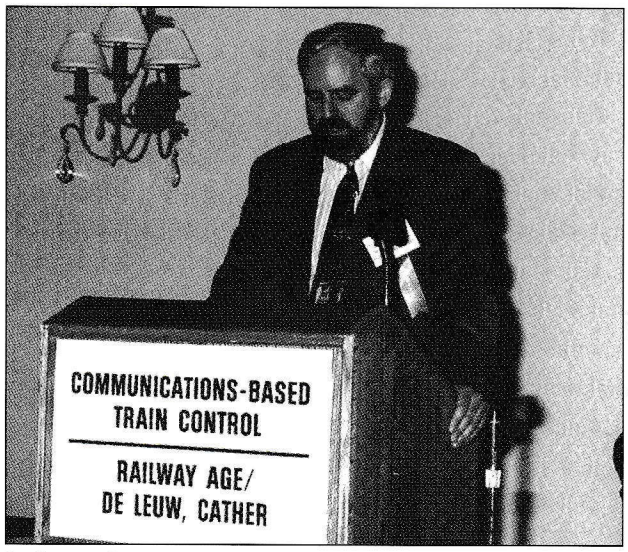
Where we are, where we're going

In a conference co-sponsored by Railway Age *and De Leuw, Cather, railways, suppliers, and consultants discussed the pros and cons of communications-based technology.*

By WILLIAM C. VANTUONO
Managing Editor

Communications-based train control, with applications in both rail transit and freight railroading, is fast emerging as an accepted, available technology that will most likely become the mainstay of rail industry signaling and train control equipment and practices. The concept of train-to-train and train-to-wayside communications without the use of track circuits is no longer the object of speculation on the part of suppliers, and the benefits of such technology, in terms of efficiency, capacity, and safety, are readily apparent to potential users. One of the biggest challenges the industry faces is the development of standards, and for this, cooperation among users and suppliers is essential.

These were some of the conclusions reached at the first International Conference on Communications-based Train Control, held May 9-10 at the Crystal City Marriott, near Washington, D.C., and co-sponsored by *Railway Age* and De Leuw, Cather & Co. The more than 180 participants came from all areas of the industry: rail transit properties, freight railroads, consultants, and the supply community. And they came from all over the world, as close as New York City and Washington, as far away as Hong Kong and London. While many different experiences with and applications of the technology were discussed, there clearly emerged more consensus than conflict, and a stronger desire to cooperate than compete.



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De Leuw, Cather's Alan F. Rumsey called for a partnership of operators, engineers, consultants, suppliers, regulators, and funding agencies, "working towards a common goal."

● **Evolution or revolution?** Why is communications-based (C-B) technology taking such a strong foothold, and so rapidly? De Leuw, Cather's Alan F. Rumsey offered an answer in his opening presentation. He said "the processing power and data communications capabilities inherent with such systems offer train control opportunities that significantly exceed those which are possible with other signaling and train control concepts." The challenge that faces the industry, Rumsey said, is how to fully exploit these opportunities.

Rumsey said there are two ways to approach C-B technology: the "evolutionary" and the "revolutionary."

"The evolutionary view," Rumsey said, "regards this technology as simply the next step in the over 100-year evolution of railway signaling, which has included developments such as absolute block working, semaphore signals, mechanical interlockings, track circuits, color-light signals, train stops, relay-based interlockings, cab signaling, automatic train operation, and, more recently, the use of processors in vital applications." This view is more technology-oriented, regarding C-B train control "as a technique for overcoming operational limitations of track-circuit-based systems, as a replacement for obsolete equipment, and as a means for minimizing wayside equipment." It also tends to minimize changes in established practices for design, procurement, operation, and maintenance.

Rumsey characterized the evolutionary view as a "bottoms-up" approach that concentrates primarily on the train protection elements of train control. In contrast, the revolutionary view is a "top down" approach that emphasizes operational requirements of the total transportation system, rather than the specifics of the train control technology. It is "a totally new approach, focusing on service delivery to customers, with the objective of maximizing operational and customer service benefits," Rumsey said. In this respect, C-B technology can be considered part of a package that includes such other elements as information management, passenger assistance, traction power subsystems, etc. It would also be designed, procured, operated, and maintained in a "non-traditional" manner.

Which view is more appropriate? Neither, said Rumsey: "If we approach this technology too heavily biased towards the evolutionary view, I would suggest that we are missing an opportunity to take a significant step forward in train control capability. If we are too strongly biased towards the revolutionary view, we run the risk of building a system design on unsure foundations. The key, therefore, is to strike an appropriate balance." Rumsey called for a partnership of operators, engineers, consultants, suppliers, regulators, and funding agencies, "working towards a common goal."

● **Technology overview.** Since *Railway Age* last reported on the efforts of suppliers in developing C-B systems (*RA*, June 1994, p. 41), significant progress has been made in a number of areas. About one dozen suppliers are now developing C-B systems for railroad and rail transit applications. In general, technological advances have contributed greatly to the feasibility of C-B systems. The speed and performance of microprocessors has

improved dramatically. The memory capacity of a typical semiconductor has grown, while at the same time, its cost has dropped. Advanced communications technologies originally developed for military applications such as GPS and spread-spectrum radio are now available for commercial use. And, there have been many advancements in vital processing techniques.

As to communication methods, the one now receiving the greatest amount of attention in the industry is high capacity, bidirectional, radio-based communication, which can be established via a free-space ("point-source") or distributed ("leaky-coax") antenna, the latter more suited to use in tunnels. As to the type of radio signal employed, spread-spectrum, a modulation method that spreads digital information over a wide bandwidth so that interference will affect less of that information, appears to be where the industry is headed. Spread-spectrum radio also does not require FCC licensing at present, as do dedicated radio channels, which in some areas are difficult to obtain.

Spread-spectrum radio systems using either the 900 MHz or 2,400 MHz (2.4 GHz) ISM (Industrial, Scientific, and Medical) band are being developed, and some suppliers have formed partnerships with communications companies to develop the RF portion of their train control systems. For example the consortium of General Railway Signal, Sensis Corp., Watkins-Johnson, Sasib Railway, and Battelle, which is developing the ATLAS (Advanced Train Location & Supervision) system, is employing a spread-spectrum radio developed by Watkins-Johnson. AEG Transportation has teamed with Andrew Corp. to develop a radio for its Flexiblok system. Safetran offers its own spread-spectrum radio, called S^3/Link.

There are two spread-spectrum techniques: frequency-hopping, also called time-hopping, and direct sequence. Some in the industry believe that frequency-hopping is the better of the two because it allows for fast signal acquisition and synchronization. The direct sequence method, however, while possibly requiring a much more complex system-wide synchronization to be maintained, is said to make better use of the available bandwidth, providing a better signal-to-noise ratio.

Most suppliers of train control equipment are well-advanced in their development of C-B systems. Harmon Industries, for example, has won a grant from the Federal Railroad Administration and the state of Michigan to demonstrate its ITCS (Incremental Train Control System) on an Amtrak-owned segment of the Chicago-Detroit freight/passenger corridor, where high speed trains could be brought into the traffic mix. ITCS is designed to enforce stops at interlockings, restricted speed for following moves, timetable speeds and civil speed restrictions, temporary slow orders, and m/w crew protection. Harmon also offers the UltraBlock system for rail transit applications.

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If a project is to keep moving, said CANAC International's Bill Moore Ede, "workable" solutions to problems are needed, rather than "perfect" solutions.

Alcatel, MATRA, GEC Alsthom Signarail, and Siemens are advancing proven systems (such as SELTRAC, the SACEM overlay system being installed on Paris RATP regional rail lines, and LZB, used on high speed ICE lines in Germany) to include C-B capabilities (all were originally developed with inductive-loop technology). ABB Signal is offering a radio-based grade crossing warning system that will be tested by Amtrak on the Northeast Corridor (*RA*, May, p. 43). HMK (Hughes and Morrison Knudsen) is moving rapidly towards demonstration of the AATC (Advanced Automatic Train Control) system being developed for San Francisco's BART.

Interoperability is a key concern, and to that end, Union Switch & Signal is developing the communications subsystem of its MicroBlok train control technology to be decoupled from the train control subsystem, thus allowing MicroBlok to be integrated with many communications subsystems. US&S said it will use standard communications protocols to ease integration with other systems. GRS plans to offer open-architecture interface protocols that will allow its ATLAS system to communicate with others.

Despite the progress being made, many questions remain: Has an environment necessary to encourage innovation been established? Should suppliers be willing to divulge the details and provide data rights of their system designs, practices that may be needed to assure future competition? And, are potential users of C-B systems discouraging suppliers from investing in new technologies by increasing risk, or by preventing a return on investment in proportion to the risk undertaken?

● **World-wide projects.** Ten properties came to the conference to report on the status of C-B projects: RATP, Toronto Transit Commission (TTC), Hong Kong Metro (MTR), London Underground, Burlington Northern and Union Pacific, San Francisco's MUNI and BART systems, Philadelphia's SEPTA, Boston's MBTA, and MTA New York City Transit.

RATP will be installing an overlay SACEM system, supplied by MATRA, on RER (regional rail) Line A to reduce peak-hour headways from 150 to 120 seconds. SACEM, though not originally designed with bidirectional radio-based communications, does contain a large base of engineering design and safety-critical software upon which a C-B system can be developed. Originally developed for RATP by MATRA, GEC Alsthom, and CSEE Transport, SACEM also features an advanced maintenance component with self-diagnostics.

On MTR, said Franco Fabbian, the existing fixed-block system accounts for 30% of all failures. Like RATP, Hong Kong has a critical need to increase system capacity during peak hours, from 32 trains per hour to 34. To increase reliability and vehicle throughput, MTR will be installing a SACEM system supplied by GEC Alsthom.

London Underground will be installing a C-B system on its 22-mile Jubilee line. Westinghouse Signals Ltd. is supplying the radio-based (licensed VHF) wayside portion, and Alcatel is supplying the central control portion.

In San Francisco, BART has received a $19.5 million U.S. Department of Defense ARPA (Advanced Research Pro-

C-B technology: the supplier's viewpoint

JENNIFER D'ANNA

Left to right, seated: John Brohm (Alcatel Transport Automation), Karl Dobler (ABB Signal), Chuck Gibson (AEG Transportation Systems), Bob Glines (General Railway Signal), Bob Heggestad (Harmon Industries), Wagih Marcos (GEC Alsthom Signarail), John Marino (MATRA Transit), Bill Petit (Safetran Systems), Jim Egnot (Union Switch & Signal), Jorg Schutte (Siemens Transportation Systems), Marvin Swensen (Hughes Aircraft). Standing at left: Roundtable moderator Frank Swithers (De Leuw, Cather).

What issues concern potential suppliers of C-B technology? Eleven supplier representatives came together in an informal roundtable session to discuss what they feel are the most pressing ones.

With the tremendous investments being made by suppliers in research and development, all agreed that a cooperative effort must be made to develop standards, so that equipment from many suppliers can work together within the same train control system. "It's not so important that I know what's in my competitor's 'black box,'" said one supplier, "as long as my black box can talk to theirs."

There was little doubt as to the acceptance in the industry that C-B technology is now enjoying, especially in terms of what it offers to users: "In a period of dwindling dollars, C-B train control offers tremendous life cycle benefits," said GRS's Bob Glines. Added Union Switch & Signal's Jim Egnot: "This is the next logical step we need to take as an industry." Investment in advanced train control technologies offers "more bang for the buck," said MATRA's John Marino, "because it can accomplish the same goals as adding cars and infrastructure."

But if the industry is to take the next step, suppliers, consultants, and users must work together to not only develop standards, but to agree on how new technology should be procured, tested, and implemented. Partnerships, it was agreed, are needed now more than ever, especially since C-B technology is still evolving.

Compatibility, though, may rest to a large degree with users of C-B technology. "Have we ever seen two users that can agree on the same system?" said Harmon's Bob Heggestad. "Look at ATCS. The [freight railroads] have not really embraced it on a large scale, even after ten years' worth of R&D." But, added Safetran's Bill Petit, "the railroads did come up with a set of ATCS specifications. We need to do the same."

Still, suppliers, especially those that are investing heavily in R&D, are a bit wary: "We are seeing a lot of fragmentation among customers," said Petit. "It's a big gamble to go in one direction and then lose the bid."

These general recommendations came out of the discussion:

—When equipment from more than one supplier is involved, liability comes into play: Who is liable for the interface? Guidelines must be established. For overlay systems, where existing equipment is to be retained or gradually phased out, more responsibility should be borne by the user. And, safety practices must be developed for overlay installations.

—Performance specifications are usually desirable over design specifications. "The key is balance," said Egnot. "Using an RFP at the outset is the way to go. The industry knows how to solve problems—the same issues existed for audio-frequency track-circuit-based systems."

—Although any system will be designed to fail in the safe mode, "fail-safe" should not mean "fail-stop." There should be a way to keep trains moving, if only at a degraded level.

—Systems should have simulation capability to minimize the impact on resources and infrastructure during testing and certification.

—Though both are important, the concepts of availability and safety should be kept separate.

jects Agency) Dual-Use grant to implement C-B train control. This is supplemented by $12.5 million from HMK, which is adapting the Hughes EPLRS (Enhanced Position Location & Reporting System) developed originally for military use. By commercializing and creating a dual use for EPLRS, this program is meant to leverage investments already made by DOD, creating a greater economy of scale.

Also in San Francisco, MUNI is approaching start-up of the SELTRAC system installed in its Market Street tunnel, where five lines merge into a single dual-track line. Sixty trains per hour, with 40-second times between departures at the Embarcadero Station terminus, are MUNI's desired operating goals.

SEPTA and MBTA are investigating C-B technology, SEPTA for light rail tunnel operation, MBTA for the Green Line light rail system. Both lines currently use a basic form of automatic block signaling, and both agencies are considering long-term plans. SEPTA wishes to initiate a final design process for a C-B system within two years, with installation complete by 2002. MBTA is looking at an 11-year, incremental installation of C-B technology, and an investment of about $98.5 million will be needed.

The two North American rail transit properties to watch are NYC Transit and TTC. Based upon recommendations from its second peer review process (*RA*, June 1994, p. 41), and meetings with potential suppliers, NYC Transit will procure its first C-B system using consultant-developed performance specifications and an RFP (request for proposals). Compatibility is an especially important criterion. According to Tom Sullivan, director-New Technology Signals, teams or temporary joint ventures of suppliers that agree to

PTS: Coping with the "if" factors

WILLIAM C. VANTUONO

Bob Gallamore, general director-strategic analysis, Union Pacific.

It might be a relatively simple matter for railroads to adopt positive train separation systems—if there were not so many factors beginning with "if," several of them beyond the control of the industry itself.

Union Pacific's Bob Gallamore, general director-strategic analysis, listed some of the "positives" at the recent *Railway Age*/De Leuw Cather conference:

—New locomotives are more powerful, meaning that there will be fewer of them to be equipped for PTS. In addition, these locomotives provide "a more friendly environment" for PTS equipment.

—Computers and telecommunications devices have been improved in power, reliability, and flexibility, even as they have come down in price.

—The satellite Global Positioning System has been fully deployed, providing a cost-effective location determination system.

—Electronic control of train brakes is coming and is in the here-and-now for locomotive brakes; electro-pneumatic brakes "fit beautifully with the PTS architecture and concept of operation. They will allow even more precision in the braking algorithm and, of course, faster propagation of the braking signal."

So far, so good. But, Gallamore added, there are several factors that have to be considered, only the first of which is fully within the railroads' control:

"A significant barrier to full deployment of PTS is the difficulty in arriving at an industry standard. Different railroads have different geographies, traffic densities, operating rules and practices, investment strategies and horizons, work force profiles, signaling and communications infrastructures, and locomotive fleet characteristics. All of these factors bear on 'interoperability standards.'"

Uncertainty as to where the industry may be headed with PTS and positive train control "has probably deterred vendors from investing in product development to the extent they might have. We hope that the UP/BN initiative will change that perception." That initiative is the joint project on PTS in the Pacific Northwest, with participation by a number of suppliers and with Harris Corp. as the systems integrator.

Then there is the Federal Communications Commission's policy on allocation of radio frequencies. FCC has had these issues under consideration for months. And as Gallamore put it, "The pending 'refarming' proposals for 160 MHz communications have to be resolved. It is worth noting that the FCC, by considering spectrum auctions that could threaten our [railroads'] 900 MHz frequencies, has already put a chill over us. We need to be guaranteed availability of railroad-only communications channels, allocations that won't be changed during today's generation of technology, or the whole PTS idea will collapse."

Finally, Gallamore said, "We need to be guaranteed full-time GPS accuracy to a minimum resolution of about 50 feet. We are counting on the U.S. Department of Transportation's assuring that this will be accomplished as part of the National Transportation Plan. If the Coast Guard's GPS system is propagated nationwide, that will suit our requirements splendidly, but other solutions are possible. If DOT doesn't come through for us, PTS can't be done."

At this point, there is at least a fair degree of confidence that the scenario will turn out to be best-case, not worst-case.

DOT, through the Federal Railroad Administration, is supportive of the PTS initiative, and it's supportive of railroad goals in the long-running FCC affair as regards refarming. The Coast Guard, of course, is a part of DOT, so the availability of the GPS system may not be a major problem, if an administrative decision is all that's required.

—Gus Welty

build a common system are likely to receive favorable consideration during the short-listing process.

NYC Transit will short-list two or three suppliers or joint ventures that will each perform a one-year test program on separate portions of the L Canarsie line, after which one system will be selected as NYC Transit's standard design. Form, fit, and function specs of the successful system will then form the basis of fully compatible systems that can be built by any number of suppliers. Testing on the Canarsie line is scheduled to commence in 1998, with full resignaling of the line to be complete by 2003.

TTC's procurement of C-B technology for its Eglinton West and Sheppard extensions is similar to NYC Transit's, but is progressing at a quicker pace. Nine suppliers originally expressed interest; seven were invited to participate, and five remain: ABB Signal, AEG Transportation, GEC Alsthom Signarail, GRS, and Harmon Industries. A six-week, off-peak-hour demonstration is scheduled for the Young/Spadina line for mid-1996. This will be followed by an RFP and contract award in mid-1997.

On the freight side, the PTS (Positive Train Separation) project is progressing as a joint venture of BN and UP, with Harris Electronics Systems Sector as systems integrator. PTS is being designed as an enforcement mechanism overlaid on the existing signal system. It uses RF communication links to deliver movement authorities to trains, deliver occupancy authority to m/w crews, and return position reports to a central computer. PTS is meant to improve existing levels of safety by insuring that signals are obeyed before a violation occurs—correcting human error—and by enforcing speed limits. Other benefits such as increased train throughput and fuel savings through better locomotive utilization are possible.

As on transit properties, remarked UP's Bob Gallamore, general director-strategic analysis, "difficulty in arriving at an industry standard is a significant barrier to full deployment of PTS" on freight roads. There are other concerns as well, including pending refarming proposals by the FCC of 160 MHz radio frequencies, possible auction of the 900 MHz spread-spectrum band, and uncertainty as to whether the U.S. DOT will move ahead with upgrade of GPS to DGPS (Differential GPS). (See sidebar, above.)

- **Commuter and high speed rail opportunities.** Since most commuter trains run on rights-of-way that are owned

and operated by a "host" carrier (typically a freight railroad), the commuter operator's only access to, or "window," to the operation is through contact with the operating side of the host railroad. The same would be true for high speed passenger trains operating on freight trackage. "The first thing I would like to have," said CANAC International's John Reoch, "would be a clear, unhindered way of looking into my own operation and knowing in detail what is really going on without having to rely on someone else to relay the perhaps-filtered information to me."

C-B technology, said Reoch, offers the technological means to obtain information at an affordable cost. It could, for example, be used to provide information to passengers such as:

—Reasons for train delays.

—Estimated arrival times.

—Advance warning of track/platform changes.

—Warning of the approach of trains (express, freight, etc.) that might be operating at unexpected times.

It could also be used be used as a means of capturing and recording operating statistics used by the host railroad for auditing purposes, and for verifying penalties and incentive payments. Such information could include:

—The number of trains and train-miles, split as required.

—Ontime performance by route and station.

—The number of operational anomalies against which penalties are assessed.

For high speed trains, the same capabilities would be desirable, with the addition of two elements:

—A system to monitor seat occupancy, so that an available seat could be sold in the event of a no-show.

—A grade crossing warning system that could detect the presence of a vehicle on the crossing.

There are three levels of system capability, Reoch said, that could be used:

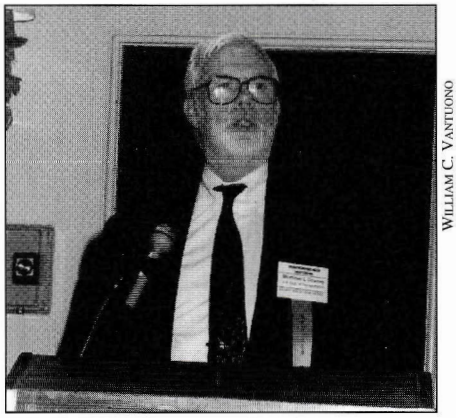
—Stand-alone monitoring, in which the operator provides a self-contained system that does not rely on information from the host railroad.

—Integrated monitoring, in which additional functionality is gained by supplementing the information from the first level with information acquired from the host railroad.

—Integrated control, which provides a moving-block capability through a full C-B system provided by the host railroad.

• Exploiting operational benefits. "To fully exploit the operational capabilities of a C-B train control system, a structured design approach, beginning with a clear definition of operational requirements, must be established early in the design process," said Alan Rumsey. "A close working relationship between operators and suppliers is essential in order to develop economically achievable system requirements."

Transit operators in particular, he said, can be freed from the constraints of fixed-block technology, and can be provided flexible operations limited only by rolling stock performance, available right-of-way, and safety requirements associated with train separation, overspeed protection, and interlocking control. In addition, said Rumsey, the future operational needs of the user must be understood.



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U.S. Deputy Transportation Secretary Mortimer Downey said that C-B technologies are "a sound investment . . . that will transform transportation."

• Detailed specs for interchangeability, safety? To what level should specifications for safety and interchangeability be developed? "Safety should be addressed as a total system approach, with functions distributed like operational functions," said Gary Pruitt, ARINC's program manager-surface transportation systems. "Safety should be a functional requirement, not a technology driver." As such, he said, system architecture should be "requirements-driven," not "technology-driven."

Standardization goals, said Pruitt, can be tailored for individual applications through systems engineering. There are various levels where standardization can be accomplished: train to wayside, "box to box," and, at perhaps the most complex level, "card (circuit board) to card." The best approach, according to Pruitt, is to standardize form, fit, and function at the box level—basically a matter of logistics.

• Learning from past experience. Bill Moore Ede, a specialist in advanced control systems at CANAC International, described some of the more significant conclusions that were reached during Canadian National's ATCS/PTS Test Bed program, which began in the late 1980s, and which included two pilot projects (in the Toronto area and on CN's BC North Line), plus an ergonomic study of a locomotive engineer's display. Although these projects were developed for freight applications, some conclusions were reached that could apply to C-B technology in either a transit or freight environment:

—Until there are proven and mature systems available "on the shelf," there will need to be a very close working relationship between user and supplier.

—If a project is to keep moving, "workable" solutions to problems are needed, rather than "perfect" solutions. "The search for perfect solutions will take longer because of the different perceptions of perfection," said Moore Ede.

—Detailed specifications should be prepared at the outset identifying functional requirements (including normal and abnormal situations), safety functions (reactions to failure conditions), and performance expectations. It is important, noted Moore Ede, that the "whats" be specified, rather than the "hows." The end result should be system requirements that can be tested, in order to judge success or failure.

—A test plan for commissioning should be established at the outset.

• The federal government's role. Both the Federal Railroad Administration and Federal Transit Administration have been actively participating in the development of C-B technology. C-B train control systems, said U.S. Deputy Transportation Secretary Mortimer Downey, "are a sound investment . . . the forerunners of a new generation of communications- and information-based technologies that will transform transportation."

Aside from providing funds for pilot programs (such as FRA's support of ITCS testing on a mixed-used corridor), how deeply does DOT plan to get involved in promoting and developing standards?

"The federal government does not wish to be prescriptive about standards," said FTA's Larry Shulman, associate administrator-technical assistance and safety. "The development of common functionality, practices, architectures, and standards belongs in the realm of users, service providers, suppliers, and professional associations. The federal role in this area will be participatory, one of a catalyst . . . supportive of industry consensus." RA

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