Train Collisions and Derailments (in Maryland)

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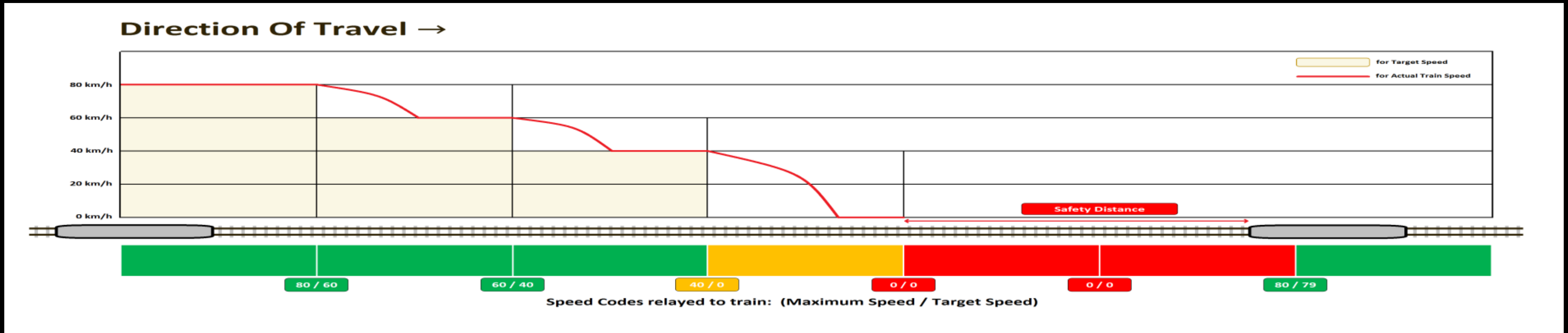
Outline

- Introduction – Topic overview, research
- Specific Cases – Silver Spring(‘96), Ellicott City(‘12), DC Metro('09)
- Failure - What happened and Why
- Failure – Prevention
- Impact – Prevention, future development(maglev)

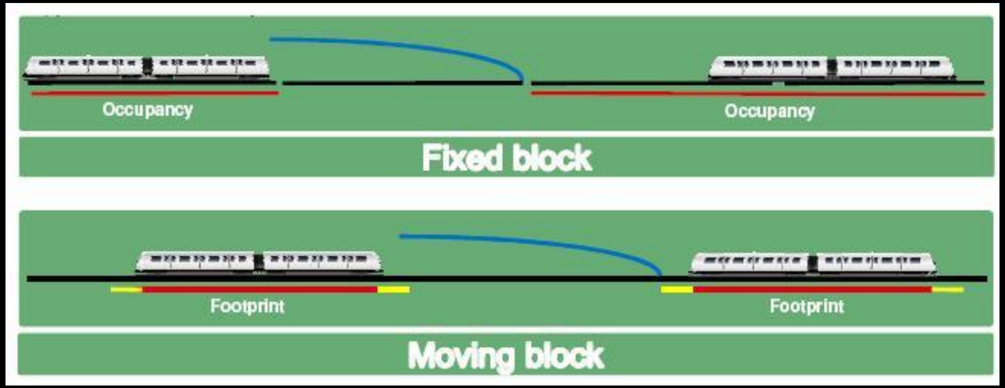
Railroad Signals and ATP

- Railroad signals communicate to driver conditions and features of the track ahead
- Automatic Train Protection is a system that uses relays inside the track to interface with a system in the driver's cabin
- The system checks that the train speed is compatible with current signaling and can apply emergency brakes if necessary



CBTC

- Communications Based Train Control is a system that makes use of radio communication between trains and ground equipment to more accurately determine the position of the train with the goal of reducing headwinds and increasing capacity
- Interfaces with the on-board ATP and ATO (automatic train operation) systems
- Used widely in countries with developed public transportation systems but mainly used in airports in US



Background research

- Each year around the world there are still several cases of train derailments on the curved tracks due to high speed, leading to big casualties and costs to the rail industries. With the ongoing increase on the speed, the possibility of train derailment will increase, especially on the sharp curved tracks.
- Maryland and DC Railroads consist of multiple freight(CSX,CTN) and passenger(AMTK, MARC) carriers along with the Baltimore Light Rail and the Washington Metro
- How are railroads attempting to stop accidents and derailments. Recent studies have shown that although fatalities in railway accidents are relatively uncommon, the number of passenger injuries is increasing.

Silver Spring Train Collision

- February 16, 1996 two trains collided near Silver Spring, Maryland.
- The trains involved were a Maryland Rail Commuter (MARC) train and a National Railroad Passenger Corporation (AMTRAK) passenger train.
- The collision resulted in numerous deaths, injuries and $7.5 million in damages.

Figure 6--Photograph of postcollision passenger coach cab control car 7752 at accident site.

What Happened?

- MARC train crew members neglected an APPROACH signal.
- The MARC train could not stop for a STOP signal at the next junction.
- Due to neglected signals the MARC train collided with the AMTRAK train.

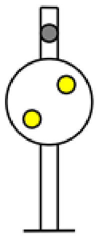
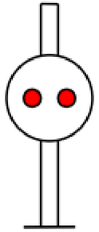
APPROACH	STOP
	
Rule C-285	**Rule C-292**
Proceed prepared to stop at the next signal. Trains exceeding medium speed must immediately begin reduction to medium speed as the engine passes the APPROACH signal.	Stop.

Figure 6--Photograph of postcollision passenger coach cab control car 7752 at accident site.

Figure 2--Aerial photograph of postcollision scene.

General Factors

- Inspections reports and event recorders showed no evidence of equipment failure.
- Toxicological reports cleared crew members of any impairment resulting from drugs or alcohol.
- Their health such as sleep, and awake cycle and the experience of the crew members was determined not to be a cause of the accident.
- The safety board concluded that the train equipment and track functioned as normal.
- Weather conditions were not enough to impair the abilities of the MARC crewmembers.

Conclusions

- Train equipment functioned as designed.
- The MARC train engineer forgot signal aspect due to distractions.
- Conductor and assistant conductor did not effectively monitor the engineer who operated the MARC train.
- Federal Railroad Administration does not require recording of train crew's voice communication so the exact cause of the accident can only be speculated.
- If implemented, a total signal system review that includes human factor analysis featuring comprehensive failure modes the accident could have been prevented.
- A train control system on the Commuter cab been part of the signal system the accident may not have happened.
- Rupture of AMTRAK fuel tank caused eight of eleven deaths.
- MARC train engineer's use of reverser during emergency braking increased stopping distance.

Probable Cause

- Human error due to multiple distractions. A safety system to compensate for human error has been suggested.

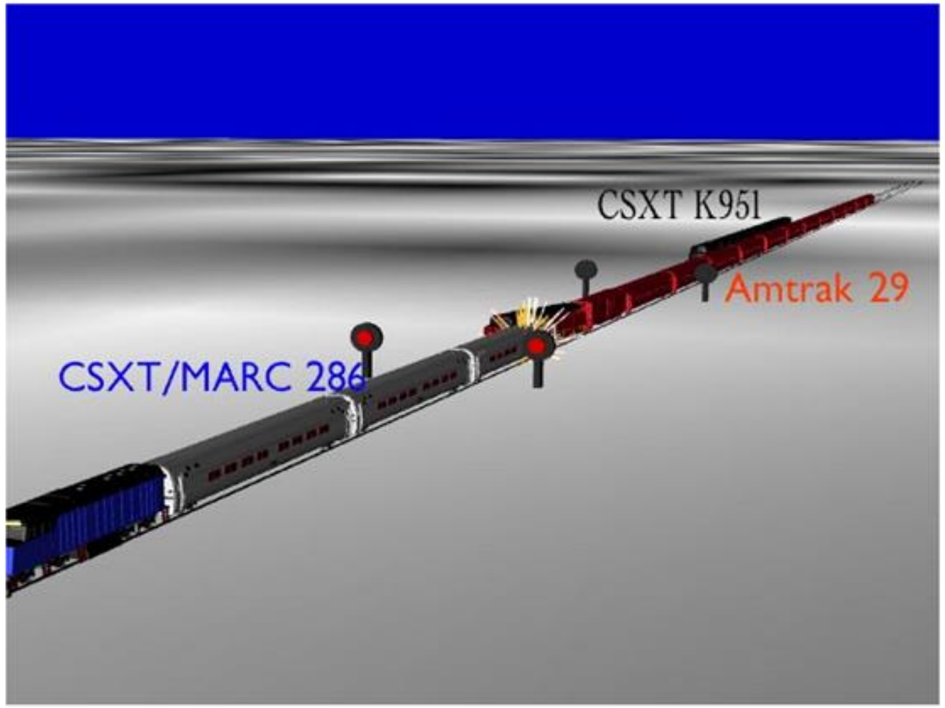


Figure 1--View of trains at point of impact.

Recommendations

- Amend regulations to require voice communication recordings.
- Require failure modes and human factor analysis for signal system.
- Install cab signals, automatic train stop and train control.
- Require train separation control systems.
- Caution engineers not to use reverser in emergency braking.
- Crash simulation testing for locomotive fuel tanks such as increasing structural strength or raising tanker as well as tank bladders and foam inserts.

Ellicot City Derailment

- On August 20th, 2012 just before noon a CSX Transportation train hauling 80 loaded cars full of coal partially derailed.

Background (Signal and Train Control)

- The Old Main Line is the oldest common carrier railroad in the United States; it was formerly known as the Baltimore and Ohio Railroad. CSXT inspects and maintains the track in the vicinity of Ellicott City in accordance with FRA track safety standards for class 2 and 3 track, which has a maximum operating speed of 40 mph.
- The accident occurred in a curve that has a restricted speed of 25 mph; the authorized operating speed on either side of the curve was permanently restricted to 30 mph. During an average day, 10 trains operate on the OML Subdivision.
- Train movements are governed by operating rules, timetable instructions, and signal indications from a traffic control system. An examination of recorded signal data indicated that the crew was operating on permissive signals. No track anomalies existed that would have either disrupted the track circuit or resulted in an alert being sent to the operations center.

In Detail, Cars and Inspections

- The two locomotives did not derail. The National Transportation Safety Board (NTSB) investigators mechanically inspected the locomotives and no anomalies were identified. The review of the maintenance and the inspection records for both locomotives indicated that all required Federal Railroad Administration (FRA) and CSXT mechanical inspections were current,

- The first car behind the locomotive pitched and rolled (that is, all wheels were off the track). The next nine cars overturned to the north of the track. Cars 11 through 17 derailed and fell into the public parking lot that was below the tracks. Cars 18 through 20 overturned. 59 cars did not derail.

- The 59 non-derailed cars were uncoupled from the train at the derailment site on August 21, 2012. NTSB investigators observed an airbrake test and mechanically inspected the cars. The brakes on the 59 cars applied and released as designed. No anomalies were identified with this equipment.

Fault

- Over 2 days, investigators recovered rail pieces from the derailment are and reassembled them to the west of the point of derailment. Investigators inventoried, measured, and documented each piece that was recovered and then began reconstructing the the recovered rail. While reconstructing the west portion of the north rail, investigators found that about 5 inches of rail were missing .

- Based on the inspection data for July and August 2012, investigators estimated that the length of rail from the west end of piece N1 to the location of the repaired defect in N19 was about 17 feet 1 inch (205 inches).

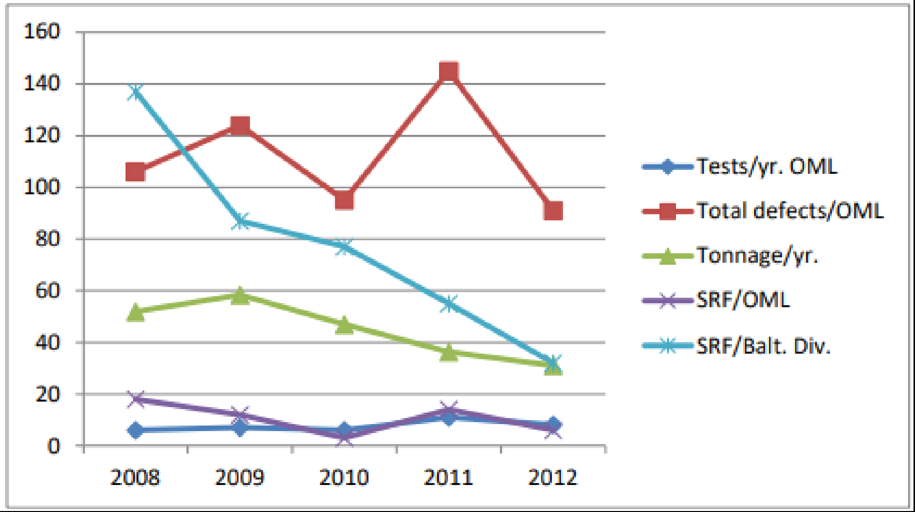
- At the accident scene on August 23, 2012, investigators examined the reconstructed rail and the fracture faces. Six rail sections and several other smaller rail pieces were sent to the NTSB materials laboratory for further examination.

- The laboratory examinations verified that 5 inches of rail were missing. The 17 feet 1 inch of rail exhibited several detail fractures; the largest was about 24 percent of the existing rail head cross section.

Testing the Track Before Derailment

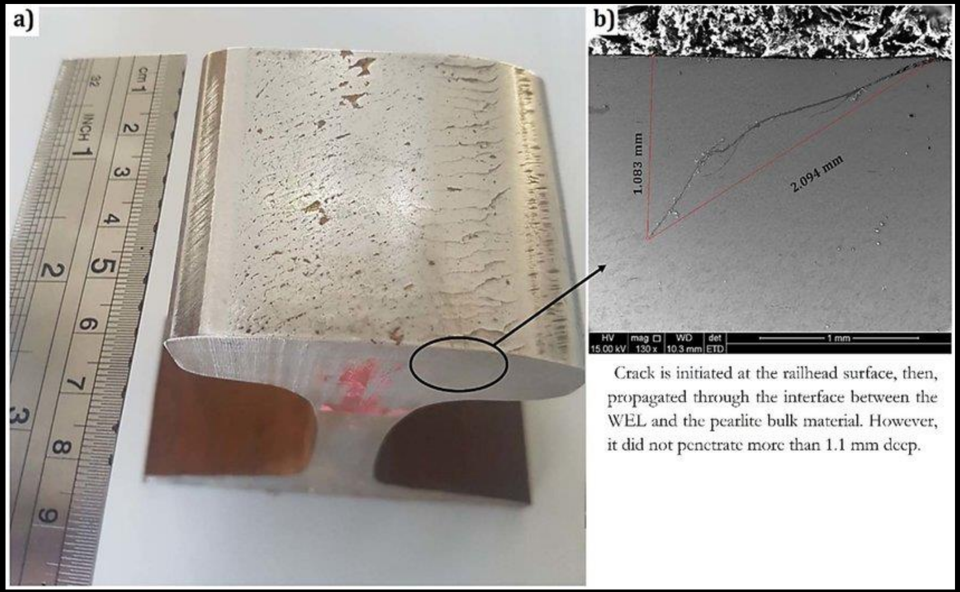
Year	Test Cycles	Total Defects OML	Transverse Detail Defects OML	Transverse Detail Defects in Curves	Service Rail Failures OML	Service Rail Failures Baltimore Division	MGT Annual Tonnage
2007							44.34
2008	6	106	57	28	18	137	51.91
2009	7	124	86	48	12	87	58.36
2010	6	95	67	44	3	77	47.00
2011	11	145	86	51	14	55	36.23
2012	8	91	44	21	6	32	31.02

- The FRA operated the Automated Track Inspection Program over the OML Subdivision on July 17, 2012. The FRA data showed no recorded defects for that test, including in the vicinity of the derailment.
- CSXT was aware of the history of rail defects on the OML Subdivision and of the increase in tonnage due to a rise in coal traffic over the previous years.
- CSXT retained a consulting firm to recommend the ultrasonic rail detection intervals. It was recommended CSXT test the OML Subdivision every 30 days.



Fault Conclusion

- At the point of derailment, the rail fractured due to a detail fracture that initiated from the head checks, patterns indicate that the primary fracture occurred at one of the ends of rail piece.
- Material properties did not appear to be a significant factor in the failure.
- NTSB investigators determined that the defect extended across just 24 percent of the remaining head area, compared to other cases where it extended from 70 to 80 percent of the remaining head area



Recommendations from NTSB and RSAC

- The Rail Safety Advisory Committee was established in September 2012 by the FRA following the Ellicott City, MD derailment and a derailment in New Brighton, PA.
- FRA through the proposed ideas of the RSCA recommended that track owners should develop and maintain a Rail Failure Prevention Program for Main Class tracks carrying 25+ milion Tons
- This includes:

1. Rail head wear guidelines, and guidelines that address the identification and management of visible rolling contact fatigue damage and improve rail performance.
2. An inspection plan that includes rail head wear measurements for comparison with established guidelines and means for identification of visible rolling contact fatigue damage.
3. Corrective actions to be taken when rail head wear guidelines are exceeded, or visible rolling contact fatigue damage is identified.
4. Training for the implementation of the procedures listed above.

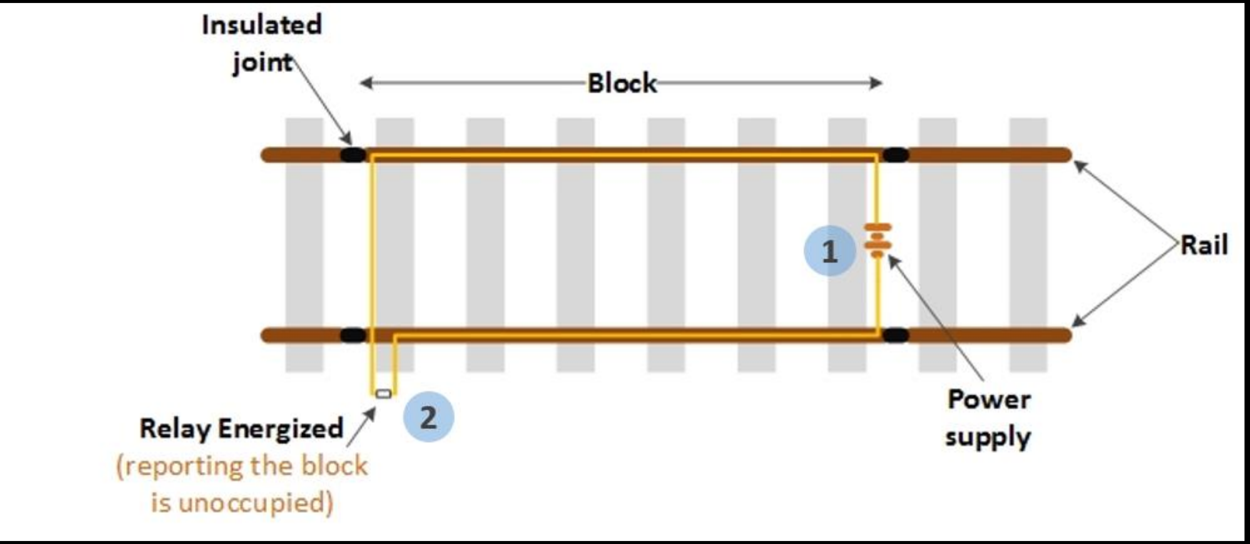
Washington Metro Train Collision

- Train on train collision, June 22 2009
- A moving train collided with a stopped train
- 8 passengers killed
- 80 injured
- Deadliest crash in history of the Washington Metro

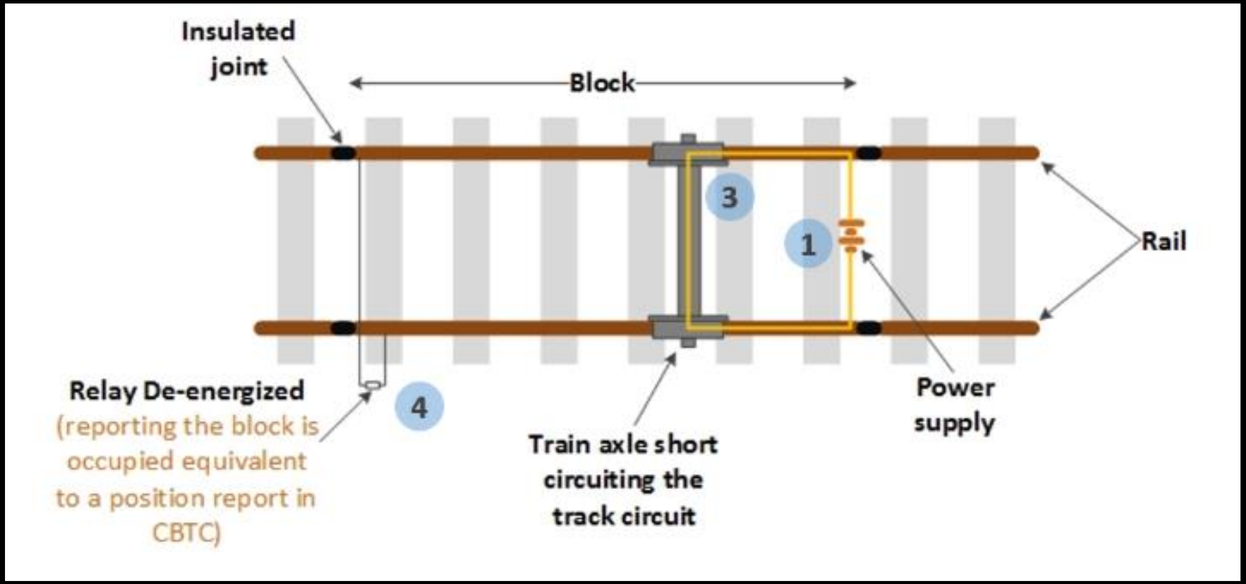
What Happened?

- On June 17th a track circuit was replaced at the site where the collision occurred
- The new track circuit suffered from parasitic oscillations – unable to communicate that the track was occupied by a train
- The still train was in the faulty circuit, so it was "invisible" to the Automatic Train Control system of the moving train
- Emergency break was applied to late

Unoccupied Track Circuit



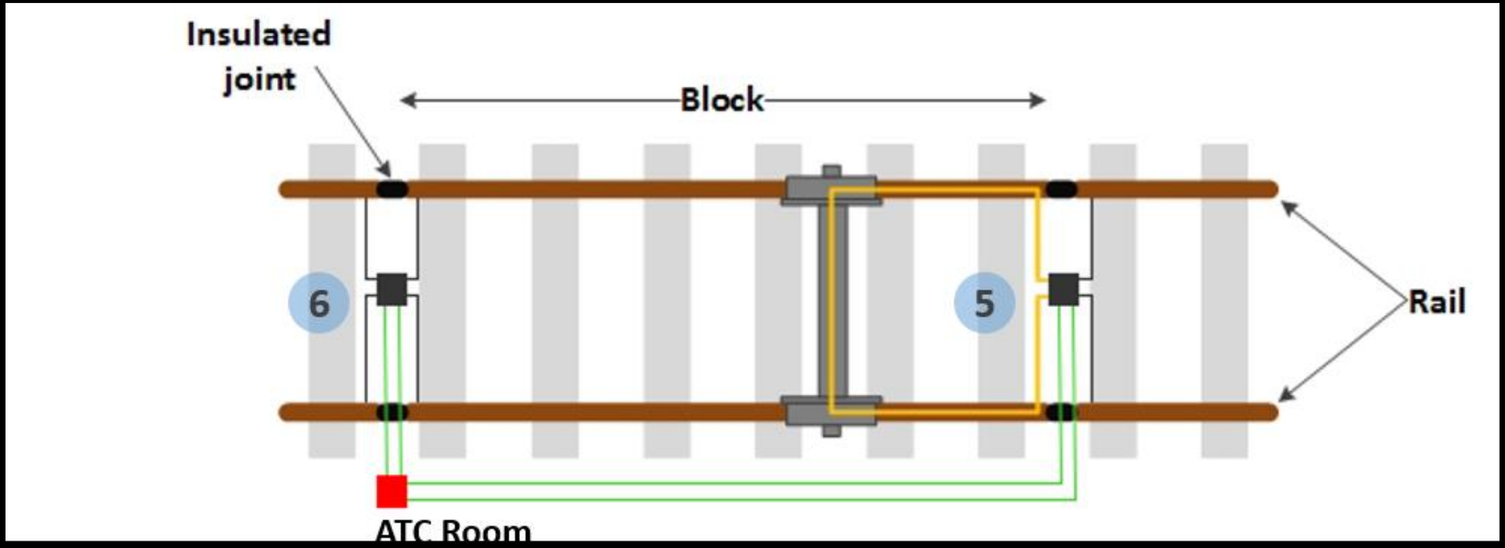
Occupied Track Circuit



How a Track Circuit Works

- Tracks are divided into blocks with signals at each end
- When the train reaches the power supply, the axle shorts the circuit which bypasses the relay
- When the relay is bypassed, a signal is sent saying that the block is occupied
- These trains must interpret the signal and take appropriate action

Metro's Train Circuit



Metro's Track Circuit

- Each block has a relay on both ends
- The bonds are split between the blocks, acting as a transmitter (5) for the first block and receiver (6) for the second
- If the transmitter and receiver have a complete circuit, then the block is considered unoccupied
- When circuit is broken the block is considered occupied, sending a signal to the Automatic Train Control (ATC)
- ATC can control the speed of these trains

What Went Wrong?

- The circuit malfunctioned, telling the moving train that the track was clear
- The first train had stopped completely inside the malfunctioning circuit
  - Other trains stopping near this spot has rolled forward enough to break the circuit in the next block
  - The first train was being driven in manual, so it was moving at a slower pace and therefore came to a complete stop on the broken circuit
- Incident was originally blamed on conductor for not applying the breaks

Failure Prevention in Track Circuits

- Test circuits more regularly
- Add more circuits to the tracks in order to keep incidents like this from happening
- Look into equipment that identifies failure in parts without having to test each circuit

Prevention of Accidents

- PTC- Positive Train Control
- Uses computers to control the trains in higher traffic areas to prevent collisions, derailments, and traveling the wrong way
- FRA is requiring that all trains that are carrying hazardous loads and commuter trains to be equipped with these
- Pay attention to railroad crossings and signs

Prevention of Derailment

- Derailment can occur if a train is going to fast around a corner, gets hits from behind, track is bet or out of alignment
- Frequent track inspection of the 140,000 miles of railway
- Prevention methods include routine maintenance and track replacement
- Upgrade and training of how PTC works
- Eliminating turns that are too sharp, ie. Seattle Accident

References

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