can see incoming cars or locomotives in need of work.
- Can be alerted well in advance of scheduled maintenance or unscheduled repairs based on real-time sensors out in the field.

**The track repair manager:**

- Knows where all crew is and that they are safe from passing trains.
- Receives live data on the condition of tracks and location of faults – even before they happen.
- Using wayside track data and real historical traffic data can predict failure and maintenance requirements for sections of track, allowing scheduled maintenance well before a track geometry car could detect a fault.

**Central management:**

- Sees all of the above and aggregates it all into easily reportable metrics that drive budgeting, cost analysis and efficiency efforts.
- Uses this data to examine all facets of operations, determine best practices and keep customers informed.

## FALSE ENFORCEMENTS IN PTC

The most immediate challenge of the PTC system is dealing with false enforcements. PTC always errs on the side of caution in the interests of safety. In the event of a malfunction — or even a temporary signal loss — the entire local area can be thrown off schedule. As much as PTC can improve safety, it can also get in the way of smooth operations.

The positive-acting nature of PTC means that in the absence of a clear "go" signal, every train must stop. Passing through a malfunctioning area of the PTC network requires permission from the dispatcher and must occur at a lower speed. This is incredibly important in a real safety-related situation and is incredibly disruptive in the case of a malfunction or temporary configuration problem with one component of the system.

Analyzing and clearing an alert, warning, error or enforcement takes time, during which an entire section of track could be halted. Clearing the enforcement may be a relatively quick process, but finding the root cause — particularly if the same issue pops up repeatedly — can be an imposing challenge. It requires a full understanding and complete picture of the train involved, the locomotive, the geography and the type of enforcement. This data may come in a variety of forms from a group of systems that may not be totally compatible.

**PTC ALWAYS ERRS ON THE SIDE OF CAUTION**

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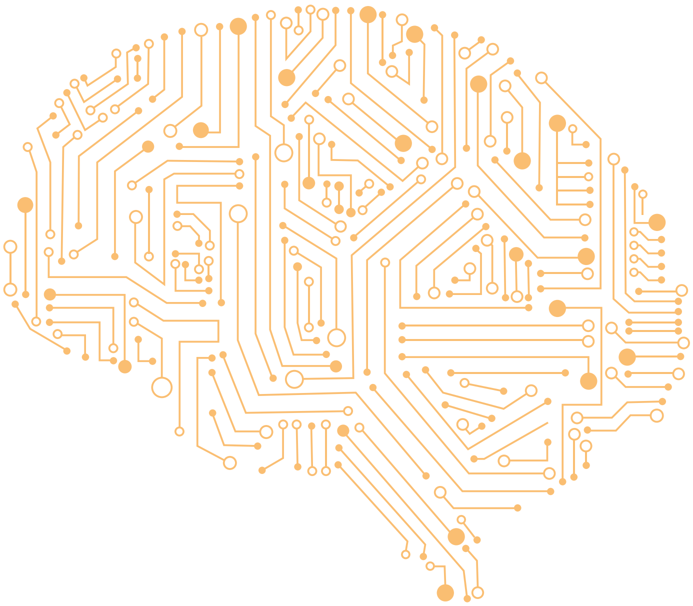
**IT BECOMES A SIMPLE MATTER TO DIRECT REPAIR AND MAINTENANCE CREWS TO THE MOST TROUBLESOME OR MORE IMPORTANT PARTS OF THE RAIL NETWORK.**

However, the deployment of this sensing and signaling equipment can also deliver an opportunity. These wayside sensors deliver a constant stream of data, which can be aggregated into not only a live view of the track, but also an analysis of historical conditions. By correlating this data with false PTC enforcements and providing a visual view of trouble spots, it becomes a simple matter to direct repair and maintenance crews to the most troublesome or more important parts of the rail network.

## CONTINUOUS PROCESS IMPROVEMENT



Through the use of machine learning algorithms, a complete analysis of the varied type of incoming data can be presented intelligently and efficiently. Once the problem is solved once, the lessons learned can be applied to other locations and situations. This takes the guesswork out of clearing a PTC issue and quickly gets everything back up and running while also indicating the type of work required to prevent a reoccurrence.

With this deep look into active operations, it is possible to make better decisions more quickly. This improves reliability and performance across the entire rail network from level 1 troubleshooters up to the engineering and design teams responsible for making the system run.

In some ways, the railroads are already doing the hard part – reworking thousands of miles of track to provide new data and new insights. Seizing the opportunity this data presents is the next step to more effective operations.

# CONCLUSION

From a regulatory perspective, Positive Train Control is intended to improve safety and avert loss of life and equipment. By the time the system is completely in place, the risk inherent in railroad operations will be reduced to historic lows.

At its most basic, PTC could be seen as a challenge to the smooth and consistent operations of a railroad. But it is actually an opportunity to gain greater insight and take more intelligent action based on a much wider set of data points.

The installation and operation of a wide range of wayside, signaling and on-board sensors is delivering an unprecedented look at railroad operations. Taking control of that data is a big challenge, but Digital Rail Works is a flexible tool that is built to understand data from disparate systems and present it in a flexible, actionable way.

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