"WIRELESS" ... A PRIMER

By Bryan Rusenko

DEFINITION

You can begin to define wireless technology more by what it isn't than by what it is. Think of all the wires you've seen connecting things that you use. In your office, there's the cord between the handset and the main unit of your desk phone. There is a cord to the wall connection. Your computer has a wall connection for the network. There are cables to your keyboard, mouse, and monitor. Here, we have the roots of two main areas of wireless technology, communications and computing. At the beginning, wireless technologies sought to replace these wires, giving us the benefits of simplicity and freedom. There would be fewer cables to tangle and collect dust. There are now standards or systems to replace all of the cables mentioned. The telephone has been reborn as the mobile, handyphone, cellular, or PCS. How long ago was it unimagined to be able to make and receive calls from almost anywhere?

Among the last groups unreachable by these phones are passengers in a commercial aircraft. That is, at least for now. Using a laptop computer during a flight isn't a novelty anymore, but sending and receiving e-mail or connecting to the Internet during a flight has just become the newest novelty, or perhaps necessity. If your laptop supports wireless networking, you may be able to connect in the taxi on the way to the airport, in the departure lounge, and now onboard a few flights. And no wire is required between your computer and the onboard passenger network.

Wireless technology onboard aircraft can be applied for crew use as well. Connected terminals for duty-free sales, crew alert systems, and video monitoring of cabin

areas such as outside the cockpit door are all proposed to use wireless networking. Most likely this will be the same wireless technology that passengers will use.

INTERFERENCE ISSUES

The use of this radio and electronic microprocessor technology in general has been regulated since the earliest days of radio, TV, and flying passengers. The issue centers on the possible interference created by these devices to aeronautical radios essential to flight operations. The obvious suspects are radio transmitters such as remote control toys, mobile phones (which transmit a "here I am" type signal whenever turned on so that a phone call can be routed to the phone), two-way pagers, and e-mail devices. As transmitters, these devices are classed as intentional radiators. There are also unintentional radiators, such as devices that leak amounts of radio frequency (RF) energy. Some radio and television receivers, as well as inadequately shielded devices using microprocessors, are guilty of this. CD players using the latest in over-sampling converters use radio frequencies internally. So do laptop computers. How can we know by looking at a unit that it is adequately shielded against leakage? There are various certifications required on manufacture, but as a unit ages and is repaired, these may no longer be valid.

SOME RADIO BASICS

What are the parameters of wireless technology? Two basic parameters are that each service is allocated a frequency and a bandwidth, which together may be thought of as a channel. Frequencies are expressed in Hertz, a term referring to the number of cycles per second. "Hertz" is a versatile measurement unit, describing frequencies of sounds we can hear at hundreds or thousands of Hertz to the radio frequencies of millions and billions of Hertz referred to as Megahertz (MHz) and Gigahertz (GHz). For example, the US broadcast television channels are assigned between 50MHz and 800MHz. Each channel is 6MHz wide. So channel 2 is assigned starting at 54MHz and ending at 60MHz. This was a fairly wide bandwidth and required by the amount of information contained in video compared to audio in radio. US FM radio has channels spaced 0.2MHz apart. In simple terms, the carrier frequency is the center of the channel, and the useful information is modulated, or encoded, onto the carrier. To carry more information

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THE BLACKBERRY™

by Research In Motion Limited, was one of the very first must-have stay connected anywhere devices. It is marketed as the one-stop, no-compromise, wireless solution that allows you to stay connected with secure, wireless access to e-mail, corporate data, phone, Web and organizer features. Every BlackBerry™ handheld includes the most advanced wireless technology. It also has an optimized keyboard, thumb-operated trackwheel, easy-to-read backlit screen, intuitive menu-driven interface and integrated software applications. With BlackBerry™, mobile professionals get effortless access to their important information and communications while on the go. Imagine the possibilities of sending and receiving messages while waiting to board your plane, placing a phone call while reading your e-mail messages in a hotel lobby, or viewing information from a corporate database in the back seat of a taxi.

BlackBerry™ 5810

The BlackBerry™ is also promised to be "Always On, Always Connected." RIM says that BlackBerry™ handhelds are designed to remain on and continuously connected to the wireless network so e-mail and other corporate data can be automatically delivered to your handheld. For travel aboard an airplane, there is a "Turn Wireless Off" mode, which then displays an airplane icon. It is up the user to remember to select it.

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requires more bandwidth or a better modulation scheme. The same concepts of frequency, channel, and bandwidth are applied to most radio services, including aeronautical radio, amateur radio, satellite television, mobile phones, and FM radio just to name a few.

A very different technology has been made possible with microprocessor control of the radio. Spread spectrum techniques utilize many carriers inside the channel bounds. At thousands of times per second, the transmitter and receiver change to a new frequency in a predetermined sequence. Both Bluetooth and Wi-Fi (Wireless Fidelity 802.11x) standards use this technique, with Bluetooth hopping between 79 different frequencies at a rate of 1,600 times a second. Why go to all of this trouble? Since only a small amount of information is transmitted on each frequency, if there is interference, only a small amount is lost. Also, because different pairs of senders and receivers may use a different sequence, many more users can co-exist in the same channel without completely impairing others. Spread spectrum sounds quite modern, and it was surely enabled by fast microprocessors. The concept was actually patented in 1942 by Heddy Lamarr and George Antheils. Yes, the same Heddy Lamarr of Hollywood fame. It took 50 years for technology to catch up. Another benefit is spectrum sharing, a very important issue.

SPECTRUM COORDINATION

The World Radiocommunication Conference meets as an international group to set worldwide frequency assignments to assure the coordinated use of spectrum. One agreed-on band is the Industrial Scientific and Medical (ISM) band at 2.4GHz. In contrast to other services, users do not need to apply for a license to use approved equipment that operates in the band. A similar band exists at 5GHz, as well as the 900MHz and 49MHz bands that we are familiar with from cordless phones. The short description of policy in these bands is that if things work, fine. If not, there are no licensees or owners of the frequencies; users just have to tolerate other legal users. So in the case of Wi-Fi and Bluetooth, any immunity to interference is a big advantage.

There are several technologies that are being discussed in the cabin environment.

WI-FI AND BEYOND

The wi-fi.org Web site explains that Wi-Fi products use radio technologies called IEEE 802.11b or 802.11a to provide connection to other users and base stations, or access points. Wi-Fi networks operate in the unlicensed 2.4 and 5GHz radio bands, with an 11 million bits per second (Mbps) (802.11b) or 54 Mbps (802.11a) data rate. The newest 802.11g standard products just being

released also operate at 54 Mbps. Just in case you were wondering, a wired Ethernet network connection is defined in IEEE 802.3.

Each of these standards defines the carrying information over some medium. In fact they are the lowest layers of the International Standards Organization (ISO) seven-layer model. Because of the layer approach, radio was able to replace wire in the lowest layers representing physical and data link just by interfacing correctly to the next layers upward. In this way the pathway of the information is unimportant compared to the information itself ... or even the program that is sending it. In other words, the contents of your e-mail will get sent no matter what connection your computer is using. Available since 1999, 802.11b is the most widely installed standard, and perhaps the one that represents Wi-Fi as understood by most people.

This technology is used to construct a Wireless Local Area Network (WLAN) that enables the same types of services as your office LAN. Computers, printers, servers, and gateways to other networks can all be a part of the network. Multiple base stations, called Access Points, may be used to cover an area. Connections between access points are usually wired.

Connectivity for passengers can be achieved by installing one or more access points in an aircraft cabin. Each access point is limited to the maximum bandwidth of the standard it employs, say 11Mb/s for 802.11b. The area of the cabin served by any one access point is determined by its power setting. More access points provide a greater aggregate bandwidth to the cabin. Since each user is associated to only one access point at a time, their effective bandwidth will be that of the access point as shared with physically adjacent users.

BLUETOOTH

Where Wi-Fi is meant to be a wireless local area network equivalent, Bluetooth is designated a Personal Area Network (PAN) technology. This is the really interesting replacement for those wires on your desk, so to speak. Bluetooth may be used to connect your computer to your PDA, to your printer, to your still camera, even to your mobile phone. It even connects your mobile phone to your headset or earpiece without wires. All of this assumes Bluetooth-enabled models. It operates in the 2.4GHz unlicensed band, along with 802.11b & g devices. A spread spectrum frequency-hopping scheme is used employing 79 different frequencies at 1MHz intervals.

While it may not have a place as part of the installed cabin and IFE systems, it is very likely that passengers will carry Bluetooth devices onboard. With such an unobtrusive and possibly pervasive technology, the question may be "Will the passenger even remember that it is turned on?" Some devices do not feature a clear way to turn off the

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radio functions of Bluetooth connections, and it can be quite easy to forget about something that is so transparent. Bluetooth was named after King Harald of Denmark who, between 940 and 985, united Denmark and Norway into a single kingdom. It was envisioned to unite telecom and computers in much the same way.

MOBILES, CELLULAR, AND PCS

These personal phone systems all have several common characteristics. They use low power to communicate with a base station, one cell in a group of interconnected stations. Hence the term "cellular" may apply to all of the phone systems but is generally used to refer to the original analog North American system and its digital replacements. What differentiates them are the operational frequency and the communication standard. Frequencies in use worldwide include 900MHz and 1800MHz. In North America 800MHz was the first band and still referred to as cellular service, with 1900MHz added and termed Personal Communication Service (PCS).

The original North American analog system is referred to as Advanced Mobile Phone System (AMPS) and it represents the widest coverage in terms of square miles in North America. Digital systems were first introduced with the Time Division Multiple Access (TDMA) standard. Later the Code Division Multiple Access (CDMA) standard was introduced. Integrated Digital Enhanced Network (IDEN) is used by one carrier and features a walkie-talkie function, or push to talk. The Global System for Mobile (GSM) also plays a part in the US. Japan has been dominated by the i-mode system, with CDMA gaining. The GSM standard dominates outside North America, with CDMA finding growth as well.

Second- (2G, 2.5G) and third-generation (3G) versions of these systems are defined and beginning to be installed, as defined by Wideband-CDMA (W-CDMA) and CDMA-2000. One of the advantages offered by these advances is higher data connectivity, enabling Internet connections at respectable speeds to a browser in the phone or a connected computer.

In the beginning, each country or provider launched a mobile telephone system with their chosen or assigned frequency band and system type. The realities of traveling around the world eventually dictated that multiple-band-capable and multiple-system-capable handsets be developed. The newest chipsets announced have begun to integrate more than one of the most modern digitalstandards.

A system to allow mobile phone use onboard with a passenger's own phone has been much requested by passengers. In its most simple form, a base station for each system type would have to be brought onboard. Any single system would exclude some users. Some systems may not adapt well to the short ranges inside the cabin. Because of the convergence in interoperability, future phones will likely be multisystem capable.

ULTRAWIDEBAND

An emerging technology that has been identified as likely to be carried aboard by passengers, if not installed by airlines themselves, is UltraWideband (UWB). Its communications applications offer a very large bandwidth currently 40–60 Mb/s and eventually up to 1000 Mb/s. That's the wireless equivalent of Gigabit Ethernet. It would be an unlicensed service operating alongside other licensed services. While it certainly sounds good, UWB has serious critics. It employs a very wide spectrum of frequency at very low power. How wide? The current proposal calls for a 3 to 10 GHz band. The use of UWB would overlay everything else in the existing bands between those frequencies, generally raising the background noise floor. Because of this potential for interference, there is much concern over the feasibility of reliable operation of many of the radio services vital to commercial aircraft, including the GPS system.

With a range of tens of feet, it could be used to deliver digital program content throughout your home. A wireless IFE system might make use of it in the same way, if approved, and any interference problems are avoided.

THE POWER CORD

You may have been struck by the thought that the power cord will still remain. Nowhere have we discussed a replacement technology for that connection. Hopefully batteries and alternate power sources will continue to improve. Unfortunately, there is no current work to broadcast power wirelessly. The efforts by Nikola Tesla, regarded as the father of the alternating current (AC) power system, may have been the last. In a demonstration conducted around 1900, he powered 200 lamps at a distance of 25 miles, without wires!

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WIRELESS ONBOARD AIRCRAFT

November 19 – 20, 2002 • Loews L'Enfant Plaza Hotel • Washington, D.C. USA

A Single-Focus Workshop presented by the WAEA and the University of Oklahoma Wireless EMC Center

In a WAEA first, the Technology Committee teamed up with University of Oklahoma Center for the Study of Wireless Electromagnetic Compatibility at Norman, Oklahoma, to present a well-received agenda of current topics. Industry and government were represented with 97 organizations and over 170 attendees.

The conference chairs were Hank Grant, Ph.D., Director, EMC Center, and Mary Rogozinski of United Air Lines, currently the WAEA Acting President. The goals of the meeting were to bring individuals from the wireless industry, the aviation industry, and government agencies together to discuss the uses and interaction of wireless technologies onboard aircraft, to collaborate on the future, identify research needs, and establish an ongoing "communication link" between the wireless and aviation industries.

Bryan Rusenko is Senior Vice President, Special Projects Engineering at Crest National Digital Media Complex in Hollywood, California. An avid technophile and digital expert, Bryan has special expertise in refining technical information into layman's terms and is a frequent and accomplished speaker at technical gatherings and industry meetings. He currently serves on the WAEA's Board of Directors and co-chairs the Association's Technology Committee.

This was a merging of views and information from the WAEA, the wireless industry, and government. Represented were WAEA airlines and vendors, the Airline Pilots Association, the Civil Aviation Authority, the Consumer Electronics Association, the Cellular Technologies Industry Association, the Federal Communications Commission, the Federal Aviation Administration, NASA, US Department of Transportation, and members of the communications industry.

Topics and sessions included a keynote address from Ralf Wolckenhauer of Airbus, a discussion of consumer wireless devices brought onboard and how to manage them, and the use and integration of wireless technology in aircraft systems. A panel of CAA, FAA, and FCC representatives discussed policy issues. A very lively session sought to identify myths and truths about wireless use aboard aircraft, including the much-anticipated presentation on UltraWideband technology by Jim Miller of United and Jay Ely of NASA. The last sessions served to predict the future of how wireless technology may be applied to aviation.

Conclusions reached at the workshop call for a need to involve equipment manufacturers in this work. A new working group in RTCA was proposed. More direct coordination with the World Radio-communication Conference may be attempted. In fact a consensus was formed that a follow-up workshop be held in Europe later this year.

The Wireless EMC Center began as a concept in the spring of 1994 with a charter to serve as an independent center dedicated to the investigation of issues related to the electromagnetic compatibility of electronic equipment with wireless devices. Within six months it had become a national forum for this work.

The Center provides education to industry and wireless users, is a clearinghouse to monitor the state of the art in trade organizations and standards committees, and a research/test facility for the products.

The mission of the WAEA Technology Committee is to identify technologies that could impact the passenger environment in the future. The TC analyzes emerging technologies, imparts the knowledge acquired to the WAEA membership, and recommends/guides the implementation of the technologies into the passenger environment. All WAEA members are welcome to participate and may contact co-chairs Al McGowan, Bryan Rusenko, and Rich Salter for more information.

See also the WAEA Web site at:
http://www.waea.org/events/single_focus/2002/index.htm
for full workshop presentation materials.