CBTC Radios – What to Do? Which Way to Go?

Industry Standard? Commercial off the Shelf? Or Custom designs? About the only thing the transit industry is able to agree upon is that it cannot.

By Tom Sullivan

Continuous bi-directional communications forms the heart of CBTC technology. By using two-way communications instead of traditional fixed block track circuits some transit operators have been able to realize significant performance improvements while at the same time increasing safety and lowering operating costs.

Consider San Francisco's Muni Metro. With CBTC technology it has been able to double the number of trains/hr in its Market Street Subway. But Muni's Alcatel Seltrac CBTC, like LZB its 1970's German predecessor , is based upon a "near-field inductive loop" operating on a 56 kHz carrier. Today, most new "RF CBTC" systems are operating in the GHz range, or about a million times faster.

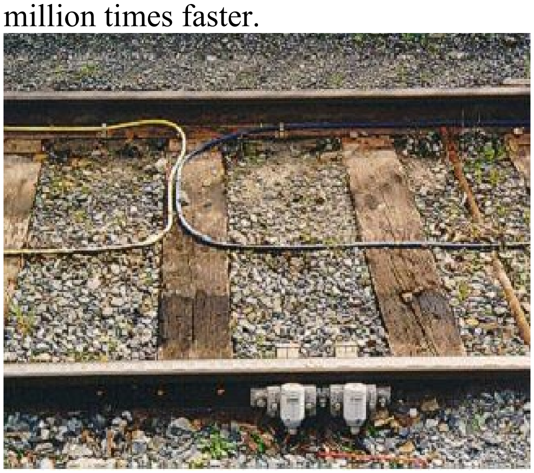

Photo1. Inductive Loop CBTC such as this one at SF Municipal Railway have thirty years of service proven history.

Loop Benefits & Liabilities

There are a lot of advantages to inductive loop CBTC. The technology has been service-proven for three decades, it's easy to install, and uses inexpensive unshielded stranded wire that is easy to repair in the field.

Today, transmit and receive interface circuitry for inductive loop systems is easy to design, build, and maintain. Technology obsolescence is of little concern because there are so many ways to design replacement subsystems using readily available Commercial Off The Shelf (COTS) components.

So why are so many new CBTC systems using RF technology? Answers are many and varied but primarily it seems most transit operators, i.e., those who have no prior experience with CBTC, simply don't like the idea of a wire loop that can be easily vandalized or perhaps even resold for scrap.

But while RF-CBTC systems largely eliminate these two concerns, they have their own problems. And while these problems are significant they were not widely understood when the transit industry, and especially MTA New York City Transit, first began to take a hard look at RF-CBTC systems in the early 1990's.

The RF Bandwagon Begins
General Railway Signal (now Alstom) was perhaps the first signal company to work with a specialty radio manufacturer (in this case Watkins Johnson) to design and build a custom transit radio for RF-CBTC.

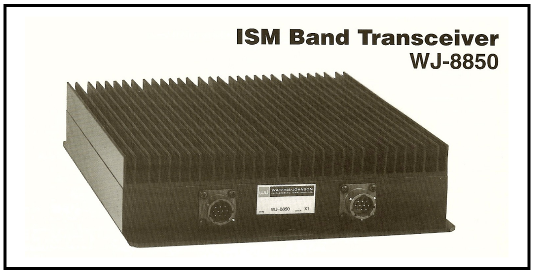

Photo2. Stillborn: Watkins Johnson's CBTC radio developed for GRS circa 1994 never saw revenue service.

Independently, but at about the same time, SF BART saw value in an advanced "radio ranging" from Hughes Aircraft Company developed for the US Army and Marines. Known as EPLRS, BART hoped to leverage the approximately $500,000,000 in sunk engineering costs the U.S. government paid to develop EPLRS and believed it could easily adapt this radio for its CBTC train system that BART called Advanced Automatic Train Control (AATC).

AEG Westinghouse (now Bombardier) also got into the act by teaming with Andrew Corporation another specialty radio manufacturer. Unlike other signal and radio suppliers, however, Bombardier and Andrew believed that a lossy line was the only way to ensure reliable communications in the subways.

A lossy line, sometimes called a "leaky feeder" is a coaxial cable with periodic openings in the outer shield to permit RF energy to leak out or radiate in. It's been used for decades in subways for voice radio but Bombardier's leaky feeder CBTC design is unique.

Today, Andrew's Model 2400 direct sequence spread spectrum radio is in successful revenue service at the San Francisco Airport, soon SEPTA, and elsewhere.

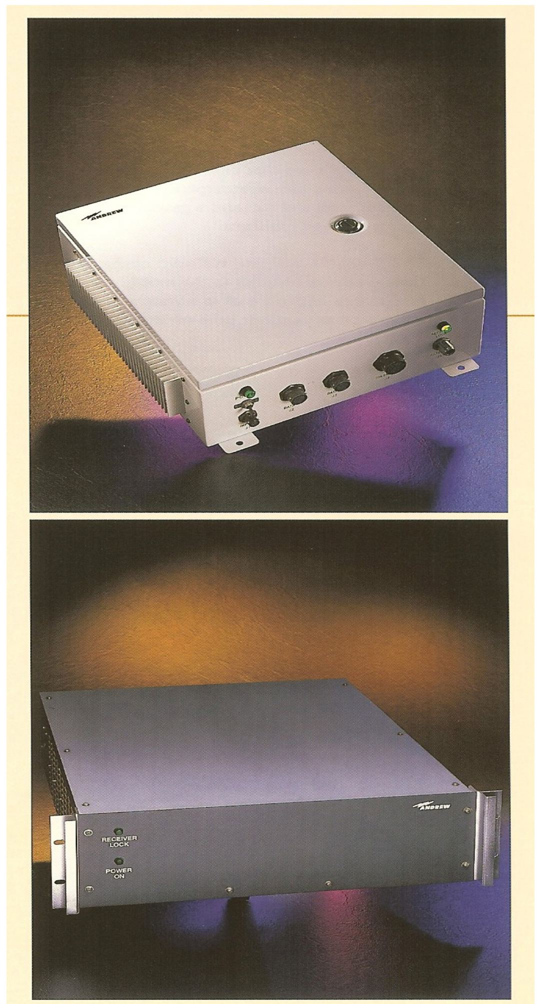

Photo 3. Andrew's Model 2400 radios is used in a number of initial Bombardier CBTC installations in the 1990's.

Trouble in RF-CBTC City
But there's a problem with the Andrew Model 2400 radio: After only a few years, it was discontinued due to poor

sales. One of the alleged reasons for its poor sales is that it was designed to work closely with Bombardier's Flexiblok (now CityFlo* 650) CBTC. Thus, while other firms might be interested, its close connection with Bombardier makes it harder to interface with other systems.

Meanwhile, back on the West Coast HMK (a joint venture of Hughes and MK) after spending all of the available federal research funds decided it wanted out. Hughes then sold its EPLRS technology to Raytheon and ultimately GE (which bought Harmon) which began to build a lower cost version of the original Hughes EPLRS radio.

Installation of AATC at BART continues and radios are installed on virtually all of its cab cars and approximately 1/3 of the system.

Photo 4. GE's CBTC radio network installed at SF BART is based upon advanced technology originally developed for the US Military

One of the challenges with any new technology is not the overall concept and design. Actually, that's where all the fun is for engineers. The challenge is in the details which is usually where many of the hidden costs begin to appear.

For example, CBTC radios are relatively small and light weight. So are the antennae. But BART and NYCT have been surprised to discover that there is significantly additional costs to ensure that these system can be maintained safely.

Consider the significant CBTC and antennae structures installed by BART in its elevated sections. An OSHA approved ladder and appropriate protections were provided to ensure worker safety.

Photo 5. BART train nearing a wayside CBTC antenna cantilevered off an elevated track section.

Radio Technology Marches Along

In April of 2003, Bombardier won yet a another CBTC job, this time in Taiwan. But because Bombardier was no longer able to purchase custom Andrew CBTC radios it needed to find a new radio.

Perhaps based upon its unfortunate experience with Andrew this time Bombardier elected to go with an inexpensive commercial off the shelf (COTS) radio made by Safetran.

At less than 1/10 the cost of Andrews' custom radio ($1600 Vs $22,000), Safetran's COTS Ethernet Spread Spectrum Radio also occupies only 6% of the volume.

Andrew's discontinued Model 2400 has a EIA RS-530 interface. The Safetran Ethernet Radio has a standard, and infinitely more popular, 10/100 BaseT Ethernet port.

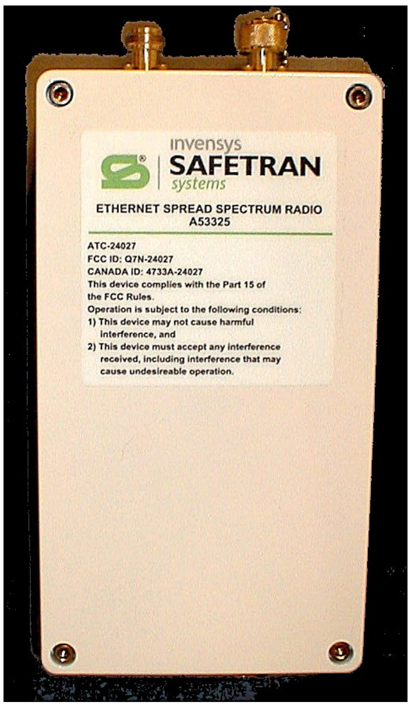

Photo 6. **Commercial off the Shelf**. Bombardier now uses a compact and inexpensive Ethernet Spread Spectrum radio by Safetran Systems

On July 15, 2004 the Las Vegas monorail went into full revenue service. Controlled by a Seltrac RF CBTC system, the data radio technology Alcatel selected was not a custom data radio, nor was it a COTS data radio. Rather Alcatel elected to use IEEE Std. 802.11 data radios.

Yes, that's right. The same very popular industry standard data radio protocol, also called "WiFi," that you probably now have operating in your notebook computer and palm pilot is now safety and reliably controlling trains in Las Vegas.

While Alcatel says it will continue to support and provide inductive loop Seltrac systems when requested, Alcatel also says that it has decided to standardize on IEEE Standard data radio technology for its RF-Seltrac systems.

A look under the hood of a typical Alcatel wayside radio location helps explain why. At Penny's Bay, Hong Kong, most of the space in the cabinet is empty. In the top left hand corner you can make out the IEEE 802.11.

While many had doubts that 802.11 could be used reliably for train control systems (and some still do) Las Vegas is proving them wrong. Clearly, the advantages to using IEEE industry standard data radios are many and profound.

To begin with, the cost of 802.11 radios is approximately 1/10 that of a COTS radio and less than 1/100 the cost of a custom CBTC radio.

Interoperability among multiple radio suppliers is ensured by an industry trade group know as the "WiFi Alliance."

IEEE 802.11 technology and interoperability continues to evolve at a dizzying rate. Recently Atheros Communications announced that is now sampling a single integrated circuit that supports 802.11a/b/g as well as the new standard for security 802.11i and the quality of service extensions associated with 80211e.

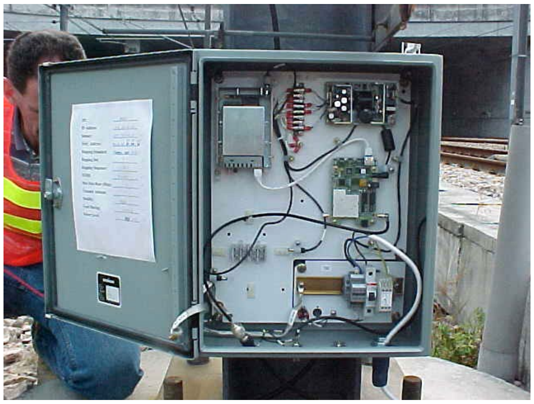

Photo 7. Alcatel's Radio CBTC systems for Hong Kong, Las Vegas and Paris Metro use multi-sourced IEEE Std. 802.11 radios (top left corner)

Thus, it appears the only thing we can really be sure about IEEE standard data radios is that they will continue to evolve and improve and continue to be supported for a long time.

But What About NYC Transit?

Back on the East Coast NYCT’s CBTC technology leader Siemens (formerly MATRA Transport) is moving ahead with the installation of its custom Siemens CBTC radio on NYCT’s Canarsie “Pilot CBTC Line.”

Photo 8. Siemens proprietary 2.4 Ghz CBTC Radio will be used only on NYCT’s Canarsie Line

The original plan for New York you may have heard was to develop a standard CBTC design by selecting one technology leader and two followers who would provide CBTC equipment compatible with the leader’s.

Unfortunately, things have not yet worked out as planned. Alstom, one of the followers has dropped out and Alcatel the other follower is still working to build a CBTC System compatible with Siemens’.

But what about the radio? And what about compatibility and interoperability and competition on future NYCT lines?

Things remain murky. As of November 2004 the specific procurement strategy for the second CBTC line, Flushing, is not resolved. Partly this is because there is only one firm who can provide the radio. But this is not the radio that is going to be used on Flushing.

Senior MTA and NYCT management desire a total of four suppliers of compatible, interoperable CBTC equipment. But currently, NYCT is having trouble getting two compatible systems let alone three or four. No small part of the problem is custom proprietary radios.

So where are we going?

Clearly, there are a lot changes in data radio technology today. Next generation "software radios" will allow their personalities to change by downloading new code. And beyond that "cognitive radios" that have the ability to adapt to a wireless spectrum or network environment automatically to accomplish some task are coming.

To help put these "radio types" in perspective and better understand these issues and recent radio history, Table 1 lists some key attributes associated with Custom, COTS, and IEEE industry standard radios.

For additional information and to participate in a discussion forum on CBTC radios please go to www.tsd.org/cbtc.

Radio Attribute	IEEE Standard	Commercial Off The Shelf	Custom Radio
Product Example (Radio & CBTC)	**IEEE Std. 802.11** +Alcatel Seltrac	**Invensys/Safetran** +Bombardier CityFlo 650	**Watkins Johnson** +GRS Atlas **Andrew** +Adtranz Flexiblok **Siemens** +Matra Meteor
Size/Weight	Smallest	Compact	Largest
Relative Cost	1	10X	100X
Product Life	Longest	TBD	Shortest
Upgrade Path and Potential	Best (802.11 b,a,g,e,i)	Good	Poor
Radio vendor Interoperability	Many (via WiFi Alliance)	None	None
Radio + CBTC Interoperability	None	None	None
Radio + CBTC in Service	Yes (Alcatel Las Vegas)	No	Yes (Bombardier – SFO)
Network Interface	Communications Industry Standard IP over Ethernet	Industry Standard (ATCS, Ethernet LonWorks)	Typically, custom or external to radio

Table 1 – CBTC Radio Types Compared