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POSITIVE TRAIN CONTROL

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***Abstract*— Positive train control (PTC) is a modern system of monitoring and controlling train movements to provide advanced safety. This system uses the latest technology in mobile wireless communication. In Sept 2008, the US Congress considered a new rail safety law that sets a deadline of 2015 for implementation of positive train control (PTC) technology across most of the U.S. rail network. The bill was developed in response to the collision of a Metro link passenger train and a Union Pacific freight train Sept. 12 in California, which resulted in the deaths of 25 and injuries to more than 135 Metrolink passengers.**

***Keywords*---PTC(Positive Train Control), locomotive, GPS(Global Positioning System), TMC(Train Management System), control center, LoMA (Limit of Movement Authority).**

I. INTRODUCTION

A. Why signals are required?

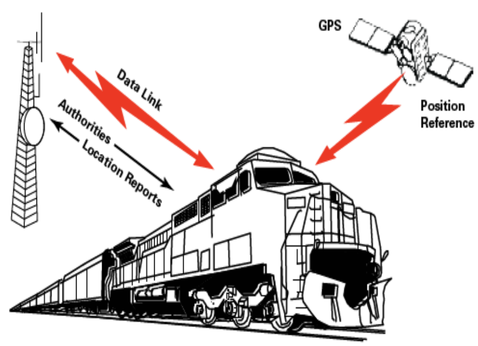
- To indicate to the driver his place of stopping.
- To protect train from collision with another train.
- To protect the level crossing gates.
- To protect the points (or to protect the trains at points).
- To improve the efficiency of train running.

B. The main concept in PTC is that the train receives information about its location and where it is allowed to safely travel. The following are the basic functions of PTC:

- To manage track occupancies through centralized route and interlocking logic
- Issue movement authorities via wireless data links to trains and work vehicles
- Determine the position of trains
- Enforce permanent and temporary speed limits
- Enforce Limits of Movement Authority (Lo MA) for trains

When deployed, PTC will provide interoperability between all the participating railroads. Trains from any railroad will be able to operate on the tracks of any other railroad, without ever losing contact with their own network operations center. There are several similarities between wireless PTC and automated air traffic control systems managing air traffic today.

Wireless PTC will provide a "safety shield" around all trains and other equipment to monitor the proper functioning of all existing signal systems, and human operation 20 of these systems. If existing equipment malfunctions or ceases to operate, or if human factors result in a potential safety/rules violation, PTC can immediately intervene slowing down or stopping one or more trains. PTC can replicate all signals and other critical information inside locomotive cabs, providing additional information to engineers.



In the future, wireless PTC may be used as the only vital signaling system, with no need for external block systems, signals or other equipment currently used in signaling systems. PTC can establish moving blocks around trains, providing sufficient separation between moving trains to ensure maximum track utilization. All signals will be displayed inside the locomotives.

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C. How safety is achieved by signaling?

Reason for train accident	How it is avoided by signalling
• Collisions of trains • Signals wrongly given by station master • Driver passes the signal at danger by mistake	• Separate the train by signals • Detect the train by track circuit • Provide automatic train protection(ATP) i.e. train brakes are applied automatically based on the signal aspect ahead
Derailment due to point not properly set	Lock and detect point and interlock with signal
Derailment due to over speed	ATP
Accidents at level crossings	• Provide gate signal • Provide ATP

II. FUNCTIONALITY OF PTC

PTC will directly support, monitor, control and include the functionality of:

A. Train Control: PTC will continually monitor trains, exchanging information with Train Management Computers (TMC) and gathering precise speed and position information from PTC will have a copy of train orders, number of cars, weight, route and track characteristics along the route, including speed restrictions, curves, grades and crossings. Track authority (permission to occupy and move on a sector of track) will be continuously updated as train dispatchers and train control computers at the network operation center issue and modify train orders and operate signals.

B. Track Circuits: In addition to information provided from track circuits PTC will provide dispatchers and train control computers precise, real time position of the train on the track. In "dark territory", where there are no track circuits, PTC will be the only real-time train location information source.

C. Signals: The aspect of all signals on the tracks will be to an onboard computer display showing all signals ahead of the train, including those that are not physically visible due to terrain, curves or visual distance. If a signal is not observed, PTC will immediately apply corrective action programmed for that event, from slowing down the train to a safe speed to the application of full emergency brakes to stop the train in the shortest possible distance. At the same time it will visually and audibly warn the engineer and report the event to the dispatcher and the train control computers.

D. Interlocking Systems: The PTC System will work with the dispatcher, train control computers and TMC to continuously monitor and identify potential conflicts between signals and switches, train orders issued to the train, and train orders other trains are using, authorized speed and maximum speed possible on that sector of track. If any conflicts or potential conflicts would be detected, PTC will immediately apply corrective action as programmed for that event, slowing down or stopping the train, and notifying the engineer, dispatcher and train control computers.

E. Wayside Equipment and Fault Equipment Detectors: All wayside equipment will be continuously monitored by PTC. PTC will issue alerts in cases such as when an automatic crossing gate is not working or a hot box detector reports some axles slightly above a certain temperature level. It will also apply corrective action in cases such as when a track integrity monitor reports a possible track breakage due to floods or extreme heat, or a hot box detector reports an axle in the train with a temperature exceeding safe operating levels, or a flood warning sensor detects the presence of water on the tracks.

F. Advanced Train Control Systems: Advanced train control systems can be indirectly queried by the wireless PTC system through the train management computer at the network operations center (ATCS and PTC radios are on different Radio Bands and each operates with its own protocol). This will be done as part of normal queries ahead and behind the train that PTC makes to track circuits, signals and switches, to enforce the interlocking principle as it was described above under "Interlocking Systems".

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III. Basic Operation

A typical PTC system involves three basic components:

- Equipment on the locomotive
- Equipment at the control center
- Bi-directional wireless data link between the train and the control center

Optionally, two additional components may exist:

- Wayside equipment
- Unidirectional data link between wayside equipment and train

IV. Equipment On The Locomotive

A GPS receiver on the locomotive receives position information. Alternatively, a transceiver is used to read transponders located on the track to locate the train's position. A data radio provides communications between the train and the control center and, optionally, with wayside devices. An onboard computer and display device displays information to the locomotive engineer (driver).

The equipment on board the locomotive must continually calculate the train's current speed relative to a speed target some distance away governed by a braking curve. If the train risks not being able to slow to the speed target given the braking curve the brakes are automatically applied and the train is immediately slowed. The speed targets are updated by information regarding fixed and dynamic speed limits determined by the track profile and signaling system.

Most current PTC implementations use the speed control unit to also store a database of track profiles attached to some sort of navigation system. The unit keeps track of the train's position along the rail line and automatically enforces any speed restrictions as well as the maximum authorized speed. Temporary speed restrictions can be updated before the train departs its terminal or via wireless data links. The track data can also be used to calculate braking curves based on the grade profile. The navigation system can use fixed track beacons or differential GPS stations combined with wheel rotation to accurately determine the train's location on the line accurately within a few feet.

V. Equipment At The Control Center

A data radio provides communications between the control center and the train. Microprocessor-based central interlocking equipment performs safety logic.

While some PTC systems interface directly with the existing signal system, others may maintain a set of vital computer systems at a central location that can keep track of trains and issue movement authorities to them directly via a wireless data network. This is often considered to be a form of Communications Based Train Control and is not a necessary part of PTC.

VI. Bi- Directional Wireless Link

A wireless communications link allows required data to be passed between the control center and train. A traditional point-to-point data link is a communications medium with exactly two endpoints and no data or packet formatting. The host computers at either end had to take full responsibility for formatting the data transmitted between them. When connected at a distance, each endpoint would be fitted with a modem to convert analog telecommunications signals into a digital data stream.

VII. How It Works- Basics

The train reports its position to the control center via the wireless data link. The control center's safety interlocking logic uses the data from all trains to issue limits of movement authority (Lo MA) and speed limits to each train, being careful to keep safe separation between trains. The train's onboard computer monitors the Lo MA and speed limit data against actual train location and speed to determine potential and actual unsafe conditions. If the train is approaching the end of its Lo MA or it is nearing its speed limit, the onboard computer warns the engineer, who is expected to take appropriate action. If the train passes the end of its Lo MA, the onboard computer automatically signals for a safety brake application to bring the train to a stop. Similarly, if the train exceeds its allowed speed limit, the brakes are applied to stop the train. The onboard computer also monitors various locomotive systems such as power and brakes, and automatically sends diagnostic and alarm data to the control center when appropriate.

The train may be able to detect the status of (and sometimes control) wayside devices, for example switch positions. This information is sent to the control center to further define the train's safe movements. Text messages and alarm conditions may also be automatically and manually exchanged between the train and the control center.

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VIII. PTC: TECHNICAL LIMITATION

Even where safety systems such as cab signaling have been present for many decades, the freight railroad industry has been reluctant to fit speed control devices due to the often heavy-handed nature of such devices having an adverse effect on otherwise safe train operation.

The advanced processor-based speed control algorithms found in PTC systems claim to be able to properly regulate the speed of freight trains over 5000 feet in length and weighing over 10,000 tons, but concerns remain about taking the final decision out of the hands of skilled locomotive engineers. Improper use of the air brake can lead to a train running away, derailment, or unexpected separation.

Furthermore, an overly conservative PTC system runs the risk of slowing trains below the level at which they had previously been safely operated by human engineers. Railway speeds are calculated with a safety factor such that slight excesses in speed will not result in an accident. If a PTC system applies its own safety margin then the end result will be an inefficient double safety factor. More over a PTC system might be unable to account for variations in weather conditions or train handling and might have to assume a worst case scenario, further decreasing performance. In its 2009 regulatory filing, the FRA stated that PTC was in fact likely to decrease the capacity of freight railroads on many main lines. The European LOCOPROL/LOCOLOC project had shown that EGNOS-enhanced satellite navigation alone was unable to meet the SIL4 safety integrity required for train signaling.

From a purely technical standpoint, PTC will not prevent certain low speed collisions caused by Permissive block operation, accidents caused by trains "shoving" in reverse, derailments caused by track or train defect, grade crossing collisions, or collisions with previously derailed trains. Wherever PTC is installed in absence of track circuit blocks, it will not detect broken rails, flooded tracks, or cars that have been left or rolled onto the line.

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