Positive Train Control for Heavy Haul Operations

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Summary: Positive Train Control (PTC) offers many safety and operational features that are designed to significantly enhance system reliability and network efficiency for heavy haul rail operations.

PTC is an emerging computer and wireless communications-based form of train control that provides operating instructions to trains. It is designed to supplement or replace conventional manual block or signaling systems. PTC does this through features such as moving block control, pacing, and enforcement of authority limits and speed restrictions. Dynamic, moving block operation is expected to improve operational efficiency by relieving many of the artifacts of traditional fixed block signaling such as excessive train spacing. Pacing reduces congestion and plan execution uncertainty by tightly controlling the flow of trains within the rail network. Compliance with authority limits and speed restrictions will be assured by automatic onboard warnings backed up by enforcement braking to avoid safety hazards before they occur. Highly accurate onboard location determination and reporting via mobile data radio will support all of the above functions while providing useful, up-to-the minute information to central office personnel.

PTC is intended to provide incremental improvements in train control through a modular design. A manual block system may be enhanced progressively by replacing voice and written authorities with data transmission and authorities displayed in the cab, then adding power switch control and later adding enforcement, for example. Thus, if the goal of a heavy haul operator is to improve the performance and reliability of the operation, PTC offers a way of achieving it.

This paper describes the principles underlying PTC, compares PTC with conventional train control systems, discusses the expected benefits of PTC, and explains how the architecture will permit incremental levels of train control. This paper focuses in particular on the PTC system being developed by the North American Joint Positive Train Control (NAJPTC) project.

Keywords: Train Control, PTC

1.0 CURRENT TRAIN CONTROL TECHNOLOGIES

Train control systems have evolved into the two different forms of control currently in common use:

Manual Block Systems (MBS) are used on lighter density lines. In these systems, authorities may include safety checking by a computer-aided interlocking performed in an office, with authorities subsequently being transmitted by voice radio to the crew using an established form. The train crew copies each authority as it is being dictated, and then repeats the authority back to the dispatcher to ensure that it was copied correctly. The authority takes effect when the dispatcher okays the authority as correct. Authorities issued in this way are referred to as Forms-based Authorities, and can take up to five minutes to issue.

In these systems, switches at sidings where trains meet are typically hand-operated by a member of the train crew. As long as the train density is low enough and the route is short enough that train meets are infrequent, an authority can often be issued for the entire route. In such cases, the operational efficiency does not suffer too much. However, when traffic levels are higher such that trains must frequently meet, train delay to receive new authorities and to set the switches manually can increase significantly.

Centralized Traffic Control (CTC) systems are used on heavier density lines. In these systems, authorities to operate are verified to be safe by track-circuit-based interlocking, with authorities being conveyed by wayside-based signal aspects.

In these systems, switches at meeting points and junctions can be remotely set by dispatchers. The signals are interlocked with the switches to ensure that the correct signal aspect is displayed. Broken rail detection is a by-product of the track circuits.

Cab Signaling is an alternate form of train control in which the wayside signals are supplemented with, or replaced by, in-cab signals. These systems generally provide for enforcement of authorities, and a limited level of enforcement of speed limits.

1.1 Emerging Train Control Technologies

PTC is a form of communication-based train control that builds on the best features of manual block systems and signal-based systems. It is designed to perform the operating and business functions of the current train control technologies, but is expected to do so more efficiently, safely, reliably, and cost-effectively. It also can perform additional beneficial functions that current train control technologies do not. Generally, PTC must perform these functions while fitting in with a wide range of legacy systems.

The term "Positive Train Control" carries with it the connotation of enforcement of authorities and restrictions, as the U.S. Federal Railroad Administration (FRA) defines it. For purposes of this paper, however, we shall use the term to mean any combination of "functional building blocks" described in this paper.

New systems face the challenge of being implemented with a wide range of different capabilities, from a simple system that might only provide enforcement features or display of authorities to full-up systems capable of performing extensive safety and operational functions. The challenge is to define functions as individual functional modules that can be assembled in building block fashion in such a way that a locomotive designed to operate in one territory can still exercise some level of PTC functionality in a different territory, with some differences in system capability.

A PTC system is being implemented on 123 miles (198 km) of the Chicago, Illinois-St. Louis, Missouri passenger and freight corridor. Testing for the first phase was successfully completed in October 2002, and the system is to be ready for revenue service around the end of 2003. This project is sponsored jointly by the Association of American Railroads (AAR), the US Federal Railroad Administration (FRA) and the State of Illinois Department of Transportation (IDOT).

2.0 POTENTIAL BENEFITS OF PTC

PTC is expected to improve the efficiency of railway operations by reducing over-the-road delays, improving the consistency of running time, increasing track capacity, increasing network velocity, reducing fuel costs, reducing congestion, and improving the overall use of railway equipment and other assets.

Key to the success of new train control technologies will be the ability to apply only the level of train and track force monitoring and control required for the type and level of operation on a particular territory; however, systems should be designed and implemented in such a way that, as traffic is added or new performance requirements are identified, additional functionality can be added to what is already there.

The importance of having a common approach to the application of PTC technology cannot be over-emphasized. Lighter density routes may not need all the functionality of heavier density routes. However, trains that operate over the lighter density routes generally operate over the other routes as well. These systems must be compatible (intra-operable) but not necessarily identical; otherwise, the operator will need to have different onboard systems for each route over which they operate — an untenable situation.

2.1 PTC Features of Interest

This section examines the various features of PTC and identifies how they contribute to the key planned benefits.

2.2 Real Time Location Reporting

Equipped locomotives report their exact location to the central office server at regular intervals: once a minute, or more frequently if required in areas of high traffic density or upon occurrence of specific events, such as train stop. This data is central to the operation of the PTC system and provides more precise and timelier information to the train dispatcher and to dispatch systems on train location than is available in present systems.

This will allow improved decision logic to be applied to meet/pass decisions, which in turn will result in reduced running times, more consistent running times, and reduced fuel consumption for trains waiting for less than optimally planned meets.

2.3 Onboard Display of Authorities and Restrictions

The display of all movement authorities, speed limits, and restrictions in the locomotive cab will minimize the possibility of misinterpretation or misunderstanding of instructions. This is primarily a safety benefit, but in territories controlled by Manual Block Systems, significant operational improvements are possible also, as the time associated with the voice communications of instructions can be largely eliminated.

2.4 Enforcement of Authorities and Restrictions (Positive Train Control)

The closed loop enforcement of movement authorities, speed limits, and restrictions protects against human error, and is a further safety benefit.

2.5 Train Pacing

Pacing is the function of providing instructions to a train to operate at a more efficient speed (never greater than the applicable speed limit) towards a point where a stop would otherwise be required. This is made possible by a more precise knowledge of train location combined with an improved ability to predict train progress. It has been estimated that, in single-track operations, a 3 to 7 percent savings in fuel is possible. Railroad traffic congestion can be reduced as well (e.g., around areas such as yards, mines, and ports).

2.6 Moving Block Operation

PTC is being designed to support the safe and reliable implementation of Moving Block operation.

In double or multiple track corridors controlled by CTC, there are two ways of increasing capacity: reduce the spacing between trains or build additional main tracks. On many territories, reducing signal spacing is not a viable option and adding main track, while viable, is a costly, disruptive, and time-consuming option. We believe that the use of PTC superimposed on or in place of the CTC system currently in place will be a cost-effective alternative.

PTC and conventional signalling are similar in that they both provide authorities to a train crew to occupy a segment of track. They differ in the way that the authority is managed. In PTC, the train will report its position in small time increments (about one minute intervals, or more frequently if required). Where one train is following another, each time the first train reports its new location, the authority of the second train can be updated by whatever distance the first train has reported to have advanced. This is known as Moving Block or Flexible Block train control. Train spacing depends on the braking characteristics of the following train, which means that slow moving and/or lighter trains will be able to operate more closely than fast moving and/or heavier trains.

In contrast, in conventional signalling, the train receives its authority from wayside signals at fixed intervals along the route. At a rudimentary level, there may be three possible signal indications (aspects): *Stop*, *Stop at the next signal,* and *Clear*. In typical operations, a locomotive engineer will operate with at least two signal blocks between the rear of the train ahead and the front of his train. The distance between fixed signals is dependent on the worst braking train, and the distance between trains is constant regardless of speed (when operating at greater than restricted speed).

A major advantage of moving block is that train headway (*time* between successive trains) is almost constant regardless of speed, in contrast to fixed block where the *distance* between trains is governed by signal spacing. This is illustrated in Figure 1 for a 6,600-foot train with 1.5-mile signal spacing.

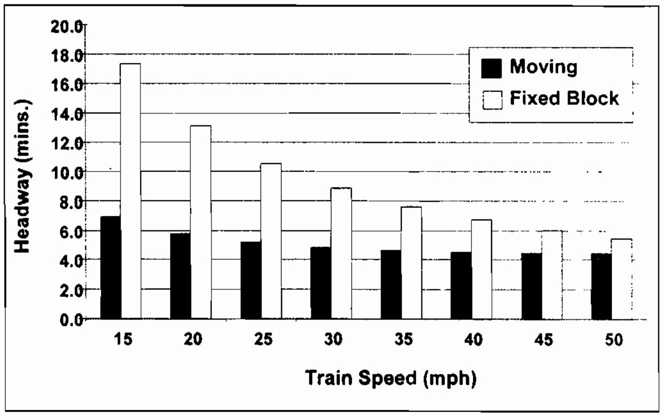

Figure 1. Comparison of Headways – Moving vs. Fixed Block

Moving block will permit more trains of differing consists to operate in multiple track territory than a fixed block system. Indeed, moving block will provide additional capacity on single-track territory at critical times.

The most critical time on a high traffic density, single-track line occurs when major track renewal must be undertaken such as during undercutting and re-ballasting or rail change-out. Frequently, for such work, the track must be taken out of service for some hours, perhaps a temporary speed restriction will be placed on the affected track, and a siding may have to be used (taken out of service) for storing the work equipment between work shifts. All this activity takes up a significant portion of track capacity — 50 to 75 percent has been measured. Many heavy haul operations do not have the luxury of alternate routes for diverting trains during such work.

Moving block will permit trains to be fleeted past the work area at close headways following a work shift, thereby returning to normal operation in much less time than with legacy systems.

2.6.1 Locomotive control of switches

Locomotive control of switches can be provided to train crews for the remote control of power-operated switches during switching moves currently controlled by dispatchers or manually by train crew members on the ground. It has been estimated that this will save about 20 minutes per occasion when such switching is performed. This reduces train transit times and has an associated fuel savings benefit.

2.6.2 Handling of Non-Equipped or Non-Communicating Trains

PTC is specified in such a way to accommodate trains that are not equipped with the PTC equipment or for which the PTC equipment has failed (collectively referred to as "non-communicating trains"). That means that freight railways will not be forced to equip a large percentage of their locomotive fleet for early implementations covering only a small percentage of the network. Keeping locomotives captive to a small territory can be costly.

2.7 Highway/Rail Interface

The highway/rail interface (HRI) can provide an interface to Intelligent Transportation Systems (ITS) and make it possible to provide additional warning to ITS-equipped high-risk vehicles, such as school buses and trucks carrying dangerous commodities, of the approach of a train at a crossing. This benefit will be most significant on routes where close to 100 percent of the trains are equipped.

In Illinois, "advanced activation" by PTC of crossing warning systems with constant warning time is being implemented. Rather than extending track circuits at crossings provided with conventional warning systems to accommodate high-speed trains, the crossings systems will be activated by a radio signal from the train.

3.0 BASIC CONCEPT OF PTC

3.1 Description of PTC

Conceptually, PTC technology is straightforward. There is a communications network consisting of a communication manager and a number of radio base stations and onboard radios. This network will pass information between a train control computer application on the locomotive and a train control computer application at some central or wayside site, as illustrated in Figure 2.

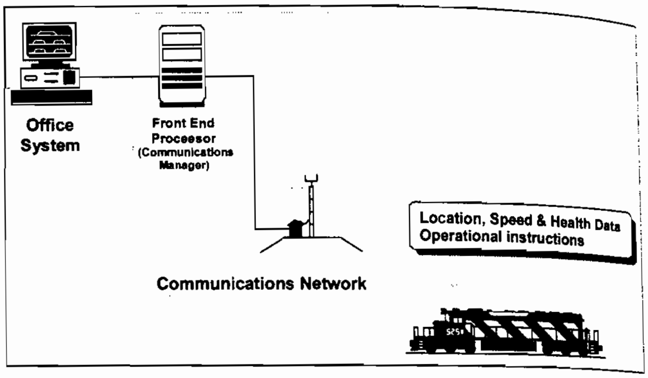

Figure 2. Basic Concept of PTC

At the most basic end of the scale, the train control application can be used to pass authorities to locomotives for display in the cab, in which case the office system would include the dispatch system. The office system is shown in more detail in Figure 3.

An example of a more business-oriented application would be a system on board the locomotive that could identify where it is and how fast it is moving. This information can be passed through the communications network to the office system, where it can be used to track assets. Additionally, the train location information can be compared with expected results, such as a timetable or last reported position. It then can be tied in with a train scheduler to plan optimal meets and passes, and fed back to trains in the form of pacing commands to allow trains to move towards meets at a more fuel efficient speed. The system on board the locomotive can also enforce the limits of authority sent by the office system; if it has the relevant permanent and temporary speed restrictions, those can also be enforced. Once there is a locomotive computer that can enforce authority and speed restrictions, train operation can be simplified.

The communications network design can be one of a number of technical offerings, from an operator-owned system following specifications prepared by the rail industry, to public networks which charge by the packet. Each system has its own operating and performance characteristics, and what is chosen will depend on the operator's performance needs, and the economics of each particular application.

One of the advantages of the railway-industry ATCS (Advanced Train Control Systems) communications is that the system was designed with message priorities, so that high priority train control messages can co-exist with lower priority administrative messages, but be handled more expeditiously. There are six pairs of frequencies that have been assigned in the U.S. and Canada exclusively for railway use, and particularly for train control. The frequencies are in the 900 MHz band, and the costs of such equipment are dropping as more equipment is fielded.

Regardless of the choice of communications network, a mobile addressing standard is central to being able to reach a l6comotive wherever it may be in North America.

Once a communications network linking onboard and stationary computers is in ~~place,~~ a number of other functions can be provided with little effort. For example, with train position and progress known more accurately, there can be better planning of track time for track maintenance forces. And if the track forces are given PTC terminals, they can get access to the track more quickly by requesting and receiving their instructions by data rather than by voice. Furthermore, they can provide more timely feedback on track conditions by reporting back through their terminals. Similarly, application or removal of temporary slow orders can reach the end user (the locomotive engineer) almost instantaneously by sending the information as data to a central office where it would be distributed to locomotives that need it.

3.2 Architecture of PTC

There are five physical subsystems in the architecture of PTC, not all of which are required for certain implementations. These are the office system (comprised of the Dispatch System and the PTC Server, which may alternatively be distributed along the wayside), the wayside systems (which may include signals), locomotive systems, and roadway worker systems. Together, these subsystems constitute a distributed system. These are linked through a communication network. Figure 3 illustrates the architecture of a typical system, with the systems being divided into onboard and off-board elements.

While this is a generic architecture, there may be implementation-specific variations on the overall concept. For example, the roadway worker system is optional. Implementations do not require the wayside subsystems if there are no field installations such as power-operated switches to monitor – this could be the case if a railroad only wished to replace voice authorities in form-based train control territory with data authorities displayed in the locomotive cab. A railroad could elect to have the server function distributed in the field (e.g., along the wayside) rather than maintaining the function in the office.

In current operations, the **Dispatch System** is central to the control of trains. In CTC territory, the dispatcher requests switch and signal settings through the dispatch system which are relayed (dotted line in Figure 3) to the field for verification. When forms-based authorities are used in CTC territory, the dispatch system typically provides checks that the requested authority is valid before it is issued. Restrictions are either handled by the dispatch system or an ancillary system, and are transmitted to terminals for distribution to train crews at their initial terminal. Updates are transmitted to trains en route by voice radio. Under PTC, the dispatch system will continue to be the interface between the dispatcher and train control. The dispatch system may be capable of automatic routing or movement planning. In that case, the dispatcher's role is primarily to handle exceptions.

The **PTC Server** is linked to the dispatch system and receives all authority requests, whether in the form of route and signal requests or forms-based requests. It will generate, maintain, and distribute Movement Authorities (MAs) to all equipped trains as data authorities to be displayed in the locomotive cab. This is a continuous display that reduces the opportunity for forgetting or misinterpreting the instructions. Where integrated with a CTC system, the server may issue authorities in such a way as to match the limits of authority as conveyed by indications of the wayside signals, and to ensure that there is no overlap between individual authorities. Location reports from the equipped locomotives are used to monitor train progress and release Movement Authorities as necessary. The server can obtain status of field devices through the communication network.

The PTC server will also maintain route characteristics and permanent speed restriction files for transmission to the controlling locomotive of trains. Temporary restrictions will also be received, maintained, and transmitted to the locomotive computer. This data is required for display of permanent and temporary speeds to the locomotive crew for enforcement, if required, and route characteristics are used for onboard location determination.

The **Locomotive System** is comprised of:

- A locomotive computer,
- One or more data radios, (labeled R1, R2, R3 in the figure),
- A location determination system (LDS),
- A locomotive ID unit, and
- A display with limited function keypad (optional).

If a railroad elects to have more than one radio network, the management of which radio to use at any particular time is performed through an onboard Communications Management Unit (CMU). If only one radio network is used in an implementation, the radio can be linked into the onboard local area network (LAN) or directly to the locomotive computer. The provision for multiple networks permits a different network to be used on different territories, if desired, or in areas where RF coverage varies. For example, on a light density line, a railroad may choose to use APCO-P25 radios for both PTC and voice so as not to have to install two different radio networks — one for voice and one for data.

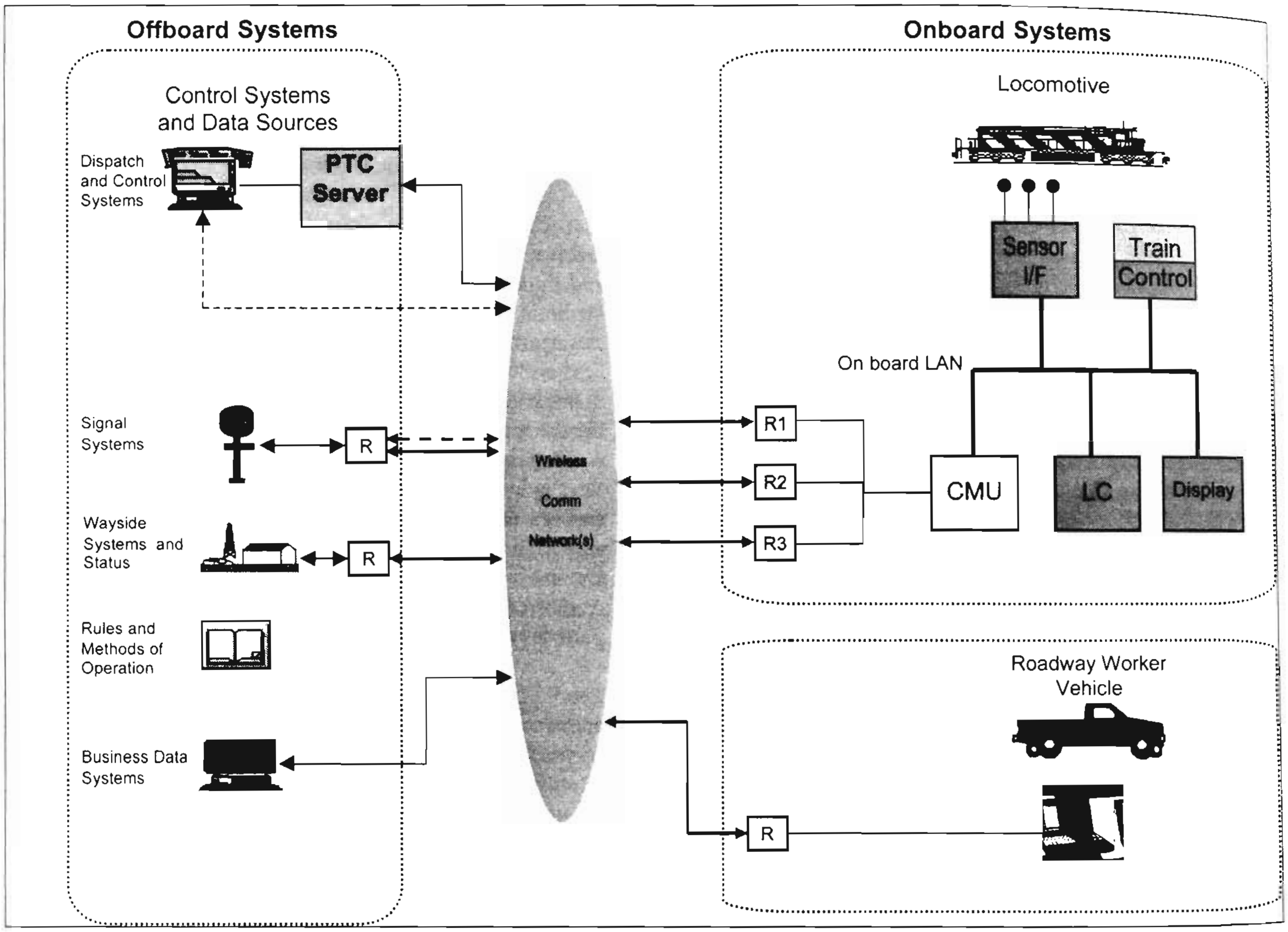

Figure 3. PTC System Architecture

The locomotive system will determine the train's position with respect to its movement authorities and allowed speeds, and will trigger enforcement to stop the train before violating a movement authority. It will also prevent violation of speed limits. Movement authorities will be enforced by determining the Safe Braking Distance (SBD) of the train from the limits of the authority and monitoring the train's position relative to the current SBD. Before enforcement is invoked, the Onboard Computer (OBC) will provide a visual and audible warning to the crew. Should the crew ignore the warning, the brakes will be applied automatically to stop the train. The Locomotive System also transmits train location reports from the LDS regularly to the PTC server.

The primary function of the **Work Vehicle System** is to provide the capability for a track maintenance foreman to communicate with the central dispatch system and other vehicles via the data communications system. This can be used to receive and display Movement Authorities, and/or to request and release Temporary Speed Restrictions. Only one radio frequency is shown, as roadway worker vehicles generally do not move off their assigned territory.

The **Field Systems** are designed to provide remote monitoring and, in some cases, control of wayside devices through Wayside Interface Units (WIU). There are four types of WIUs:

Control Point WIUs interface with controlled switches and signals to monitor their status (position and aspect, respectively) and health and to provide that information to the PTC Server. In addition, they control the switches and signals upon requests from the dispatch system and/or commands from the PTC server. They also provide information on the occupancy of associated track circuits for the purpose of tracking non-communicating trains ~~(those~~ without active PTC equipment) and detecting broken rail.

Intermediate Signal WIUs interface with the associated track circuits (if present) to provide occupancy status of track circuits between intermediate signals. This will allow the system to distinguish between train occupancy and broken rail or other route integrity problems. These also provide input to the Server to permit the tracking of non-communicating trains.

Train Defect Detector WIUs interface with Defect Detectors (e.g., hot box, dragging equipment, etc.) so that detector information can be transmitted directly to the train and displayed in the locomotive cab.

Highway Crossing WIUs interface with the activation mechanism of the crossing warning system to provide a capability for higher speed trains to activate the warning at the appropriate time without requiring costly extensions to the present track circuits.

The fifth system — and the PTC backbone — is the **Data Communication System,** which ties the various information processing systems together. The function of the communications system is to ensure that components of the PTC system are able to communicate with each other when required. Figure 4 illustrates the architecture of the communication system.

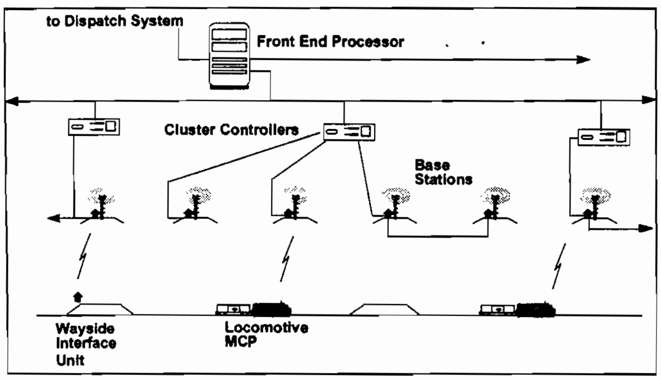

Figure 4. The Data Communications Network Backbone of the PTC System.

The Dispatch Subsystem/PTC Server and the Front End Processor (FEP) are connected, through the terrestrial network, with a number of radio base stations located at different points throughout the PTC territory. For large networks, a lower hierarchical layer of routers, known as Cluster Controllers (CC), is used between the FEP and the base stations. Part of the FEP/CC routing process is to measure signal strength of incoming calls from each field device to determine which base station, known as a Base Communications Package (BCP), is most appropriate for outgoing messages to that device. This includes tracking of vehicles. The BCPs will communicate, through the Radio Frequency (RF) network, with individual locomotives, track maintenance vehicles, and wayside devices.

Locomotives, track vehicles, and wayside devices are equipped with Mobile Communication Packages (data radios) that provide the interface between the respective computer system and the radio network and hence the office systems.

4.0 PTC FUNCTIONAL BUILDING BLOCKS

PTC was conceived as a modular system so that a railroad can implement only those features needed for a specific route or application. The key building blocks or functional modules are described in the following sections.

4.1 Location Tracking

The role of this module is to track and report train location and speed with great precision. This information is needed to support some of the other PTC modules. It can also be used in a stand-alone manner such as to make accurate predictions of train arrival times at required locations for operations management purposes.

The module can also be used to make better meet/pass decisions to reduce train delay and to provide shorter and more consistent transit times. For this benefit to be achieved, there must be a corresponding meet/pass algorithm in the dispatch system in addition to the Authority Management module.

Other potential users of train tracking are passenger or commuter operations that can use the information for passenger information systems.

Another potential application of tracking is for roadway worker vehicles, which would use the system for determining that they are accessing the track within their authorized limits. In such an application, the roadway workers would be shown the milepost on their Roadway Worker Terminal display when they are adjacent to or on the track. This is a safety benefit rather than a productivity benefit.

4.2 Speed Management

This module comes in two parts. The first is the management and display of permanent speed limits. The second is the management and display of bulletined restrictions; that is, Temporary Speed Restrictions and Maintenance-of-Way Protections.

Speed Management would not be a stand-alone module, but would always be used in conjunction with the Location Tracking module. The premise of this module is that trains are less likely to operate over speed if train speed is continuously displayed in conjunction with permitted speed. The primary benefit of this module is safety, but there is an element of commercial or productivity benefit in that, if trains are operating more closely to design speed, less track maintenance will be required.

4.3 Authority Management

This module will perform the functions of receiving authority requests, verifying that they are safe to issue, transmitting them to the addressed train OBC or roadway worker terminal, and canceling them when they are fulfilled or on dispatcher request when it is safe to do so.

There are both safety and commercial benefits for this module. The safety benefits will come from two key features:

- The continuous display of authorities that will all but eliminate the possibility of forgetting the instruction. Accidents have occurred because train crews have forgotten what the last signal was or what the written instruction is. It protects against a crew reading a signal meant for another train as one intended for them.
- The unambiguous display of authorities. In manual block territories with forms-based authorities, the ability to miscommunicate the authority will be all but eliminated by replacing voice communication with data.

The commercial benefits will depend on the type of implementation.

When used in conjunction with the predictive capability within the Location Tracking module, it should be possible to provide significant improvements in Roadway Worker productivity. Their productivity can be impaired due to the time it takes them to get access to the track — dispatchers may make very conservative decisions to allow access to the track when they do not know the precise location of a train, so that the train is not delayed.

Time spent transmitting and repeating authorities by voice can also be saved with the Authority Management module.

4.4 Warnings and Enforcement

Warnings and Enforcement will primarily provide safety benefits, although some reduction in track maintenance can be expected if trains are encouraged (warnings) or enforced to observe speed limits and restrictions. This module requires the Location Tracking, Speed Management, and Authority Management modules to be in place.

4.5 Route Integrity Monitoring

The Route Integrity Module is one that monitors the status of power-operated switches, hand-operated switches including electric locks, slide fences, high-water detectors, and other such route integrity devices. This module requires the location-tracking module in order to be effective.

The benefit of this module is entirely one of improved safety. It is most likely to be implemented as part of a larger system, but it is not inconceivable that the module would be implemented in Manual Block System territories to monitor selected manual switches as an alternative to installing a CTC (signaling) system or some other form of control system.

4.6 Power Switch Control

The power switch control module will provide the capability of controlling the power-operated switches either from the office or from the locomotive. The benefits of this module are entirely in terms of productivity.

The benefits of having switch control in manual block territories, where the switches have been manually operated, is the reduction of time when the train has to stop to line a switch before using it. The saving is about 10 minutes if the train crew is permitted to leave the switch reversed for the next train crew, or at least 30 minutes if the crew is required to re-line the switch after using it. This provides both a gain in capacity and a reduction in running time.

The benefit of having locomotive switch control for switching purposes in CTC is that the locomotive engineer no longer has to wait until the dispatcher has time to perform the switch-tending duties. This applies at locations where switches are powered such as intermediate yards. It has been estimated that this could result in a savings of 20 minutes per work location.

4.7 Pacing

The Pacing module will provide the ability to instruct trains to operate towards a point of potential conflict with other trains at a slower speed such that, by the time it gets there, the conflict is resolved and the train does not have to stop. It has been estimated that there could be a fuel savings of between 5 and 10 percent of the total fuel bill if this module is implemented on a wide-scale basis. It is more likely in the 3 to 7 percent range.

Pacing can also reduce congestion and can reduce variability in service time.

This module requires the location tracking function to be in place, and it also requires some additional functionality in the dispatch system above that currently implemented in most systems.

4.8 Highway Crossing Activation

The primary use of this system in the short term is in corridors where high-speed passenger operation is planned. It is a cost reduction strategy, as the incremental cost of including this module should be less costly and less complex than having to extend the circuits of the track-circuit-based technology in use today.

4.9 Train Defect Monitoring Interface

This module interfaces to train defect detectors to provide digital messages to equipped trains on the status of the rolling stock. Generally, these have been designed as talkers that provide "voice" messages over the radio. These talkers have no "listen-before-transmit" feature, and occasionally interfere with normal voice communications, and can drown out "Stop" commands. As the TDD message is only broadcast once, a train crew can either miss or forget the message. In urban areas, where there may be a number of TDDs that can be heard from nearby subdivisions, the frequent broadcasts can be a nuisance factor.

The primary benefit of this module is safety, but if the system is combined with an Automatic Equipment Identification system that will provide car number instead of axle number in the train, there is potential for productivity improvement as the train crew is more likely to find the offending car the first time. The productivity benefit is small, and would generally not justify putting in such as system except as an add-on. Additional benefits may be obtained by also routing the radio reports of defect detector data to the office for doing trend analysis in support of reliability-centered maintenance.

5.0 POTENTIAL MIGRATION PATHS

Heavy haul operations take place on all types of territories – Manual block, CTC with wayside signal, and CTC with cab signals. PTC can be used to advantage on all three types of territories. The following paragraphs discuss examples of potential applications and benefits of PTC as migrating from the legacy system.

5.1 Manual Block Territories

In manual block territories, an authority can take 3 to 5 minutes to issue by the time it is read and copied, read back and okayed. Digital transmission and display of the authority should take only a few seconds, leading to a significant reduction in the delay to trains and roadway workers, a significant reduction on over-the-road time for trains and for track patrols, and reduced dispatcher workload. This can also result in an increase in the capacity of the line; that is, more trains being over the line before significant plant upgrades are needed. Thus, one potential step is to use Authority Management alone, and to display the authorities in text on a locomotive display.

Alternatively, one could apply the Location Tracking feature coupled with Authority Management. This has the advantage of feeding back to the dispatch office the location of the train within the authority issued. It adds a level of safety in that it will become possible to detect when a train approaches (or exceeds) its authority limit, and to provide predictive (or reactive) enforcement of authorities. Typically, this level would include the Speed Management module and may also provide automatic roll-up of authority behind the train.

The next level of sophistication would add power control of switches. Protection against broken rail through the use of track circuits is optional. There would be some form of occupancy detection at switches, but approach locking can be provided by the PTC system. The key advantage for this level is that the significant delays required by the manual operation of switches when meeting other trains are eliminated. This will have the effect of reducing transit time and increasing capacity.

Other modules, such as Route Integrity Monitoring, Pacing, Train Defect Monitoring Interface, or Highway Crossing Activation can be added whenever the Speed Management module is present.

As long as the number of locomotives to be equipped does not govern the cost of installation, it is expected that PTC can be installed at less cost than CTC.

5.2 CTC Territories

A typical first level of application in CTC territories is location tracking alone, as it provides more precise train tracking than track circuits. The more precisely train location is known, the better dispatching decisions can be made — both for train meets and overtakes and for providing track time to track maintenance forces.

With an improved knowledge of train location, Train Pacing can be added for fuel savings and other business benefits.

CTC provides many of the same functions as PTC, but a value added by PTC in high-density territories will be the ability to go to moving block operation, which adds to the capacity of a route.

An alternative scenario is for PTC to replace a CTC system that has outlived its economic usefulness.

5.3 Cab Signal Territories

Cab signal systems provide an element of speed control, but they are rather inflexible for the application of temporary speed restrictions and protection of maintenance of way forces. In those cab signal systems that include enforcement, absence of the signal in the track only enforces the upper limit of restricted speed.

Besides enforcing train separation even at restricted speed, a key advantage of PTC in Cab signal territory is to fill the gap in applying temporary speed restrictions and maintenance of way protections by using the Speed Management module in conjunction with the Location Tracking module.

Other migration paths will also be possible besides the above examples.

6.0 WHY DO WE RECOMMEND PTC FOR HEAVY HAUL APPLICATIONS?

First and foremost because of the flexibility of implementation afforded by the technology. The modular architecture is designed to allow railways to select, purchase, and install PTC components in a pattern that fits their current rail plant and equipment infrastructure conditions, capital improvement and maintenance spending plans, and not least, safety enhancement efforts. PTC's building block approach is designed to provide a variety of migration paths from a simple train control system to one that provides added functionality progressively through a number of steps, each one being a useful system in its own right, and this without having to redo or throw out large portions of the prior system.

Indications are that choice of PTC technology will provide additional benefits over conventional signalling when increasing rail capacity: reduced need for additional track, creating less environmental impact and less disruption for operations and for those living in areas where such expansion would take place, and more predictable operations not only because of a more precise knowledge of train location but also because of an ability to detect and correct faults and equipment failures earlier than with current systems.

Further, train pacing has the potential not only to reduce fuel consumption – an environmental benefit, but also to reduce congestion and lead to greater customer satisfaction as there will be fewer occasions when trains will have to make unscheduled stops.

7.0 NAJPTC PROJECT TEAM

The NAJPTC project is funded jointly by the Federal Railroad Administration (FRA), the Association of American Railroads (AAR), and the Illinois Department of Transportation. The prime contractor providing project management is Transportation Technology Center, Inc. (TTCI), a wholly owned subsidiary of the AAR. The system engineering effort is led by ARINC, including team members CANAC, Battelle and Parson Transportation Group (PTG). The System Developer/Integrator is the Lockheed Martin team, which includes Wabtec, Union Switch and Signal (US&S), Parsons-Brinckerhoff, and the University of Virginia.