Amtrak

Signal and Train Control Systems

PRACTICAL PTC

On Amtrak Owned Property

November 20, 2008

AMTRAK®

PRACTICAL
POSITIVE TRAIN CONTROL
on
Amtrak

ACSES / ATC in the Northeast Corridor
+
ITCS for the Emerging Corridors

AMTRAK®

PRACTICAL
POSITIVE TRAIN CONTROL
on
Amtrak

Developed Incrementally
Building Block by Building Block

AMTRAK®

Signal and Train Control in the Northeast Corridor

- **The Northeast Corridor (NEC) is the safest main line rail corridor in the USA.**
- **Amtrak trains safely operate at speeds up to 150 mph on the same tracks with commuter and freight trains.**
- **Safe operation is made possible through our signal and train control system.**
- **Our Automatic Train Control (ATC) system provides a level of protection far superior to a stand alone wayside signal system.**
- **ATC is a combination of our Cab Signal System (CSS) w/ Speed Control (SCS), developed incrementally over a number of years (CSS + SCS = ATC).**
- **All trains operating on the NEC are required to have ATC operating and fully tested before being dispatched.**
- **Our Advanced Civil Speed Enforcement System (ACSES) provides an additional layer of protection in the highest speed portions of the NEC.**
- **Developed Incrementally: ATC + ACSES = PTC.**

Automatic Train Control (ATC)

- What is ATC?
  - **ATC is a continuous cab signal system with speed control based on vital (fail-safe) discreet codes through the rails to the front of the train, providing broken rail detection and immediate notification of changed conditions ahead.**

- What ATC Provides:
  - **Enforcement of speeds associated with wayside signal aspects.**
  - **Enforcement of speeds through turnouts and crossovers.**
  - **Speed enforced down to "Restricting" (20 mph) approaching a "Stop Signal".**
  - **Safe train separation (prevents rear end collisions).**
  - **Requires acknowledgement, with speed reduction when required, each time cab signal goes to a more restrictive aspect to avoid a penalty brake application.**
  - **Very Secure & Reliable with transmission of codes through the rails.**
  - **More Secure & Reliable than data transmitted 100% through wireless networks.**

Automatic Train Control (ATC)

- While the ATC system is very effective at preventing accidents,
  it does not provide all the protection
  that a full Positive Train Control System (PTC) provides.

- What ATC does not provide:
  - **Enforcement of Maximum Authorized Speed (MAS).**
    - **ATC does not enforce MAS speeds below 125 mph in territories where lower speed maximum speeds are in effect.**
  - **Enforcement of a Positive Train Stop (PTS).**
    - **The cab signal system enforces a speed reduction to 20 mph, and requires acknowledgement approaching a stop signal, but it does not actually enforce a positive stop.**
  - **Enforcement of Civil speed restrictions.**
    - **The cab signal system does not enforce permanent speeds restrictions on curves or over bridges, nor does it enforce temporary speed restrictions (slow orders).**

Advanced Civil Speed Enforcement System (ACSES)

- What is ACSES?
  - **ACSES is a transponder-based overlay system that works with the ATC system to provide Positive Train Control.**

- What ACSES Provides.
  - **Enforcement of Maximum Authorized Speeds (MAS).**
  - **Enforcement of civil speed restrictions (speed restrictions on curves, etc.).**
  - **Enforcement of temporary speed restrictions (slow orders).**
  - **Positive Train Stop (PTS) enforcement at Interlocking Home Signals.**
    - **Prevents a train from running a stop signal into the path of another train. at Junctions called Interlockings.**

- Together ATC and ACSES provide Positive Train Control (PTC).
  - **They mitigate train to train collisions, over-speed derailments, incursions into roadway worker working limits, and monitor all switch positions in the path of each train.**

ATC + ACSES Installation Base

- ATC is installed on the entire Northeast Corridor [1486 Track Miles]:

  Washington to Boston,
  Including the Connecting Corridors,
  Philadelphia to Harrisburg, PA, and
  New Haven, CT to Springfield, MA.

- ACSES is installed at the following locations [435 Track Miles (29.3%)]:

  - **New England (337 track miles):**
    New Haven to Boston - all trains equipped.

  - **New Jersey (44 track miles):**
    New Brunswick (MP 32.8) to Trenton (MP55.7)
    on Tracks 2 & 3 (high speed tracks) -
    only Amtrak trains equipped.

  - **Delaware & Maryland (54 track miles):**
    Wilmington, DE (MP29.7) to Perryville, MD (MP 57.3)
    on Tracks 2 & 3 (high speed tracks) -
    only Amtrak trains equipped.

ACSES Delivery of Temporary Speed Restrictions

- Full PTC also requires delivery of Temporary Speed Restrictions (TSRs)
  from the Dispatchers' Office to individual trains.

- This requires a wireless network to convey the TSRs
  from a Safety TSR Server (STS)
  to each individual train upon request by the train
  as it approaches each point of restriction.

- There is also a "select-check-execute" link
  between the Dispatcher and the STS
  to ensure that all required TSRs are available in the STS
  when queried by trains approaching each zone.

- The Data Radio TSR Delivery Network only needs to cover zones
  approaching Interlockings (Junction Points)
  in order to perform TSR deliveries well,
  greatly reducing the amount of wireless infrastructure needed.

NEC PTC Building Block Summary

1. CSS (Cab Signal System) **Introduced in 1926, continually improved.**

2. SCS (Speed Control System) **Introduced in 1952, continually improved.**

3. CSS + SCS = ATC (Automatic Train Control).

4. ACSES (Advanced Civil Speed Enforcement System)
   Introduced in Sweden in 1950s
   as an intermittent transponder-based system.

5. **ATC + ACSES = PTC (Positive Train Control)**
   Introduced by Amtrak in late 2000, blending the strengths
   of ATC (quick, reliable, easily understood for operation & maintenance)
   and ACSES (large amounts of data per message).

6. **TSR Delivery Network (Only feature requiring data radio coverage).**
   Introduced in 2004 and fully tested in 2005.

7. **All Building Blocks kept relatively simple, relatively easy to operate,**
   and to diagnose and correct faults when they occur.

NEC PTC Building Blocks Took Time to Develop Safely

<u>BUT</u> these features took time to ensure that the new features were being developed in a way that did not create new safety problems due to unknown features embedded in the new technologies, but not yet discovered and dealt with.

<u>Let's look at some history of train control:</u>

1. **1872 Track circuit invented and perfected in 1874.**
2. **Mid-1880s "Modern" Auto Block Signals began based on track circuits.**
3. **1**892-1902 PRR Main tracks from JCY to PAO equipped with ABS.
4. 1902-1907 Many false proceeds began to show up in all the new ABS installations.
5. 1907-2008 a group of Signal Engineers from 21 eastern RRs went to work on the FP problem, reducing the annual total from many hundreds to a handful.
6. 1922 The ICC ordered 49 RRs to install some form of train control.
7. 1923-1926 "Modern" cab signaling developed on the PRR.
8. 1930-1950 PRR made very extensive installations of cab signals.

NEC PTC Building Blocks Took Time to Develop Safely

Let's look at some history of train control (continued):

1. **1872 Track circuit invented and perfected in 1874.**
2. **Mid-1880s "Modern" Auto Block Signals began based on track circuits.**
3. **1**892-1902 PRR Main tracks from JCY to PAO equipped with ABS.
4. 1902-1907 Many false proceeds began to show up in all the new ABS installations.
5. 1907-2008 a group of Signal Engineers from 21 eastern RRs went to work on the FP problem, reducing the annual total from many hundreds to a handful.
6. 1922 The ICC ordered 49 RRs to install some form of train control, as yet undeveloped. (Sound familiar?)
7. 1923-1926 "Modern" cab signaling developed on the PRR.
8. 1930-1950 PRR made very extensive installations of CSS.
9. September 11, 1950, 33 fatalities at Morgan Run, OH with CSS.
10. 1952 PRR began to install Speed Control: CSS+SCS=ATC.
11. 1987 Chase, MD.
12. 1996 ACSES test bed in Delaware, first revenue service in late 2000.

NEC PTC Building Blocks Took Time to Develop Safely

Let's look at some history of train control (continued):

6. 1922 The ICC ordered 49 RRs to install some form of train control, as yet undeveloped. (Sound familiar?)
7. 1923-1926 "Modern" cab signaling developed on the PRR.
8. 1930-1950 PRR made very extensive installations of CSS.
9. September 11, 1950, 33 fatalities at Morgan Run, OH with CSS.
10. 1952 PRR began to install Speed Control: CSS+SCS=ATC.
11. 1987 Chase, MD.
12. 1996 ACSES test bed in Delaware, first revenue service in late 2000.
13. 2004 ACSES TSR Delivery Proof of Concept fully tested.
14. 2005 ACSES TSR Delivery 30-Day Reliability Testing proved it is ready for revenue service.
15. 2004-2008, 400 Engines equipped to receive TSRs from data radio.
16. 2008-2009 Dispatcher Training to actually deliver TSRs into ACSES from their consoles.
17. 2009, Hopefully, the final block will be in place on 435 track miles, and we will be ready to tackle installation on the remaining 1051 track miles in the NEC.

Incremental Train Control System (ITCS)

- ITCS is installed on Amtrak's Michigan Line,
  between Porter, IN and Kalamazoo, MI.

- What is ITCS?
  - **ITCS is a wireless communication based train control system providing the basic features of PTC.**
  - **ITCS uses Differential GPS and the tachometer for determining train location relative to wayside points of interest.**
  - **It overlays and monitors the wayside signals, enforcing the speeds associated with the signals, as well as permanent and temporary civil speed restrictions.**
  - **ITCS uses a data radio network that interfaces with the wayside signal system, to provide display and enforcement of required track and signal speeds.**

Incremental Train Control System (ITCS)

- ITCS is in the final stages of development,
  and because of serious radio coverage issues,
  the original 900 MHz ATCS frequencies are being retired
  in favor of a much more robust
  up-to-date 220 MHz data radio network.

- Current wireless communications based systems
  have an inherent delay in the transmission of information,
  when conditions change ahead of the train,
  as compared to the very quick updates
  through the rails inherent in traditional ATC systems.

- As passenger train speeds are raised to improve reductions in trip times,
  this “latency” is currently a limiting factor
  in totally wireless PTC systems.

Incremental Train Control System (ITCS)

- When ITCS (out of service for the upgrade since October 13),
  is restored to service with the 220 MHz data radio network,
  we expect a very large reduction in false restrictive failures,
  but we do not expect that it will be as free of FRs as ATC.

- Wireless communications based systems must have
  a very robust, redundant radio infrastructure
  to be able to compete with the reliability of ATC.

- ITCS to date has been in revenue service since March 20, 2000,
  and has enabled Amtrak to exceed the “79 MPH barrier”
  since January 7, 2002.

- Since January 7, 2002, ITCS has enabled 90 MPH for a saving of
  approximately 4 minutes in the 40 miles east of Niles, MI.

ITCS History and Lessons Learned

- History:
  1. Jan 1995 Grant awarded and installation began late 1995.
  2. Oct 1996 100 MPH Demo on 20 miles east of Niles, MI.
  3. Mar 20, 2000 Display activated on revenue trains.
  4. Apr 18, 2001 Enforcement with maximum speed still 79 MPH.
  5. Jan 7, 2002 Speeds raised to 90 MPH.
  6. Nov 2003 V&V Effort began with 3rd Party Safety Audit.
  7. Sept 19, 2005 Raised speeds to 95 MPH,
  8. 2008-2009 3rd Party Audit nearing completion, which will then permit operating speeds up to 110 MPH in ITCS Territory.

- Lessons learned in our experience with ITCS are similar to that of the lessons of PTC in the NEC:

1. It takes time to do these things right, and to integrate them into the fabric of a very highly developed, safety sensitive, RR culture, and

2. The simplest possible building blocks work best in the RR environment.

QUESTIONS?