ORAL PRESENTATION OF STEVEN R. DITMEYER
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POSITIVE TRAIN CONTROL FORUM
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Panel 1 – Positive Train Control (PTC) Systems as Envisioned versus Implemented

Chairman Hersman, Vice Chairman Hart, and Members of the National Transportation Safety Board, I thank you inviting me to speak at this PTC forum. My presentation will focus on what was originally envisioned by the people working on the earliest version of PTC, the Advanced Railroad Electronics System (ARES), in the 1980's and early 1990's.

ARES was based on aviation electronics, or avionics. The new chairman of Burlington Northern Railroad (BN), Richard Bressler, was curious if new developments in avionics had any applicability to railroads. I had just arrived at BN as Director of R&D in late 1981, so I got in contact with Rockwell International's Collins Air Transport Division, and they agreed to work with BN to see what the possibilities might be.

By late 1983, BN and Rockwell realized that the technology was available to implement an integrated command, control, communications, and information (C^3I) system on a railroad. They then proceeded to work together to design the system that became known as the ARES, based on digital communications and the global positioning system (GPS). Rockwell assigned as head of its new Railroad Electronics business unit Ronald McGraw, who had been in charge of Rockwell's development of the avionics for the Boeing 757 and 767 aircraft and who was the son of a locomotive engineer for the Chicago & Eastern Illinois Railroad. He knew how railroads operated, and he knew how avionics were specified, designed, manufactured, and used.

Following a presentation on ARES that I made to the BN Board of Directors in July 1985, BN senior management committed to a demonstration of the ARES PTC system on the Minnesota Iron Range. BN contracted with Rockwell to serve as designer and system integrator of ARES. Rockwell would write form, fit, and function specifications for the components so that BN, when implementing ARES, could competitively procure the components from multiple vendors. BN, recognizing that it did not have people within its organization with system integration skills and knowledge of radionavigation systems to manage the ARES program, hired three retired senior Air Force officers who had served in the GPS Joint Program Office.

The ARES PTC demonstration on the Minnesota Iron Range involved 250 miles of track, 17 locomotives, 3 maintenance vehicles, and a control center in Minneapolis. It was operational for 5 years, from 1987 through 1992. A portion of the territory had centralized traffic control (CTC) on it, a portion had automatic block signals (ABS), and yet another portion was dark (unsignaled) territory. ARES worked the same way on each of these different territories.

Dispatchers, using the control center computer, issued movement authorities to train and maintenance crews in the same manner, tracked the location of the trains and maintenance vehicles, and could remotely intervene to enforce movement authorities. The control center computer continually updated the operating databases with information on the location of trains, locomotives, cars, and crews.

The locomotive on-board computer would compare actual train location and speed with the locations and speeds specified in the movement authorities, and if the on-board computer sensed that the locomotive crew was not complying with the movement authority, would automatically enforce it after first warning the crew.

Here are the principal characteristics of the ARES PTC system:

- It was based on a new paradigm: *real-time, precise, continuous information* about the location and speed of trains and maintenance vehicles and the principle that no two things can occupy the same space at the same time.
- ARES was not based on the traditional paradigm of using track circuits to determine track block occupancy, and signal systems using relay logic to determine what authority could be granted to a train.
- ARES continued to use existing track circuits for broken-rail protection but did not use them for train location.
- ARES was not connected with intermediate wayside signals.
- ARES used commercial, off-the-shelf digital data radios and the railroad industry's FCC-assigned 160 MHz radio channels.
- To obtain very accurate information on train and maintenance vehicle location and speed, information obtained from GPS receivers was integrated with information from on-board odometers, switch position indicators on all switches, and map-matching algorithms in on-board computers, and this information was automatically transmitted to the control center computer.
- A locomotive throttle-brake interface was connected with the on-board computer.
- ARES had both graphical and textual displays in the locomotive cab.
- ARES received data from AEI and Work Order Reporting systems and merged it with UMLER data and waybill data so that accurate train consists, train weights, and train lengths were known and that end-of-train locations and train braking distances could be determined.
- ARES received data from all wayside defect detectors.
- ARES used data from the Locomotive Analysis and Reporting Systems on the status of propulsion and braking systems – both air and dynamic – so that acceleration rates and braking distances could be calculated.
- ARES connected with the control center computers and the tactical and strategic traffic planners so that real-time position and speed of trains and maintenance vehicles could be used to better predict the future location and speed of them for more efficient dispatching of the railroad; collision avoidance and improved allocation of space and time on the track were combined at a single workstation.
- Analyses showed that ARES would reduce the dispatchers' *communication load,* improve the dispatchers' *communication efficiency and speed,* increase the dispatchers' *communication precision,* radically change the dispatchers' *communication focus* (traffic planning and problem solving would replace

information gathering and movement authorization as dispatchers' primary tasks), reduce dispatcher *job stress,* and increase dispatcher *productivity*.

- ARES implementation would not be limited to passenger train or hazardous materials routes; benefits compounded as more of the network was tied together.
- ARES would make possible the creation of a new, simpler code of operating rules to replace the current GCOR and NORAC rulebooks that were based on an assumption of delayed information flows.
- ARES would affect most every department of the railroad, just as air brakes and knuckle couplers did 100 years ago, as diesel locomotives did 60 years ago, and as deregulation did 30 years ago.
- The ARES project team had full-time representatives from all affected departments of the railroad.
- ARES was built on the philosophy of ensuring that timely and accurate information got to where it was needed, when it was needed, and to those who need it most.

BN and Rockwell management recognized early that the cost of a system like ARES would not be justified if only the costs of the accidents prevented were considered. They realized, though, that the real-time, precise, continuous information about the locations and speeds of trains and maintenance vehicles could also be used to obtain business benefits, such as improved meet-pass planning, shorter running times, closer spacing between trains, reduced fuel consumption and emissions, improved productivity of maintenance crews, and higher asset utilization. The benefit-to-cost ratio of a system-wide implementation of ARES was calculated to be approximately 3-to-1. BN conducted analyses on all these business benefits, and they were summarized in a Harvard Business School case study in 1991.

Union members were brought in early in the project to help design the ARES cab and dispatcher displays and to receive training. BN communicated regularly with its unions about ARES, recognizing that their members were the people who would install, operate, and maintain the system. And the unions were quite supportive of the ARES program.

BN hired The Charles Stark Draper Laboratory to help oversee the development of the system and analyze its safety. Draper Lab had served as a systems designer and system integrator for NASA, the US Navy, and the US Air Force on many C^3I systems projects. Draper Lab used Markov modeling techniques that showed that ARES would reduce the probability of collisions and overspeed accidents on the BN system by a factor of 100. The safety of ARES PTC systems derived from an integrated, fault-tolerant architecture that provided checks and balances to limit the impact and propagation of human error. In its analysis, Draper Lab used component failure rates based on avionics failure rates supplied by Rockwell with consideration of the railroad environment.

BN invited railroad executives, union officials, shippers, FRA and NTSB staff, Congressional staff, and journalists to the Minnesota Iron Range to observe the ARES PTC demonstration, and, in 1992, brought one of its ARES-equipped locomotives and an office car to Washington Union Station for a week to demonstrate the functionality of

ARES to others, including AAR, TRB, ICC, World Bank, and Amtrak staff. BN management decided to place technical reports, brochures, and videos in the public domain so that others could learn from BN's experience.

I thank you for the opportunity to make this presentation. I would be pleased to answer any questions you might have.