MICHIGAN POSITIVE TRAIN CONTROL PROJECT
INCREMENTAL TRAIN CONTROL SYSTEM (ITCS)

NATIONAL TRANSPORTATION SAFETY BOARD
POSITIVE TRAIN CONTROL (PTC) SYMPOSIUM
MARCH 2-3, 2005

AMTRAK®

PROJECT PARNERSHIP

- Federal Railroad Administration
- Michigan Department of Transportation
- Amtrak
- GE Transportation Systems – Global Signaling (formerly, Harmon Industries)

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ITCS PROJECT MILESTONES

ACTIVITY	DATE
FRA Project Grant Award	March 1995
ITCS System Design & Installation Commencement	June 1995
ITCS Demonstration (Signal 175 to Signal 195)	October 1996
Phase 1-ITCS Implementation (393 days) 79 mph without ITCS Enforcement	March 20, 2000
Phase 2-ITCS Implementation (271 days) 79 mph with ITCS Enforcement	April 18, 2001
Phase 3-ITCS Implementation 90 mph with Enforcement	January 7, 2002
Phase 4-ITCS Implementation 110 mph with ITCS Enforcement	GOAL: Spring 2006

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ITCS PROJECT BUDGET: 1995 TO PRESENT

- 66 miles: Upgraded track structure from FRA Class 4 to FRA Class 6
- ITCS design, manufacture, install and test
- Private grade crossing removal (19 crossings)

FUNDING	BUDGET (in millions)
FRA	$19.1
Michigan DOT	10.7
Amtrak	3.9
GE Transportation Systems – Global Signaling (formerly, Harmon Industries)	4.9
TOTAL	**$38.6**

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ITCS PROJECT BUDGET – BY ACTIVITIES

ACTIVITY	BUDGET (in millions)
Track Infrastructure Upgrades – FRA Class IV to FRA Class VI	$11.7
ITCS – Technology Development, Installation, Implementation & Software V&V Program	$26.4
Fencing	.5
Consultants	.0
PROJECT TOTAL	**$38.6**
Private Crossing Eliminations* *Separate Michigan DOT Funding Grant	.9
ITCS PROJECT CORRIDOR – GRAND TOTAL	**$39.5**

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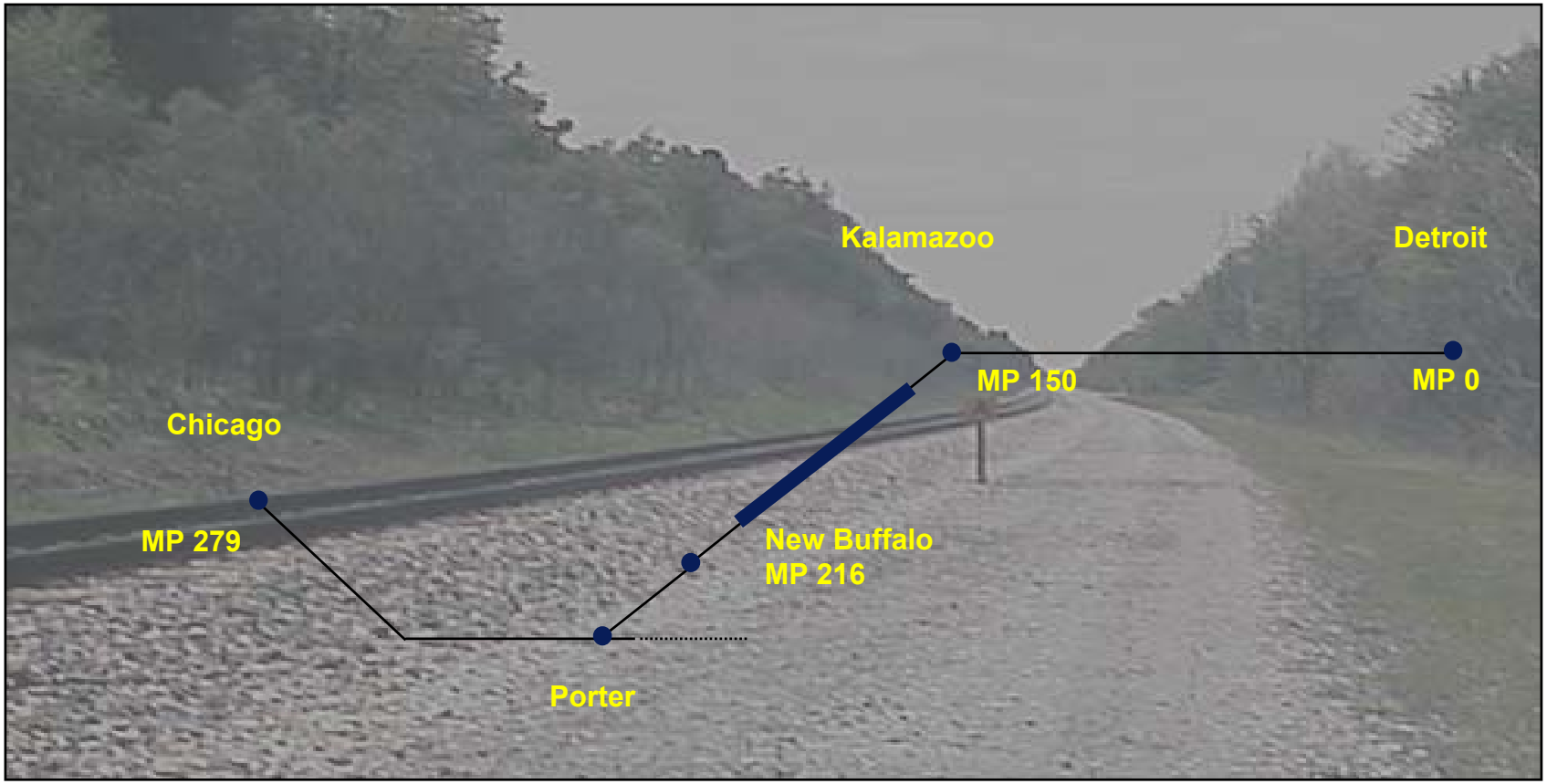
INCREMENTAL TRAIN CONTROL SYSTEM (ITCS)



Signal 150 to Signal 216: Kalamazoo to New Buffalo, Michigan

ITCS – HOW DOES IT WORK?

- Vital, GPS-based Location System
- On-board computer with map “draws” railroad
- Wayside Communication updates train for condition of signals, switches, crossings
- On-board Computer calculates speed limits, braking curves, and supervises movement

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ITCS MAJOR SUBSYSTEMS

- Wayside
  - Overlay on existing Centralized Traffic Control (CTC) signal system
  - VHLC based for both WIU Servers and links
  - GETS GS MCP radio for ATCS communications with on-board
  - Spread Spectrum Radio (SSR) for communications with LAN
  - GPS reference stations providing differential corrections

- Office-to-Wayside Link Computer

- On-Board
  - Ultracab II Based
  - GETS GS MCP radio for ATCS with wayside
  - GPS receiver
  - Compact Locomotive Display (CLD) for person/machine interface

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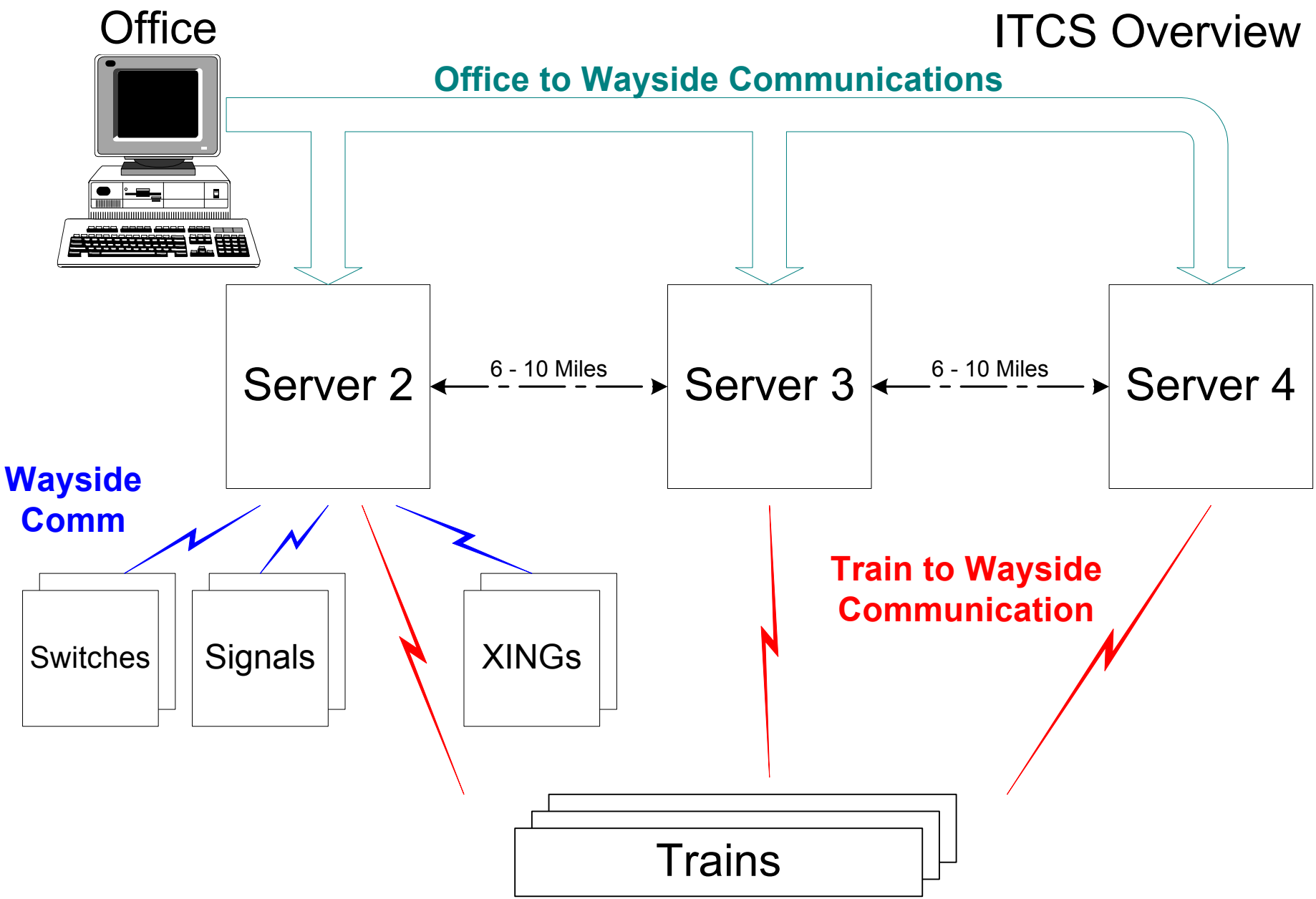
Office
ITCS Overview
Office to Wayside Communications
Server 2
6 - 10 Miles
Server 3
6 - 10 Miles
Server 4
Wayside Comm
Switches
Signals
XINGs
Train to Wayside Communication
Trains

ITCS WAYSIDE EQUIPMENT

- Departure Test Devices
  - Chicago, Illinois (Amtrak)
  - Kalamazoo, Michigan (Amtrak & Norfolk Southern)
  - Burns Harbor, Indiana (Norfolk Southern)
  - Pontiac, Michigan (Amtrak)
  - Niles, MI (Amtrak) – Portable Unit
  - Elkhart, IN (Norfolk Southern) – Portable Unit
- Wayside Interface Units = 11 Server Locations
- Office-to-Wayside Link Computers
  - Amtrak Michigan Line Train Director's Office – Chicago, Illinois
  - Amtrak Project Office – Niles, Michigan

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ITCS WAYSIDE SERVER FUNCTIONS

- Store track profile segment database
- Poll WIUs in Wayside LAN
- Maintain Current Status of WIUs
- Send track profile updates to train on request
- Broadcast function status to trains

ITCS WAYSIDE LINK FUNCTIONS

- WIU Interlocking Functions
  - Monitor interlocking function status (switches, signals, tracks)
- WIU Intermediate Signal Functions
  - Monitor status of signal aspects and track circuits
- WIU Crossing Functions
  - Monitor normal controls and warning devices
  - Receive “Advance Start Enable” from server
  - Report “Start Delay” command from server
  - Report “Advance Start Acknowledge” to server

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ITCS SIGNAL OVERLAY FEATURES

- Display and enforcement of speed limit
- Display and enforcement of signal aspect
- Support of high speed mixed operations
- High speed advanced start of crossings
- Feedback of crossing “health” status

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ITCS OFFICE-TO-WAYSIDE LINK COMPUTERS – APPLICATION OF TEMPORARY SLOW ORDERS

- **TSOs are transmitted wirelessly to all trains and enforced on board based on data input of:**
  - Type of train (passenger or freight)
  - Location
  - Direction
  - Track Number

- **ITCS Office-To-Wayside Link Computers (2)**
  - Amtrak Michigan Line Train Director – Chicago, IL
    - Activate & Deactivate TSO
  - Amtrak Engineering Maintenance of Way – Niles, MI
    - Activate TSO

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ITCS EQUIPPED LOCOMOTIVES

- **Amtrak**

  - P-42

    Maximum Authorized Speed = 110 mph

  - NPCU F-40

    Maximum Authorized Speed = 100 mph

- **Norfolk Southern**

  - 6 GP-38

    Maximum Authorized Speed = 50 mph

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ITCS TRAIN TYPES BASED ON BRAKING ALGORITHMS

- Passenger Trains
  - High Speed Passenger (125 mph)
  - Passenger (110 mph)
  - Mail & Express (90 mph)

- Freight Trains
  - Light Engine
  - Mixed Freight
  - Intermodal Freight
  - Unit Freight

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ITCS ON-BOARD FUNCTIONS

- Position tracking
- Maintain current track profile data
- Request and receive profile updates
- Determine operating restrictions
- Display status and restrictions
- Enforce operating restrictions
- Interactive interface for vehicle operator

ITCS COMPACT LOCOMOTIVE DISPLAY (CLD)

Information Displayed

- Is ITCS operating -ON/OFF
- Maximum Authorized Speed
- Actual Speed
- Short-Term Restrictions
- Braking Profile

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EXAMPLE:

Approaching a

Diverging Signal

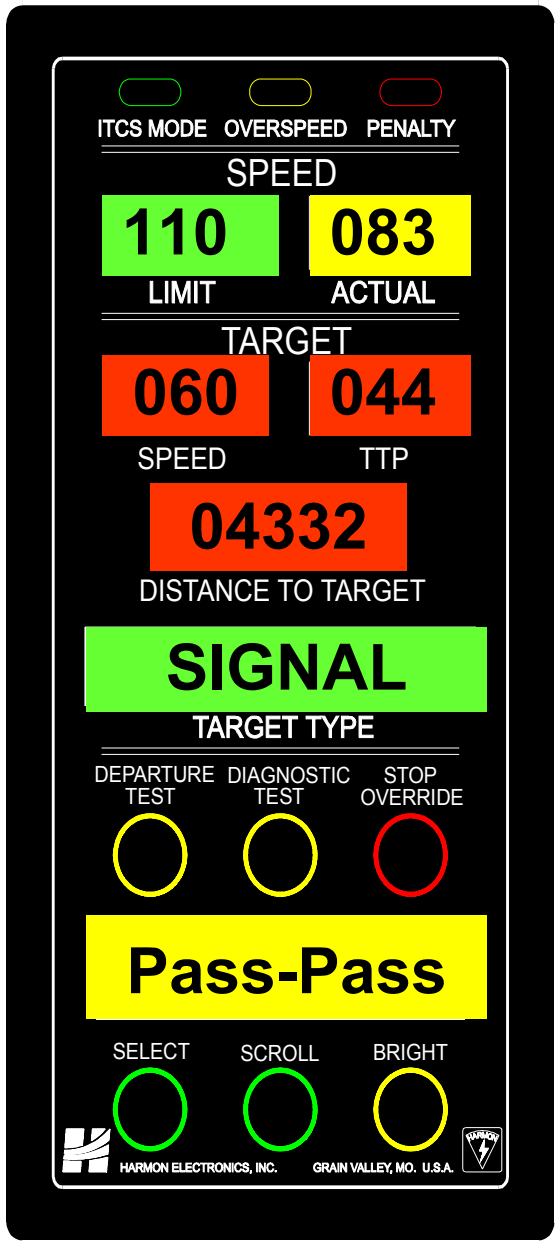
Speed Limit = 110 mph

Actual Speed = 83 mph

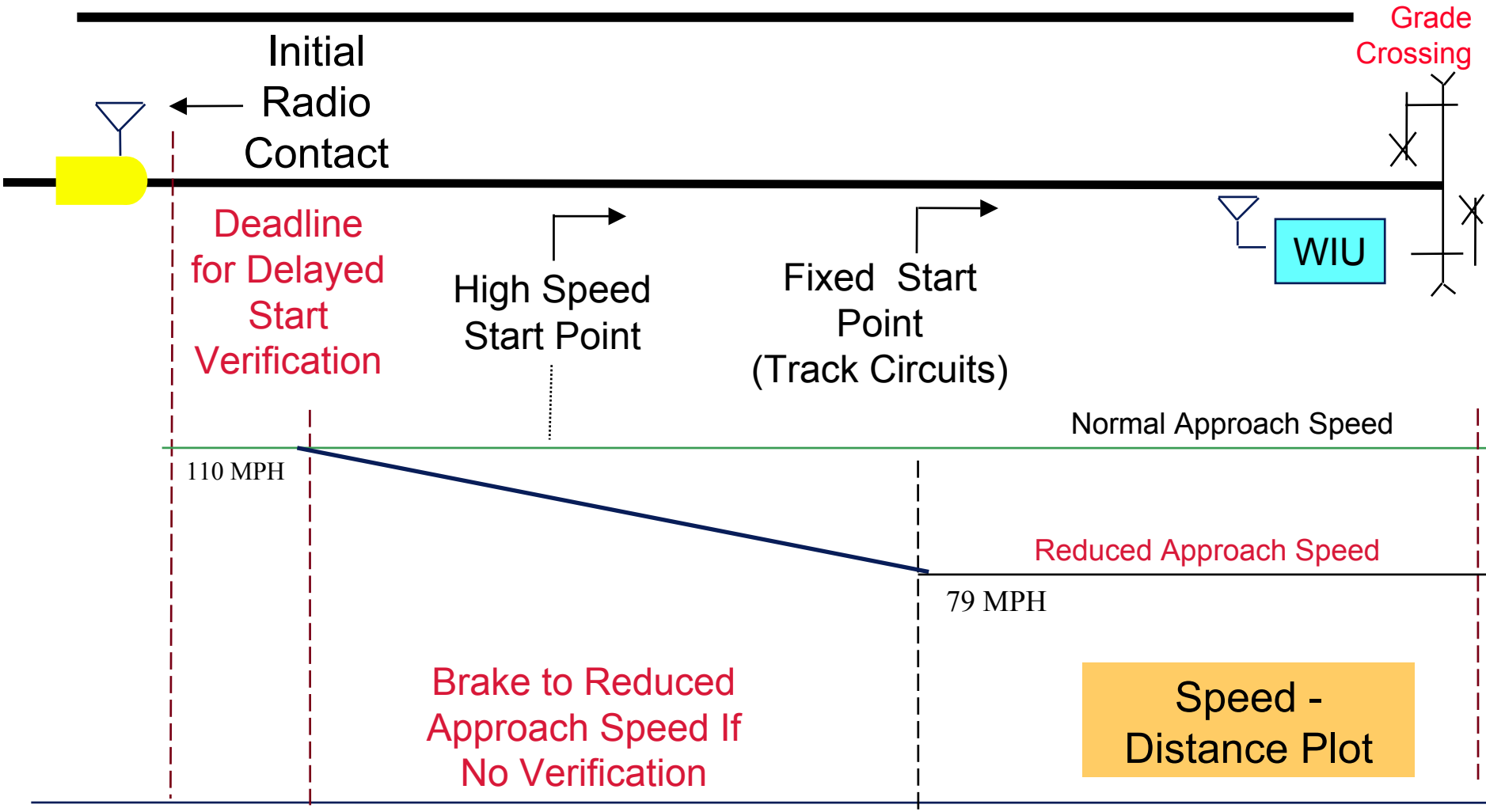
Target Speed = 60 mph

Time-to-Penalty = 44 seconds

Distance to Target = 4,332’



ITCS – GRADE CROSSING WARNING ADVANCE HIGH SPEED START



ITCS TARGET TYPES

TARGET	OPERATING RULE
ITCS IN	Prompt to place ITCS switch **IN**
RESTRCT	Immediately reduce to Restricted Speed
AUTOSIG	Approaching Automatic Block Signal
HOMESIG	Approaching Control Point or Interlocking Signal
XING	Highway Crossing Warning System Operation may be causing restriction
TRK SPD	Approaching Permanent Track Speed Restriction
TMP SPD	Approaching Temporary Track Speed Restriction or Out-of-Service Track

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ITCS TARGET TYPES

TARGET	OPERATING RULE
TMP APP	Train is *approaching* an area where ITCS may not display or enforce temporary speed restrictions. Engineer must immediately begin reduction to the speed required by any temporary speed restrictions that may be in effect, not exceeding 40 MPH. Dispatcher and Conductor must be notified as soon as possible without delay to train. After reviewing the content of any temporary speed restrictions with the train crew, Dispatcher may authorize movement at Normal Speed, not exceeding 79 MPH.
TMP UNK	Train is *within* an area where ITCS will not display or enforce temporary speed restrictions. Engineer must immediately reduce to the speed required by any temporary speed restrictions that may be in effect, not exceeding Restricted Speed. Dispatcher and Conductor must be notified as soon as possible without delay to the train. After reviewing the content of any temporary speed restrictions with the train crew, Dispatcher may authorize movement at Normal Speed, not exceeding 79 MPH.

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ITCS TARGET TYPES

TARGET	OPERATING RULE
S.O.XX	Stop Override Countdown (“xx” seconds until Stop Override Button may be operated)
EXIT	Approaching End of ITCS Territory
ITCSOUT	Prompt to place ITCS switch **OUT**
NO ACK	Failure to Acknowledge caused penalty
NO MAP	ITCS has failed to verify database for next Server Section
FAILCAL	Automatic Wheel Calibration Failure
F-XXXX	On board failure with error codes
C-XXXX	Indicating type and/or location of failure
I-XXXX	These codes should be included in report of failure to Dispatcher or Operator.

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ITCS SOFTWARE VERIFICATION & VALIDATION (V&V) PROGRAM

- **GETS GS commenced 30-month FRA-required Software V&V Program during December 2003**

- **ITCS Software requiring Verification & Validation**
  - Location Processor
  - Wayside Processor
  - Host Processor

- **Third-Party Independent Safety Audit of GETS GS ITCS V&V Program**
  - Battelle Memorial Institute

- **Program completion scheduled for June 2006**

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MILESTONES IN RAILROAD HISTORY

ITCS REVENUE SERVICE IMPLEMENTATION

PASSENGER & FREIGHT TRAIN OPERATIONS

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ITCS CUTOVER & REVENUE SERVICE IMPLEMENTATION

Phase	General Description	Maximum Passenger Train Speeds	Commencement Date
1	ITCS Cutover – P2A Valve Cut-Out	79 mph	03/20/2000
2	Post Cutover – P2A Valve Cut-In	79 mph	04/18/2001
3	Revenue Service - Limited	90 mph	01/07/2002
	Revenue Service – Unlimited	110 mph	GOAL: Spring 2006

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PHASE 1: 79 MPH WITHOUT ENFORCEMENT – MARCH 20, 2000

- Locomotive engineers viewed and reported ITCS without enforcement
- Mechanical and C&S employees were able to troubleshoot reported ITCS on-board and wayside equipment anomalies
- Establishment of ITCS reporting criteria

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PHASE 2: 79 MPH WITH ITCS ENFORCEMENT – APRIL 18, 2001

ITCS-EQUIPPED PASSENGER & FREIGHT LOCOMOTIVES

- Locomotive engineers operated at 79 mph with ITCS
- Mechanical and C&S employees further refined ITCS troubleshooting for on-board and wayside equipment failures
- Identification and resolution of recurring ITCS anomalies causing train delays

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PHASE 3: 90 MPH WITH ENFORCEMENT JANUARY 7, 2002

January 7, 2002

Amtrak #364
Locomotive #26 (P-42)

- Decreased run times for passenger train operations over project corridor (Schedule reduced between Kalamazoo and Niles by 5 minutes)

- Passenger train operating schedule enhancements will be achieved (reduced travel times)

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ITCS TECHNOLOGY PROVIDES POSITIVE TRAIN CONTROL CORE FUNCTIONS

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1. PREVENTING TRAIN-TO-TRAIN COLLISIONS

- Track circuits sense trains and pass data to vital logic controller
- Vital logic controller controls switches and sets signal aspects based on track occupancies
- Signal aspects are seen by locomotive engineer and govern movement of the train(s). ITCS enforces via radio communications.

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2. PREVENTS TRAINS EXCEEDING SPEED LIMITS

- **Permanent Speed Limits**
  - Operating speeds are programmed into software by train type, which is selected during ITCS departure test process
  - Civil speeds, based on track geometry, are programmed into software

- **Temporary Speed Limits**
  - Application of Temporary Slow Orders **(TSOs)** through ITCS Office-to-Wayside Link Computer via telephone line to Wayside Local Area Network Server

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3. PREVENTS TRAINS ENCROACHING INTO THE WORK LIMITS OF ROADWAY WORKERS

- Absolute block to protect Roadway Workers is enforced through ITCS Office-to-Wayside Link computer application of **TSO = 0 mph** between work limits

- TSO application can only be deactivated by Michigan Line Train Director (Chicago)

- Roadway Worker Protection is absolute

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4. PREVENTS GRADE CROSSING INCIDENTS FROM MONITORING THE "HEALTH" OF WARNING DEVICES

- Wireless Pre-Start: The train pre-starts the crossing for operations with no modifications to existing track circuits required.

- Continuous Health Monitoring: If crossing does not activate or is active in excess of 5 minutes, the train is informed and slowed to a safe speed prior to reaching the highway/rail crossing.

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LESSONS LEARNED

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PROJECT PARTNERSHIP

- Ongoing partners' commitment required
- Involved from conception to completion
- Invaluable resources, knowledge and expertise
- Ongoing phased funding authorizations to progress ITCS technology development
- Vital positive train control system can be developed, installed and implemented with small team possessing knowledge, expertise and motivation

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NEW TECHNOLOGY DEVELOPMENT

- Railroad domain knowledge is critical to new technology development and application
- Communications-based networks are ever changing and require long-term planning of system design
- Product research and development is ongoing through system acceptance process
- New technology availability outpaces system implementation
- ITCS Hardware
  - Most components are COTS with open architecture
  - Minimal components are “Proprietary & Confidential”

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SYSTEM HARDWARE & SOFTWARE

- ITCS hardware product selection must be suitable for exterior locomotive mounting
- System design has limited additional memory capacity for ITCS host processor (on-board computer) functions
- Expanded software code requirement was greater than originally conceived to ensure ITCS functionality

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PASSENGER VS. FREIGHT LOCOMOTIVE APPLICATION

- Differences were experienced in:
  - On-board equipment wiring
  - Software databases
  - Braking algorithms
  - Braking tests
  - Primary and secondary speed sensor interference

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SYSTEM CUTOVER TESTING

- FRA-required testing was more complex to ensure system functionality of:
  - Crossings
  - Braking tests on APPROACH aspects
  - Temporary Slow Orders
  - Civil Speeds
  - Signal Aspects
  - Interlocking & Hand-Operated Switches
  - Operation with Two Trains

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DOCUMENTATION

- Resources need to be allocated to create FRA-required documentation for:
  - Test Plans and Forms
  - Migration Plan
  - Configuration Management Plans
  - Supplement to Operating Rules
  - Supplement to Train Handling Procedures
  - Daily Operations Report
  - Anomalies & Resolution Report
  - Training Qualifications
  - Audit Requirements

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NEXT STEPS

- Continued reporting on ITCS operations, anomalies and resolutions
- Continued progress on resolving radio communication networks infrastructure weaknesses
- ITCS cutover between Signal 195 and Signal 216
- ITCS software verification and validation (by June 2006)
- Completion of 110 mph testing
- FRA authorization for 110 mph passenger train operations

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ONGOING TECHNOLOGY DEVELOPMENT

- Expanded remote monitoring of ITCS wayside equipment
- Implement dark territory ITCS application

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AMTRAK

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