Exhibit 28

TRAIN WRECK

The FORENSICS of RAIL DISASTERS

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Roger W. Baugher in *Railway Age* explains the difference between vital and non-vital with a highway analogy. If car traffic is controlled at an intersection with a traffic light and the traffic light fails, everyone understands that the intersection is now a four-way stop. Traffic continues, albeit less efficiently. The traffic light is a non-vital overlay. If, on the other hand, cars are spaced on a highway every 100 feet (30 m) at 70 mph (113 km/h) with computer control, the control system must be a safety critical vital system. If anything breaks, all traffic must stop. The non-vital system is less complicated and less expensive; the vital system is more efficient.

Different railroads are responding differently to the choices of vital, non-vital, overlay, or stand alone. It may depend on how happy they are with their current signal system or on anticipated future growth. These many choices contributed to another problem holding back PTC.

INTEROPERABILITY

Main track is typically owned and operated by one railroad company, but is usually shared with many railroad companies. Computer and communications must be standardized to allow one company's locomotives to pass seamlessly into another company's territory. All railroad companies, the FRA, and equipment suppliers have to agree on technical standards for shared operations.

When Congress passed the Rail Safety Improvement Act in 2008, there were nine different railroads operating incompatible PTC systems under various stages of testing and development. Besides vital or non-vital considerations, railroad companies approached the communication and control problems with a variety of schemes. Are communications and controls located mainly on the locomotive, along the track, or at a central office?

After three years of study and negotiations, the AAR established rules for interoperability at the end of 2008; it essentially agreed on what must be standardized. Because every railroad was approaching the PTC problem with different communication and computer architecture, the problems of interoperability proved more difficult than expected. Two years later, only 3 of 40 detailed engineering specifications had been finalized. (Specifications are required for communication protocols, data management, messaging, displays, interfaces, etc.) Without completed specifications, prototype 220-Mhz digital radios are not even expected until 2012. System testing has started, with temporary radios operating at the wrong frequencies. Recall that 99.9999% reliability is required. And compare that to the reliability of today's cell phones.

A similar problem of interoperability exists in Europe. The current

slides, and transmit a warning to the train crew or dispatcher. Today trains use radio signals to activate the emergency brakes in the back of the train and to remotely control additional locomotives on long trains.

Railroad communications is a massive hodgepodge of different needs and technologies of different vintages. Currently, railroads operate about 16,000 base transmitters, 90,000 mobile radios, 125,000 hand-held radios, 12,000 trackside defect detectors, 100,000 signal lights, perhaps 50,000 signaled road crossings, and thousands of remotely controlled switches.

The Radio Spectrum Is Crowded

All electromagnetic radiation (X-rays, thermal radiation, gamma rays, visible light, radio waves, etc.) travels at the speed of light with variable frequencies or oscillations per second known as Hertz.

The Federal Communications Commission (FCC) regulates the radio spectrum in the United States. Fundamentally, its purpose is to protect the integrity of vital government communications such as the military, air traffic control, police, and firemen.

A license from the FCC allows transmission at a specific frequency (i.e., 120 megahertz, or MHz, or 120 million cycles per second). Each transmission channel is separated by a 25-kilohertz bandwidth. The FCC will approve two transmitters operating at the same frequency if they do not interfere. Interference depends on distance between transmitters, transmission power, how close the two transmitted frequencies are, and local topography. Avoiding interference also depends on the details of antenna design and many other engineering issues.

A pair of two-way radios operates at two frequencies so that both radios can transmit simultaneously, similar to how two people normally talk. Almost all railroad radio communication requires two-way transmissions and therefore requires a pair of licensed frequencies.

Up until the late 1980s, there was more spectrum than demand and radio spectrum was free. Beginning in 1994, the FCC began auctioning frequencies. With the explosion of cell phones and other wireless devices, the problem is getting worse.

In the late 1980s, hundreds of individual licenses were granted to the railroads for thousands of base stations transmitting 6 pairs of frequencies in the 900-MHz band.[14] These frequencies were reserved in anticipation of future PTC radio transmissions. In 2000, the American Association of Railroads (AAR) petitioned the FCC to combine all the licenses into one single license to be administered by

Meanwhile, cell phone use exploded and gobbled up unused 900-MHz spectrum. The railroads had to start over. In October 2008, four major railroad companies agreed to standardize PTC at 220 MHz. The problem is especially acute in metropolitan areas, where the radio spectrum is most crowded. Railroads are still hoping for FCC intervention to obtain more spectrum.

To create more channels the FCC is phasing in a reduction of the current channel spacing of 25 kHz to 12.5 kHz by 2013. All existing radio transmitters must be replaced to transmit on 12.5 kHz channels. A further reduction to 6.25 kHz is anticipated in the future.

Meanwhile, the railroads are scrambling to obtain required

spectrum. Los Angeles's Metrolink, working with Amtrak, Union Pacific, and BNSF, agreed to fast-track PTC in metro Los Angeles by 2012. (Recall the 2008 collision in Los Angeles that killed 25; see the beginning of Chapter 1.) As of early 2012, Metrolink was still battling a year-long legal challenge blocking the FCC from assigning 40 channels of 220 MHz spectrum for its new PTC system. The Southern California Regional Rail Authority is struggling to design a resilient communication network with sufficient redundancy to be 99.99% available even after cable cuts, earthquake, fire, and power failures. With key technology still unavailable, the 2012 deadline (promised since 2008) has now officially slipped into 2013.

To reduce wireless PTC transmissions on crowded spectrum new methods are being used to transmit information. In Los Angeles a communication network is being designed with digital microwaves, fiber optics, and copper cables. New software is required to manage the digital system and provide system redundancy.

Analog versus Digital

Analog versus Digital

The world is an analog place with infinite resolution. The computer world is digital; everything is described with a binary system —1's (on) or 0's (off). Computer resolution is limited to the maximum number being processed by the computer. An old-fashioned analog image on film can be magnified to the limits of a light microscope, whereas magnification of a digital image is rapidly limited by the number of pixels available.

An analog signal is digitized by sampling the signal and converting the analog signal into numbers suitable for computer input. The more numbers sampled, the better the digital representation of the analog signal, but of course it takes more computer effort to process more information. As the computers became bigger and faster, digitization became increasingly more accurate and useful.

Why bother to digitize analog information? Once the analog information is inside the computer, it can be manipulated. In the case of digital images, red eye can be removed or blurry images can be sharpened.

The opportunities for the railroads are enormous. Once all the signals are digitized and collected in one place, the entire rail network can be optimized. The communication problems for the railroads are immense, however, and Positive Train Control remains to be conquered.

Currently, all railroad transmissions are designed and optimized for voice analog communications. All signal, data, and voice communications must be digitized. The railroads must meet the FCC deadline to convert all radio transmitters to 12.5-kHz narrow band by

2013, design for the 2015 FRA PTC deadline, and anticipate future bandwidth reduction to 6.25 kHz.