Enhancing Railroad Security with Intelligent Railroad Systems

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Intelligent Railroad Systems

Use digital data communications, sensors, and computers on railroads to:

- Improve safety and security
- Raise effective capacity
- Improve asset utilization
- Improve customer satisfaction
- Manage and control costs
- Improve energy efficiency
- Reduce emissions
- Increase economic viability and profits
- “Manage the unexpected”

Intelligent Railroad Systems

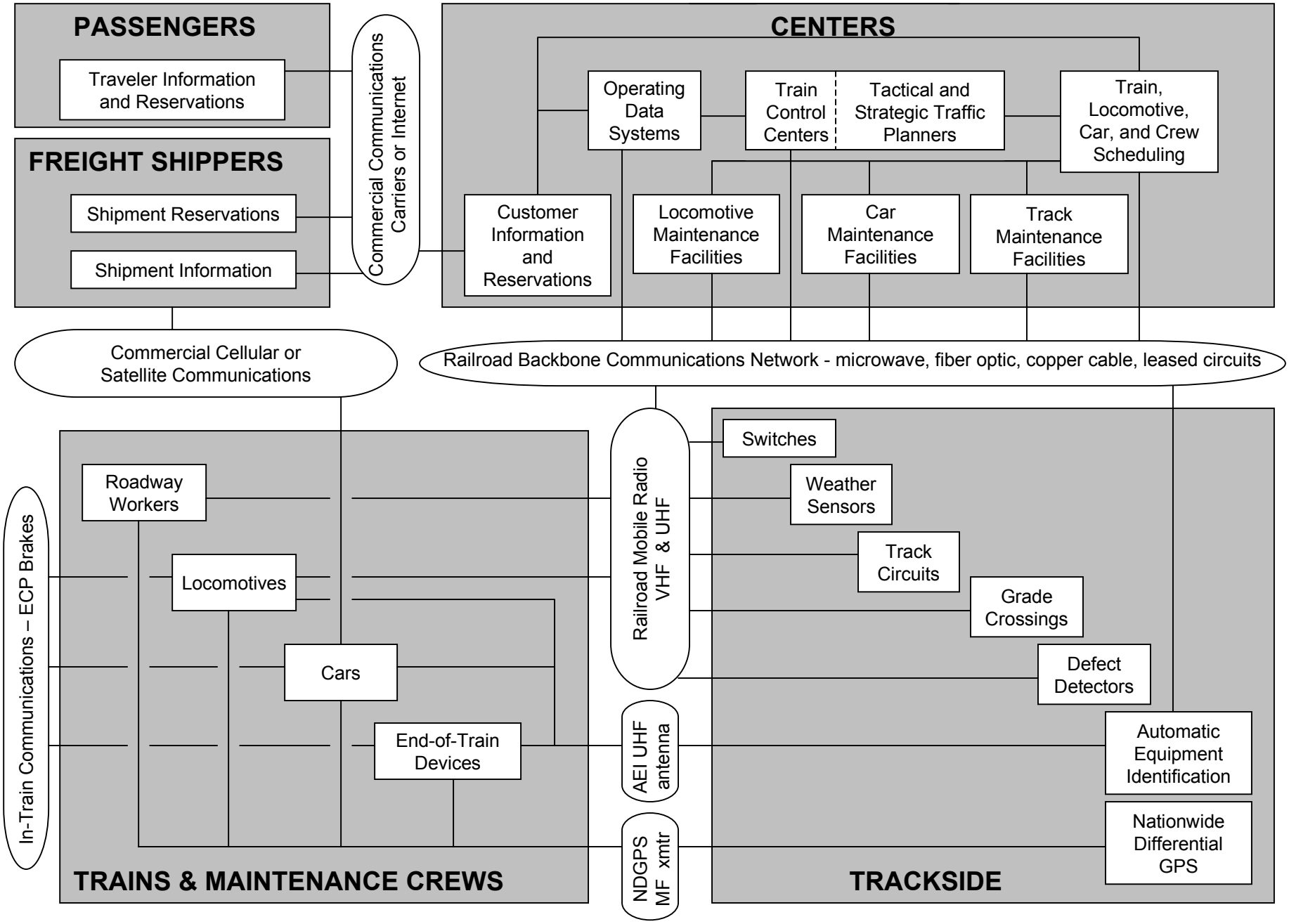
- Apply the same technologies used in:
  - Intelligent Transportation Systems
  - Air Traffic Control
  - Maritime Vessel Tracking Systems
  - Parcel Delivery Services
  - Emergency Response Services
  - Military Command and Control
- Use the technologies to enhance security through:
  - ***Prevention*** of incidents -- ***Detection*** of incidents
  - ***Notification*** of incidents -- ***Recovery*** from incidents

"Continuous, real-time information;
no more snapshots"

The Principal Intelligent Railroad Systems

- Digital data link communications
- Positive Train Control (PTC)
- Nationwide Differential GPS (NDGPS)
- Automatic Equipment Identification (AEI)
- Electronically-controlled pneumatic (ECP) train brakes, plus sensors
- Intelligent grade crossings

INTELLIGENT RAILROAD SYSTEMS



Digital Data Link Communications

- The enabler of Intelligent Railroad Systems
- Can use any communications medium as a backbone: microwave, fiber, copper cable, cell phones, communications satellites
- FCC has provided 182 VHF and 12 UHF frequencies for RR mobile radio
- Permits discretely addressed messages with single or multiple addressees

System Security

- Must be designed into Intelligent Railroad Systems before deployment
- Data regarding trains, cars, crews, and shipments must be kept confidential
- Unwarranted extraction of information from communications net must be prevented
- Authentication of data will insure that the content is genuine, unaltered, and complete
- Encrypt data to keep it out of wrong hands

Positive Train Control Components

- Along the wayside
  - Digital data radios and backbone communications network
  - Wayside interface units at switches and detectors
- On locomotives and maintenance vehicles
  - On-board computer with digital maps
  - Positioning system
  - Throttle-brake interface
  - Integrated displays
- At the control center
  - Dispatching computers with displays

Positive Train Control

- Provides safety benefits by:
  - Preventing collisions
  - Preventing overspeed accidents
  - Protecting roadway workers
- Provides enhanced security through:
  - Monitoring location and speed of all trains
  - Monitoring all switches
  - Only authorized persons controlling trains
  - On-board enforcement of all movement authorities
  - Remote intervention capability

PTC Positioning

- Train positioning integrates multiple inputs:
  - Odometer
  - Digital track map
  - Switch position indicators
  - Augmented GPS
  - Inertial sensors
- System design copes with GPS signal loss in tunnels
- Position sent by data link to control center
- Track centers are 4 m apart, which requires 1-2 m accuracy (i.e., NDGPS)

Effects of GPS Loss on PTC

- Backup systems are adequate for safety
- PTC train ops would continue without GPS
  - Using alternate sources of location/speed
  - Safety would not be compromised
- Efficiency of railroad ops could be affected
  - Larger band of uncertainty around location of trains and maintenance vehicles

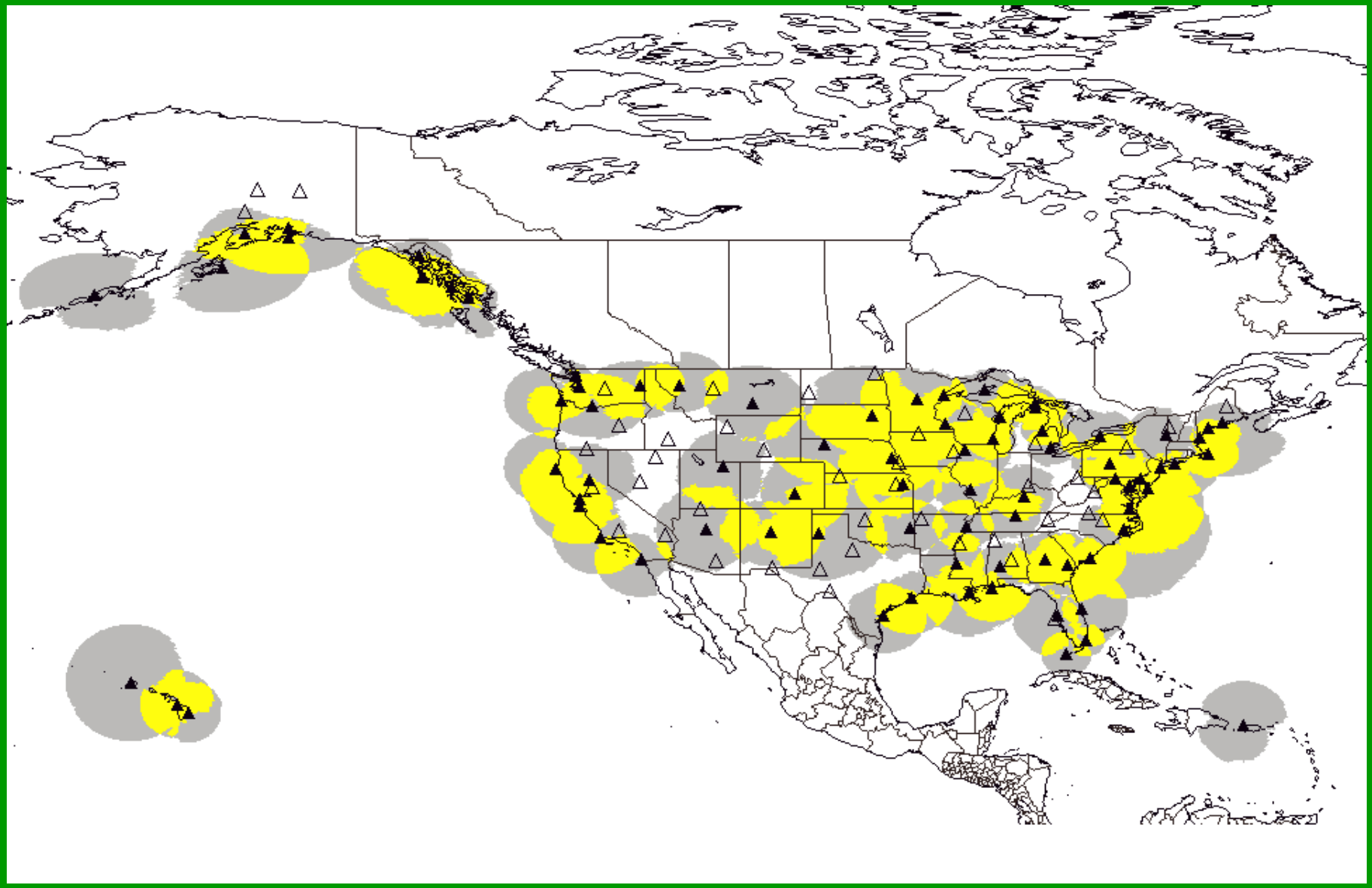
Nationwide Differential GPS

- Augmented GPS: 1-to-2 meter positioning accuracy
- International standard developed by US Coast Guard; used in 40 countries
- Utilizes decommissioned USAF GWEN sites
- Receivers on locomotives and maintenance-of-way vehicles calculate location and speed
- Location and speed transmitted to railroad control center over digital data link network

Nationwide Differential GPS

- Currently operational with single coverage over 80% of continental US, dual coverage over 45%
- Schedule to complete is slipping due to budget issues; now scheduled to be fully operational in 2004
- Managed and monitored continuously at USCG Nav Cen, Alexandria, VA
- Signals available to anyone with proper receiver; no user fee

NDGPS Coverage - End of 2001



NDGPS and Transportation Security

- Imperative now to monitor location of hazmat shipments by rail, container, truck, ship, and barge
- Emergency responders can use NDGPS even in absence of physical landmarks
- NDGPS usable by any surface user
- NDGPS monitors GPS integrity; users receive warning of GPS degradation within 5 seconds
- NDGPS network largely in place; relatively little effort required to complete it.

Automatic Equipment Identification

- Two passive AEI tags installed on each freight car and locomotive since 1995; AAR Interchange Rule, no Federal involvement
- Readers at track-side interrogate tags at 900 MHz radio frequency
- Tags respond with vehicle initial and number
- Can be integrated with wayside equipment sensors to identify specific cars with problems
- Active tags with read-write capability also available; require periodic battery replacement

Automatic Equipment Identification (AEI) Tags

AEI Tag Readers

Work Order Reporting

- Instructions sent from control center to train crews to set out and pick up loaded and empty cars en route
- On-board train consist updated automatically based on crew acknowledgement of work order completed
- Train consists in central computers also updated in real time
- Customers can be automatically notified of impending or actual car placement
- Important for establishing “custody chain” of shipments

Tracking Hazmat and Other Shipments

- AEI confirms the locos and cars on each train
- NDGPS receiver determines location of the loco to within 1-2 meters and speed to within 1-2 km/hr
- Data radio transmits train location and speed info back to dispatchers and operating data system
- Work order reporting system confirms set outs and pick ups
- Operating data system then combines train location, train consist, and car/shipment data
- Authorized parties (railroad and shipper) can inquire about precise car/shipment location

Electronically-Controlled Pneumatic (ECP) Brakes

- Electronic application and release of train brakes
- Permit simultaneous application of all brakes on the train
- Shorten braking distance
- Reduce in-train coupler forces & slack action
- Wireline and spread spectrum radio based ECP brake systems being tested
- Enable monitoring of condition of car components and car contents

Car On-board Component Sensors

- Sensors are mounted on rolling stock to monitor condition of components
- Conditions monitored include: overheated bearings and wheels, impacts and vibrations from flat or derailed wheels, excessive truck hunting, excessive longitudinal forces, braking system status
- Data is transmitted via the ECP braking system to the cab and then over data link to control center and car maintenance facilities for immediate or future action as appropriate

Car On-board Commodity Sensors

- Sensors are mounted on freight cars to monitor the status of the commodities being carried
- Data include temperature, pressure, load position, radiation, vibration
- Data transmitted via ECP braking system to cab and then over data link to control center, car maintenance facilities, and shippers for immediate or future action as appropriate
- Proprietary sensor and satellite or cellular communications packages are also used for tracking and condition monitoring

Intelligent Grade Crossings

- Establish communication between rail and highway systems
- Train presence and arrival times can be communicated to highway traffic control centers and motor vehicle operators
- Stalled vehicle detection
- Near side station stop capability
- Second train on approach warnings
- Reduction in gate down times and traffic congestion

Crew Registration and Time-Keeping Systems

- Use passwords, card keys, or biometrics to identify crew members authorized to operate trains
- Movement authority issued only when designated crew is on board and logged in
- On and off duty times, and terminal departure and arrival times, automatically sent to operating data system for payroll accuracy
- Data link necessary to carry this out

Track Forces Terminals

- Provide means for moving information and instructions between roadway workers and control centers
- Can be laptop computers or PDAs
- Enable crews to determine future track occupancy and to request “track and time”
- Enable crews to place slow orders and to transmit administrative data
- Roadway workers, along with train crews, are railroads’ “eyes and ears” in the field

Wayside Equipment Sensors

- Equipment sensors detect anomalies of rolling stock components; tying in with AEI provides for positive ID of defective cars
- Information is transmitted to train crews, control centers, and car maintenance facilities for immediate or future action as appropriate
- Conditions detected include: overheated bearings & wheels, deteriorating bearings, cracked and flat wheels, derailed wheels, excessive truck hunting, dragging equipment, excessive lateral & vertical forces, skewed trucks, excessively high and wide loads

Wayside Track Sensors

- Track sensors detect anomalies/conditions that occur on or alongside the track
- Information is transmitted to control center and to track forces for immediate or future action as appropriate
- Conditions detected include: switch position, broken rail, misaligned track, high water, rock and snow slides, washouts, excessive rail stress, misaligned bridges and trestles, blocked culverts, weather information

Vehicle-Borne Track Monitoring Sensors

- Vehicle-mounted sensors to detect various defects or conditions; now on special inspection vehicles, possibly locos in future
- Rail flaws, broken rail, misaligned track, corrugated track, and excessive rail stress could be detected
- Data presented in inspection car or loco cab and transmitted over data link to control center and track forces for immediate or future action as appropriate

Intelligent Weather Systems

- Combine data from railroad weather sensors (wayside & on-board) and national, regional and local forecast data
- Alert control centers, train crews, and track forces of actual or potential hazardous weather conditions
- Advanced warning for flooding, track washouts, high winds, sudden temperature variations, snow, mud, and rock slides

Tactical Traffic Planners

- Enable dispatchers to look ahead in time
- Identify where trains should meet and pass, and which trains should take sidings
- Feedback provided by the PTC system will allow replanning as necessary
- System, rather than local, optimization is possible
- Objective functions can be altered to meet security requirements

Strategic Traffic Planners

- STPs can measure train movements against a set of externally-defined schedules
- Cost-minimizing decisions can be made on whether, and how, to adjust train priorities and schedules on a real-time basis
- Display the performance of trains against schedule and show the real-time location and future location of every train by type
- Important for detection of and recovery from disruptions
- FAA “Central Flow Control” is a good analogy

Emergency Notification Systems

- Automated reporting of rail incidents
- Notification of all involved organizations
- Coordination and control of organizations involved
- Information services for media and passengers
- Registration and analysis of performance
- Faster resolution of problems and resumption of service

Other Intelligent Railroad Systems

- Knowledge display interfaces
- Crew alertness monitoring systems
- Locomotive health monitoring systems
- Energy management systems
- Train, locomotive, car, and crew scheduling systems
- Yield management systems
- Travelers' advisory systems

Impediments to Implementation of Intelligent Railroad Systems

- Magnitude of costs; competition for capital
- Time to implement; lack of trained staff
- Fear of liabilities
- Interoperability issues come into play
- Fear of change, institutional and individual
- Insistence on using existing systems
- Implementation issues can appear daunting
- Uncertainty about customer response to improved service

Summary

- Intelligent Railroad Systems can be implemented as independent or integrated systems
- Benefits are compounded when implemented as integrated systems
- Minimizing the cost of individual systems does not necessarily minimize total costs or maximize benefit-cost ratio
- Use of improper decision criteria can lead to suboptimal deployment or no deployment
- Implementation options *are* varied
- Railroad security *can* be enhanced